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Original Research Paper

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3D DATA ACQUISITION IN MAXILLOFACIAL PROSTHESIS FABRICATION

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ABSTRACT Accurate three-dimensional (3D) data acquisition is fundamental to the digital workflow in maxillofacial prosthesis fabrication. Reliable capture of anatomical details enables the design of patient-specific prostheses that restore function, aesthetics, and quality of life. Current acquisition methods are broadly categorized into medical imaging and surface scanning. Computed tomography (CT) and cone-beam computed tomography (CBCT) provide high-resolution volumetric data of hard tissues, with CBCT offering reduced radiation exposure. Magnetic resonance imaging (MRI) is invaluable for visualizing soft tissues but less effective for bone assessment. In contrast, surface scanning methods—including laser scanners, structured light scanners, intraoral scanners, facial scanners, and stereophotogrammetry—allow non-invasive capture of external topography without radiation risk. These technologies are particularly useful for defects involving auricular, nasal, and orbital regions. Each modality presents distinct advantages and limitations in terms of accuracy, tissue visualization, cost, and clinical applicability. Comparative analysis demonstrates that no single approach is universally superior; instead, a multimodal strategy that combines complementary techniques often yields the best clinical outcomes. Ongoing innovations in acquisition speed, resolution, and accessibility continue to expand the role of 3D technologies in maxillofacial rehabilitation. Collectively, these advances are reshaping prosthetic workflows, enabling precise, efficient, and patient-centered treatment.

KEYWORDS : 3D Data Acquisition, Maxillofacial Prosthesis, CT, CBCT, MRI, Surface Scanning, Photogrammetry, Digital Workflow

INTRODUCTION

Precise three-dimensional (3D) data acquisition is fundamental for designing and fabricating maxillofacial prostheses. Digital technologies now allow detailed visualization of hard and soft tissues, supporting accurate, patient-specific rehabilitation. Broadly, acquisition methods are classified into medical imaging (CT, CBCT, MRI) and surface scanning (laser, structured light, intraoral, facial, photogrammetry). Selection depends on defect type, anatomy, and clinical objectives.

1. Medical Imaging Modalities

1.1 Computed Tomography (CT)

CT creates cross-sectional images using X-rays and detectors rotating around the patient. The slices are reconstructed into 3D models.

Applications: Contralateral datasets are mirrored to fabricate auricular, orbital, and nasal prostheses.

Advantages: High-resolution, no tissue overlap, reliable for surgical and prosthetic planning.

Limitations: High cost, significant radiation, and poor soft-tissue contrast compared with MRI [1].

1.2 Cone-Beam Computed Tomography (CBCT)

CBCT uses a cone-shaped X-ray beam and flat-panel detector to capture volumetric data.

Advantages: Radiation ~15 times less than CT (≈12 panoramic radiographs), short scan times, and good hard tissue detail.

Limitations: Lower soft-tissue contrast, image artifacts in some regions [2].

1.3 Magnetic Resonance Imaging (MRI)

MRI employs strong magnetic fields and radio waves to visualize tissues.

Advantages: Excellent for soft tissue, multiplanar views, no ionizing radiation.

Applications: Tumor mapping, soft-tissue asymmetry, vascular assessment.

Limitations: Poor bone visualization, contraindicated with implants/pacemakers, expensive, lengthy scans [3].

2. Surface Scanning Modalities

2.1 Laser Scanning

Projects a laser line on the object, captured by cameras for triangulation.

Advantages: High precision, non-invasive, captures contours for auricular/nasal/orbital prostheses.

Limitations: Requires multiple scans, sensitive to movement, safety issues for eyes, difficulty capturing texture [4].

2.2 Intraoral Scanning (IOS)

Optical scanners such as 3Shape TRIOS and Carestream capture digital impressions.

Advantages: Comfortable, accurate, immediate feedback, CAD/CAM integration, better communication with labs.

Applications: Defect impressions, intraoral prostheses, occasionally extraoral scans.

Limitations: Limited field for large defects, difficulty with reflective/scarred tissue, bulky scanner tips [5].

2.3 Structured Light Scanning

Projects patterned light and captures distortions.

Advantages: Sub-millimeter accuracy, rapid, reproducible.

Applications: Widely used for implant-supported auricular, nasal, and orbital prostheses.

Limitations: Affected by ambient light, reflective surfaces, costly equipment [6].

2.4 Facial Scanning

Captures external facial contours using optical scanning.

Findings: Convex regions scan accurately; concave/undercut areas (oral commissure, nostrils, ear canal) less precise.

Advantages: Full facial capture, quick, non-contact.
Limitations: Reduced accuracy in deep or complex surfaces [7].

2.5 Stereophotogrammetry

Reconstructs 3D geometry by analyzing multiple 2D photographs.
Advantages: Non-invasive, fast, accurate for overall facial shape.
Applications: Craniofacial mapping, orbital and nasal prostheses.
Limitations: Lower resolution than CBCT; errors with hair, posture, reflections [8].

3. Comparative Considerations

- CT vs. CBCT: CT excels in soft-tissue imaging; CBCT is preferred for bony structures due to low radiation.
- MRI: Indispensable for soft-tissue cases but less practical for hard-tissue prosthesis design.
- Surface scanners: Offer radiation-free alternatives but are limited by motion, reflections, and deep undercuts.
- Stereophotogrammetry: Ideal for quick, full-face capture but less precise than volumetric scans [9].

CONCLUSION

3D data acquisition has transformed maxillofacial prosthesis fabrication by enabling highly precise and patient-specific designs. Medical imaging (CT, CBCT, MRI) provides critical anatomical information, while surface scanning (laser, structured light, intraoral, facial, photogrammetry) offers safe, accurate external capture. No single modality is universally superior; often, combined use achieves the best outcomes. With ongoing technological refinement, acquisition will become faster, more accurate, and accessible, enhancing both clinical efficiency and patient rehabilitation.

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