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Review Article

Intraoral scanner in orthodontics

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ABSTRACT:
Intraoral scanners (IOSs) are digital tools that simplify the capture of virtual diagnostic models. Some IOSs include specialized software features designed to evaluate volumetric differences between two scans taken from the same patient at different time points . These devices that digitally capture the three-dimensional (3D) shape of both soft and hard intraoral tissuesby projecting a light source, such as a laser or structured light, onto the scanned surfaces, imaging sensors record video or individual images .which are then processed by the device's software to generate a 3D surface model.
Keywords: computer-assisted image processing, dental impression technique, dental models, oral diagnosis, permanent dental restoration, prostheses and implants

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INTRODUCTION

Intraoral scanners (IOSs) play a crucial role in digital dentistry,by enabling the capture of intraoral optical impressions (IOIs) and the creation of highly detailed virtual models. Recent advancements in IOS technology, including hardware innovations and software enhancements, have significantly improved scanning efficiency and accuracy, particularly in computer-aided design and manufacturing (CAD-CAM), which remains their primary application[1].

When integrated with imaging techniques like cone-beam computed tomography (CBCT) and 3D facial scanning, IOSs have expanded their functionality beyond impression-taking. They are now used for diagnostics, treatment planning, and patient monitoring [2-3]. As digital and imaging technologies continue to evolve , IOSs are expected to become even more essential in various aspects of dentistry and oral and maxillofacial surgery

Digital impressions have revolutionized the process of impression-taking, partially replacing traditional methods like alginate and polyvinyl siloxane (PVS)[4]. IOSs offer several advantages, including enhanced patient comfort, increased efficiency, streamlined clinical workflows, and the ability to capture and store highly precise data[5]. In orthodontics, has expanded to include full- arch scanning, indirect bonding,and the digital fabrication of fixed orthodontic appliances. Additionally, IOSs support orthodontic diagnosis and treatment planning by enabling fast electronic data transfer, instant access, and minimal storage needs[1].

IOSs assist orthodontists in measuring arch width and length, tooth dimensions, transverse distances, Bolton discrepancies, overjet, and overbite with exceptional accuracy and efficiency[2]. They also allow generation digital diagnostic setups and treatment plans simulations improving patient-orthodontist communication. Furthermore, digital dentistry, particularly IOSs, is reshaping interactions between dentists and dental laboratories[3]. The seamless flow of digital information within clinics and between patients and dental labs enhances treatment ergonomics, reduces shipping delays, lowers costs, and minimizes errors.

Despite the growing body of research on IOSs , comprehensive reviews examining multiple factors simultaneously remain limited[6]. This article aims to provide a critical review of IOSs in orthodontics, analyzing existing evidence and offering an up-to-date overview of their clinical application [7].

HISTORY

Intraoral digital scanners were first introduced in 1984, coinciding with the emergence of chairside Economical Restoration of Aesthetic Composites (CEREC) and Computer- Aided Design and

Manufacturing (CAD-CAM) technologies. The CEREC-1 system, later known as the sirona dental system, was presented by PROF.Dr. Warner Moremann in Switzerland in 1986. Subsequent Advancements led to the introduction of CEREC 2 in 1994, CEREC 3 in 2000, and the CEREC 3D system in 2003, which enhanced the creation of 3D digital virtual setups.

In 2001 , Cadent introduced the ortho CAD system for models and indirect bonding trays. In 2006 , Brontes Innovations developed the Lava Chair Side Oral Scanner (C.O.S) , which was later acquired by 3M ESPE. Cadent also pioneered the development of in-office iTero digital impression devices, which evolved to support full-arch scanning by 2008. By late 2009, Cadent introduced the iOC system for iTero users. In 2012, 3M ESPE launched the True Definition scanner, followed by Ormco's release of Lythos six months later.

GENERATIONS OF INTRAORAL SCANNERS

The Ios system has evolved through several generations:

1. First Generation: Data acquisition was slice-by-slice , with a single radiation source and detector.
2. Second Generation: Integrated multiple detectors into the scanning plane, improving functionality.
3. Third Generation: Advanced detector and data collection technologies significantly enhanced system capabilities.
4. Fourth Generation: Featured a mobile radiation source and a fixed detector ring.
5. Fifth Generation: Focused on reducing motion and scatter artifactsto improve imaging quality.

ADVANTAGES OF INTRAORAL SCANNERS

1. **Enhanced Patient Comfort and Compliance:** Digital impressions reduce discomfort, particularly for patients with a strong gag reflex, trismus, or anxiety.
2. **Versatile Applicability:** Suitable for complex cases involving multiple implants or severe undercuts
3. **Simplified Clinical Procedures:** Eliminating the need for bite registration and gypsum casts, saving time and storage space.
4. **Environmental Impact:**Reducesmaterial waste and disposal, aligning with sustainable healthcare practices.
5. **Enhanced Precision and Consistency:**Provides superior accuracy in capturing dental structures, ensuring precise treatment planning .
6. **Improved Visualization:** Allowsclinicians to view preparations from multiple angles for better assessment.
7. **Immediate Feedback:** Real-time display enable prompt correctionsduring the impression process.
8. **Better Communication:** Facilitates effective communication between dental practitioners, lab staff, and patients.

DISADVANTAGES OF INTRAORAL SCANNERS

- Difficulty in identifying sub-gingival boundaries on prepared teeth.
- Challenges in scanning areas with bleeding tissues.
- Steep Learning curve for operators.
- High acquisition and maintenance costs.
- Accuracy disruption due to reflections from saliva, enamel crystals, or polished surfaces.
- Patient discomfort caused by the use of powder in some systems.

