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From Analog to Digital: Role of Intraoral Scanners in Dentistry - A Review Article

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ABSTRACT

Intraoral scanners (IOS) have revolutionized the field of dentistry, offering a cutting-edge alternative to traditional impression methods. These innovative devices enable dentists to capture highly accurate digital impressions of a patient's teeth and surrounding tissues, streamlining the treatment process and enhancing patient care. Recent years have witnessed notable IOS technology advancements, characterized by hardware innovations and software breakthroughs. These developments improved intraoral scanning efficiency and accuracy in computer-aided design and computer-aided manufacturing (CAD-CAM), which remains IOS's most common use case.

Keywords: Intraoral scanners (IOS), computer-aided design and computer-aided manufacturing (CAD-CAM), Dentistry.

INTRODUCTION

An intraoral scanner is a handheld device, often shaped like a wand or pen that captures 3D digital impressions of a patient's teeth and soft tissues. They allow for the acquisition of intraoral optical impressions and the representation of data as detailed virtual models. Intraoral scanners boast magnification capabilities 5-10 times higher than traditional visual examinations. Light source from the scanner is projected onto the scan objects, such as full dental arches, and then a 3D model is processed by the scanning software which is displayed in real-time on a touch screen. The device provides accurate details of the hard and soft tissues located in the oral region through high-quality images. [1]

EVOLUTION

Young and Altschuler were the first one to develop an intraoral grid surface mapping system by suggesting the idea of using optical instrumentation in 1977.[2] In the 1980 a Swiss dentist, Dr Werner Mormann in association with Marco Brandestini, an Italian electrical engineer invented first digital intraoral scanner. The developed concept was introduced in1987, CEREC by Sirona Dental Systems at the University of Zurich, after which, evolution continued and resulted into the many intraoral scanning technologies with better techniques.[3]

Specialized and Emerging IOS Applications

- **Prosthodontics**

Fixed Prostheses: Ensures the accurate fitting of crowns, bridges, and veneers.

Removable Prostheses: Improves the design and fit of removable prostheses like dentures and partials. [4]

- **Implantology**

Surgical Guides: Assists in creating accurate surgical guides for implant placement, improving precision and outcomes. [5]

- **Restorative Dentistry**

Precision: Achieves highly accurate digital impressions for crowns, bridges, inlays, and onlays. [3]

- **Endodontics**

Diagnostic Accuracy: Assists in diagnosing complex root canal anatomy and pathology. A newer approach would be to use intraoral scanners to scan the accessed pulp chamber and produce STL files. [6]

- **Orthodontics**

Clear Aligners: Facilitates the design and fabrication of clear aligners by providing precise digital models. Pahuja *et al* evaluated that intraoral scanner is an effective tool for orthodontic diagnosis and treatment planning. Additionally, they have clinically acceptable accuracy, reliability, and reproducibility of the tooth measurements. [7]

- **Oral Surgery**

Surgical Precision: Facilitates the planning and execution of surgical procedures with accurate digital models. Treatment Planning: Enhances pre-surgical planning and post-operative monitoring. Angelone *et al* concluded that intraoral scanner is excellent tool in evaluation of scarring and asymmetry of the upper lip in surgically managed cases of unilateral cleft lip and cleft palate. [4]

- **Cosmetic Dentistry**

Smile Design: Enables precise smile design and cosmetic treatments, enhancing aesthetic outcomes. Patient Involvement: Involves patients in the design process by showing them digital previews of their potential smiles.

Customized Treatments: Allows for the creation of customized cosmetic solutions such as veneers and bonding. [8]

- **Pediatric dentistry**

Intraoral scanners provide non-invasive impressions, engage young patients with 3D visualizations, aid in interceptive orthodontics, and encourage participation in oral care. By incorporating this technology, dentists can deliver precise, patient-centered care, fostering positive dental experiences for children and their families. [1]

DIAGNOSTIC APPLICATIONS OF IOS

- **Detection of caries:** Michou *et al.* compared the diagnostic performance of an intraoral camera with that of conventional caries detection methods and concluded that conventional caries detection methods showed inferior sensitivity at initial caries lesion stages as compared to an intraoral camera. [9]
- **Assessment of dental wear:** Michou *et al* assessed the feasibility of detecting and monitoring early erosive wear and concluded that it showed good performance for early detection and monitoring of tooth wear *in vitro* and has promising potential for *in vivo* application. [10]
- **Periodontal disease diagnosis:** Icen *et al* compared the diagnostic accuracy of CBCT units with different voxel sizes with the digital intraoral scanning technique and concluded small voxel sizes and smaller CBCT FOV has the highest sensitivity and diagnostic accuracy. [11]
- **Oral cancer screening**
- **Orthodontic assessment**
- **Diagnostic planning of implants**
- **Restorative treatment planning**

