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Digital Impression in Prosthodontics: A Review

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ABSTRACT:

Digital impression technology is transforming prosthodontics by enhancing the accuracy, efficiency, and patient comfort in the creation of dental prostheses. This technology captures precise 3D images of dental structures, facilitating the design and fabrication of various prostheses through CAD/CAM systems. In complete dentures, digital impressions ensure accurate representation of edentulous arches, leading to better-fitting prosthetics. For removable partial dentures, they streamline the design and production process, providing a precise fit for metal frameworks and prosthetic teeth. Fixed partial prostheses benefit from detailed digital scans of prepared teeth, allowing for the creation of crowns and bridges with optimal margins and occlusion. In maxillofacial prosthetics, digital impressions capture facial structures accurately, enabling the creation of custom prostheses that match the patient's anatomy. Implant-supported prostheses use digital impressions combined with CBCT data to design custom abutments and prosthetics, ensuring precise placement and fit. Overall, digital impressions in prosthodontics improve accuracy, reduce chair time, and enhance patient outcomes, representing a significant advancement in dental care.

Introduction

In recent years, digital technology has significantly transformed prosthodontics, particularly through the advent of digital impressions. Using intraoral scanners to capture the details of teeth and surrounding tissues, digital impressions offer numerous advantages over traditional methods, including improved accuracy, patient comfort, and efficiency. Traditional impression techniques, which involve trays and impression materials, can be prone to errors such as distortions or bubbles, leading to ill-fitting prostheses. Digital impressions, however, utilize advanced optical scanning technology to capture precise 3D images, eliminating these issues and ensuring superior fit and function of restorations. Digital impressions not only enhance accuracy but also reduce the time required for both patients and clinicians. The scanning process is quick and non-invasive, sparing patients the discomfort of impression trays. The digital data can be immediately transferred to dental laboratories, speeding up the turnaround time for prostheses. Furthermore, digital impressions facilitate better communication and collaboration between dental professionals, streamlining

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workflows and reducing errors. Integrating seamlessly with CAD/CAM technology, digital impression systems enable the automated design and manufacturing of prostheses, allowing for greater customization and consistency. This paper aims to provide an overview of how digital impressions constitute a major advancement in prosthodontics, offering improved accuracy, efficiency, reduced time requirements, and enhanced patient satisfaction.

Background and Evolution of Impression Technique

Impression techniques in prosthodontics have evolved significantly over time. Early methods used rudimentary materials like wax and plaster, which lacked precision. The mid-20th century saw the introduction of alginate, offering improved accuracy, followed by elastomeric materials such as polyethers and polyvinyl siloxanes, which provided superior dimensional stability. The late 20th century marked the advent of digital impressions, employing intraoral scanners to capture precise 3D images of the oral cavity. Digital technology offers enhanced accuracy, efficiency, and patient comfort, and reduces the need for physical impression materials. It also integrates seamlessly with CAD/CAM systems, allowing for rapid design and fabrication of dental restorations, improving clinical outcomes and patient satisfaction.

Digital Impression

Advances in CAD/CAM production concepts in dentistry have revolutionized the field, offering three main production methods based on the location of CAD/CAM system components:

Chairside Production is where all components are located within the dental office. This method utilizes intra-oral cameras instead of conventional impressions, allowing for the creation of same-appointment restorations. An example of a chairside system is the Cerec® System.

Laboratory Production involves sending impressions to a dental laboratory, where master casts are created, and the CAD/CAM process is completed. This process uses dental design software and milling devices, with the veneering done by a ceramist.

Centralized Production is a method where dental laboratories use satellite scanners and send data to a centralized production center. The center fabricates the restorations and sends them back to the lab. This approach reduces investment in equipment but may limit flexibility due to closed systems. Veneering is performed in the dental lab, and some centers accept impressions directly from dentists.

CAD/CAM Components in dentistry include scanners, design software, processing devices, milling variants, materials for CAD/CAM processing, and future technologies.

Scanners are divided into optical scanners, which use light (laser or white light) for 3D imaging, examples CEREC®, E4D, iTero, and Lava C.O.S and mechanical scanners, which use a ruby ball to mechanically read structures, examples the Procera Scanner by Nobel BioCare.

Design software is used for creating dental restorations such as crowns and FPD frameworks. While many systems use the STL data format, some use proprietary formats, balancing between broad capabilities and user-friendliness.

Processing devices convert design data into physical restorations using milling devices, which come in three types: 3-axis (e.g., inLab by Sirona, Lava by 3M ESPE), 4-axis (e.g., Zeno by Wieland-Imes), and 5-axis (e.g., Everest Engine by KaVo, HSC Milling Device by etkon).

Milling variants include dry processing for zirconium oxide blanks, which is cost-effective but has higher shrinkage, and wet milling, which uses a cooling liquid to prevent overheating, making it suitable for metals and glass ceramics.

Materials used in CAD/CAM processing range from metals like titanium and chrome cobalt, resins for provisional or long-term restorations, silica-based ceramics such as lithium disilicate, infiltration ceramics like Vita In-Ceram variations, and oxide ceramics including aluminum oxide and yttrium-stabilized zirconium oxide.

Future technologies in this field involve generative production, which adds material rather than subtracting it. This is used in laser sintering for cost-effective restorations.

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For dentists, CAD/CAM technology has expanded material options and improved production efficiency. However, tooth preparations must be adapted for optimal scanning and milling to achieve the best results.

Data Files and Designing

Digital impression systems create two types of data files:

Open architecture files, typically known as STL files, are manufacturer-independent and can be used with various design software. This flexibility allows broader business opportunities and compatibility with different labs and applications. For example, a lab using an open-architecture system can become an outsourcing partner for other laboratories or integrate new interfaces with emerging CAD software platforms. Individual dentists can work with multiple labs, maximizing their investment with options such as implant restorations and orthodontics.

Closed architecture files are manufacturer-specific, offering integrated solutions for CAD and CAM from the same manufacturer. This ensures compatibility and support, often providing better accuracy and ease of use. In a closed system, one company controls both CAD and CAM configurations, understands the milling unit's performance specifications, and adapts the software accordingly. For instance, using Sirona Connect, a participating Sirona Connect lab can receive files from any CEREC device, design and mill on an in-lab system, and deliver a restoration to a dentist using CEREC. Manufacturers advocate for closed architecture files to ensure accuracy and user-friendliness.

Table 1: Available Systems

CEREC	Sirona Dental System GmbH (Germany)
iTero	CADENT Ltd (Israel)
E4D	D4D TECHNOLOGIES, Llc (USA)
Lava™ C.O.S.	3M ESPE (USA)
Trios	3SHAPE A/S (Denmark)
MIA3d™	Densys3D Ltd (Israel)
DPI-3D	DIMENSIONAL PHOTONICS INTERNATIONAL, Inc. (USA)
3D Progress	MHT S.p.A. (Italy) and MHT Optic Research AG (Switzerland)
Direct Scan	HINT – ELS GmbH (Germany)
IOS Fast Scan	IOS TECHNOLOGIES, Inc. (USA)
Blue scan	TRON 3D GmbH (Austria)
Plan scan	Planmeca Oy (Finland)
Condor	Remedent Inc. (Belgium)
CS 3500	Carestream Health, Inc. (USA)
Dig Imprint	Steinbichler Optotechnik GmbH (Germany)

Figure 1: Various Intraoral Scanners Available

Applications of Digital Impressions

Complete Denture: Digital impressions revolutionize the process of fabricating complete dentures by capturing precise 3D images of edentulous arches. This allows for the accurate design of the denture base and teeth arrangement using CAD software. Virtual try-ins enable adjustments for optimal fit and occlusion before the physical dentures are milled or 3D printed. The result is a quicker, more comfortable process for patients, and dentures that fit better and function more effectively when tried in the patient's mouth.

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Removable Partial Denture (RPD): It starts with scanning the dental arches, including both existing teeth and edentulous areas. CAD software is then used to design the metal framework and prosthetic teeth.

This design is digitally simulated to ensure proper fit before being fabricated using additive manufacturing or milling. The final assembly, which involves adding teeth and flanges to the framework, results in a precise, custom-fit RPD that can be tried in and adjusted as necessary for patient comfort and functionality.