- **Patient education and communication [1]**

ADVANTAGES [12, 1, 8]

- **High accuracy:** Intraoral scanners produce highly accurate digital impressions, eliminating common errors associated with traditional impression materials, such as distortions, voids, and discrepancies. This precision contributes to better-fitting restorations and improved treatment outcomes.
- **Faster impression taking:** Digital impression taking with intraoral scanners is faster and more efficient than traditional methods, as it eliminates the need for material setting times and impression tray adjustments.
- **Image management and archiving**
- **Reduce the risk of infection:** The scanning tip of an IOS is autoclavable, and thus, sterilizable. In addition, the 3D images digitally obtained by the optical-impression is transmittable data and do not require the handling of impression materials or conventional models, which are a possible infection source.
- **Streamlined workflows**
- **Comfortable and non invasive**
- **Precise treatment planning**

LIMITATIONS OF IOS [1, 5]

- **Training requirements:** Since precise and swift measurements are essential in oral-cavity optical-impression, training is mandatory for IOS operation.
- **Visualization of a dry operating field/ moisture control:** Since oral fluid can cause a measuring error due to optical refraction, controlling it, especially gingival fluid, is important.
- **Fixed mandibular position:** The mandibular position acquired with an IOS is changeable; it cannot simulate dynamic occlusion at the present.
- **Cost:** Purchasing an IOS is a substantial investment.
- **Data security and privacy:** Health records must be carefully addressed to ensure patient confidentiality and protection of sensitive health information.

VARIOUS TYPES OF IOS [13]

- **Powder-based scanners:** These scanners use a powder to capture the digital impression.
- **Powder-free scanners:** These scanners use a camera or laser to capture the digital impression without the need for powder.
- **Hybrid scanners:** These scanners combine powder-based and powder-free technologies.

COMMONLY USED IOS [4]

- **Condor intraoral scanner:** Has a wide focal length, so it can be placed on or away from the tooth to capture a good image. It comes with three scan tips: standard, smaller, and laterally oriented.
- **Medit i700:** Weighs 245g, making it 25% more compact and 12% lighter than earlier models.
- **Planmeca Emerald S:** Has a small tip size and lightweight design. It can integrate with Planmeca's digital ecosystem for treatment planning.
- **Aoralscan:** Can help dentists and technicians easily obtain digital impressions.
- **CerectPrimescan (Dentsply Sirona):** Has a large window on the scanner and can capture clear images quickly.
- **iTero Element 5D:** One of the heaviest intraoral scanners on the market, weighing close to 500 grams. Used for orthodontic diagnosis.
- **3D shape TRIOS:** used for periodontal defects, soft tissue analysis and analysis of nasolabial region.

HOW IOS IS BETTER THAN CONVENTIONAL IMPRESSION

1. Intraoral scan is beneficial in recording intraoral surrounding soft tissue, capable of color scans for shade selection

reference and clinical finding documentation rather than conventional. [7]
2. In IOS, there is virtual set up for multiple treatment plans whereas for conventional method we need more impressions or duplication of model set up. [8]
3. Conventional impression is more technique sensitive whereas IOS is less technique sensitive. [7]
4. No tearing or laceration in intraoral scans whereas in conventional there is tearing over the margin, large undercut area, or brackets when the impression is removed. [8]
5. Gag reflex, unpleasant smell from the impression material in conventional impression which are not present in IOS. [14]

CONCLUSION

IOSs are pivotal in advancing digital dentistry, offering multifaceted applications and substantial benefits in patient care. From CAD-CAM integration to treatment planning, diagnostics, and monitoring, IOSs enhance patient comfort and streamline various clinical workflows. Despite some limitations, the continuous advancements in scanner technology are addressing these challenges, making intraoral scanners an indispensable tool in dental practices. As we move forward, the integration of intraoral scanners with other digital technologies, such as CAD/CAM systems and artificial intelligence, promises to further revolutionize dental care. By adopting these innovative tools, dental professionals can provide better patient outcomes and streamline their workflows, ultimately elevating the standard of care in dentistry.

Declaration by Authors

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