Fixed Partial Prosthesis: For fixed partial prostheses, digital impressions provide a high-accuracy scan of the prepared teeth and surrounding tissues. This data is used to design bridges or crowns with CAD software, ensuring that fit, margins, and occlusion are accurately represented.

The prostheses are then milled or 3D printed using durable materials such as zirconia or ceramic. This technology not only speeds up the production process but also enhances the precision and fit of the final prosthesis, which is cemented and adjusted in the patient's mouth.

Maxillofacial Prosthesis: The initial scan captures detailed 3D images, which are used to create a digital model of the prosthesis with CAD software. Virtual try-ins allow for adjustments in fit, colour, and texture, ensuring a natural appearance.

The prosthesis is then fabricated using 3D printing or milling techniques with materials like silicone or acrylic, providing patients with a customized, high-quality solution that is finely adjusted for comfort and aesthetics.

Implant-Supported Prosthesis: Digital impressions start by scanning implant sites and adjacent teeth, integrating this information with CBCT scans for a complete 3D model. CAD software designs custom abutments and prostheses tailored to the patient's anatomy, which are milled or 3D printed from durable materials like titanium or zirconia.

The final prosthesis is securely affixed to implants and adjusted for optimal fit, providing patients with a precise, efficient, and durable treatment option.

Figure 2: Digital (3D printed) v/s traditional physical (poured impression using dental stone) cast

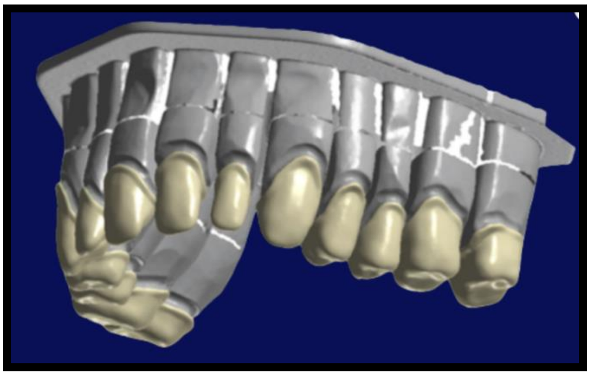

Figure 3: Screen-shot of CAD-construction of 14 single crown copings

Advantages: Digital impressions offer unparalleled accuracy by capturing highly detailed 3D images of teeth and surrounding tissues, eliminating common errors found in traditional impressions. This precision results in better-fitting prostheses, enhancing patient comfort and satisfaction. They are time-efficient, reducing the need for multiple appointments, and the data can be instantly shared with dental labs, speeding up turnaround times. The non-invasive nature improves the patient experience by eliminating discomfort from impression trays. Integration with CAD/CAM technology ensures consistent, customized prostheses, and enhances communication between dental professionals for high-quality outcomes.

Disadvantages: The initial investment in digital impression systems, including scanners and software, along with maintenance and updates, can be costly. The learning curve is steep, requiring significant training. Compatibility issues between different digital systems

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may limit flexibility and workflow integration. Reliance on digital systems means technical issues can disrupt workflows, potentially causing treatment delays.

Intraoral Scanners: Intraoral scanners utilize technologies like confocal microscopy and optical coherence tomography to capture detailed images of the oral cavity.

Scanning Procedure: Teeth are prepared as for traditional impressions. Then Intraoral scanners quickly and non-invasively capture images of the prepared area. These images are then processed by the scanner's software to generate a precise digital 3D model of the oral cavity, ensuring accuracy and efficiency in capturing the necessary data.

Digital Design and Manufacturing: In lab, CAD software is used to design the restoration, which is then fabricated using CAM machines with materials such as zirconia, lithium disilicate, or metal alloys.

Conclusion

Digital impressions in prosthodontics have revolutionized the field by offering superior accuracy, efficiency, and patient comfort compared to traditional methods The integration of digital impressions with CAD/CAM technology has revolutionized the way dental restorations are designed and fabricated, leading to improved clinical outcomes. As digital technology advances, its application in prosthodontics will likely expand, further enhancing the quality of dental care. As digital technology continues to evolve, it is likely that digital impressions will become the standard of care in prosthodontics.

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