Diagnostic Criteria

Advancements in IOS technology have expanded their diagnostic potential. IOSs are now used for:

1. Caries Detection:Utilizes fluorescence or near – infrared imaging to identify carious lesions.
2. Tooth Wear Monitoring: Incorporate image superimposition software for quantitative evaluation of surface changes.
3. Oral Hygiene Assessment: Planimetric techniques quantify dental plaque coverage.
4. Soft-Tissue Evaluation: Monitors gingival recession and peri-implant soft-tissue stability.
5. Tooth Shade Determination: Some IOSs with color imaging capabilities assist in shade matching, though they are less reliable than spectrophotometers.

3D IMAGING IN ORTHODONTICS

The digital revolution has transformed orthodontics, with digital models replacing traditional plaster models. IOSs, combined with CBCT and facial scans, enable the creation of comprehensive digital patient models. The integration reduces radiation exposure and enhances treatment planning for orthognathic surgery, mini-screw placement, and ectopic tooth management.

Digital Model Acquisition

IOSs provide direct method for acquiring digital models, eliminating the need for physical impressions. The scanning process involves capturing the maxillary and mandibular arches, followed by recording the occlusion in maximum intercuspation . This method improves patient comfort and reduces errors associated with traditional impressions

Scanning Technologies

IOSs use various imaging technologies including

- Triangulation
- Accordion Fringe Interferometry (AFI)
- Confocal Laser Scanning Microscopy (CLSM)
- Active Wavefront Sampling (AWS)
- Optical Coherence Tomography (OCT)

These technologies rely on optical scanning to capture intraoral tissues and generate 3D digital images.

Examples Of Intraoral Scanners

- Cadent iTero
- 3M Lava COS
- Dimensional photons International 3D
- Orametrixora scanner
- D4D Technologies Intraoral Digitizer

3M Lava COS

This System, unlike intraoral scanners , uses a video stream to capture 20 3D data sets per second and then process and display these in real time.

Advantages

- Exceptional strength
- Biocompatible
- Minimal tooth preparation
- Stain resistant
- Long lasting polish
- Wide shade range
- Predictable results

Disadvantages

- Needs coating
- No in office milling units

Fig 1. 3M Lava COS Intraoral Scanner Cadent I Tero

The cadent unit includes a computer, software, wand, and a built-in-air compressor.

The success of the iTero (fig 2) intraoral scanner in orthodontic practices can be attributed to its advanced scanning capabilities and seamless integration with Invisalign®. Features such as a dual-aperture lens system, customizable scanning sequences, automated processing, an integrated color sensor, scan-in-motion video sequencing, and real-time data saving contribute to its overall effectiveness and efficiency in orthodontic applications.

The iTero (fig 2) intraoral scanner functions as a complete workstation, including a wand, CPU, display, keyboard, and mouse. It utilizes parallel confocal laser scanning technology and follows an S-motion pattern for scanning each quadrant. Typically, the process takes around 10 to 15 minutes. However, with advancements in the latest version, the time required for a full-arch scan has been significantly reduced to just 60 seconds.

iTero(fig 2) Lumina is a recent addition to the iTero™ scanner lineup. It features iTero Multi-Direct Capture (MDC) technology, offering a field of view three times larger than previous models. With a maximum capture distance of 25mm, it simplifies scanning in challenging areas. This scanner enables the production of photorealistic scans with greater ease, enhanced speed, and improved accuracy.

Fig 2. Cadent I Tero intraoral scanner

Advantages
- No need to apply any coatings to the teeth
- Generates a colored 3D virtual model
- Can have output files in STL formats

Disadvantages
- Larger scanner head
- No in office milling units

Orametrixorascanner

Fig 3. Orametrixorascanner intraoral scanner

Advantages
- Accuracy
- Faster
- Patent comfort
- Improved communication

Disadvantages
- Expensive
- Not suitable for all patients
- There may be occasional technical difficulties with Intraoral scanning
- Learning curve

Dimensional photons International 3D
DPI have an intraoral scanner which uses accordion fringe interferometry (AFI).

Advantages
- High bandwidth and low latency
- Reduced power consumption
- Reduced electromagnetic interference (EMI)
- Improved signal integrity

Disadvantages
- High manufacturing complexity
- Higher costs
- Limited material selection
- Reability concern

D4D Technologies Intraoral Digitizer
The Scanner allows for fog free scanning and features an ergonomic design for easier positioning. It allows powder free Intraoral image capture. The scanner uses Removable tips for infection control and has active heat dissipation for full arch scanning, color-coded feedback to operator, and adjustable field of view.

Hint -ELs Direct scan
It is a digital Intraoral Scanner used to scan 3D images for castings and measurement. It can be used in individual dies as well as in complete dental arches. It can capture images with rapid accuracy and has a lightweight and ergonomic wand. It can provides a portable dental impression unit.

Densys3D
This scanner uses a handheld wand with a camera to capture multiple images of the teeth and oral cavity. These images are then processed by the system's software to generate a 3D model. It's emphasis on accuracy, speed, and affordability could make an attractive choice for dentists. It can be used for various dental procedures including- crowns,

Fig 4. Densys 3D intraoral scanner

Medit i500

The Medit i500 (fig5is among the most affordable intraoral scanners available. It utilizes triangulation and 3D scan-in-motion video sequencing technology to capture highly accurate intraoral scans. Equipped with two high-speed cameras, it ensures fast scanning, while its adaptable design allows for flexible scanning sequences without requiring a fixed order.

A distinctive feature of the Medit i500 (fig 5) is its scan replay function, which enables users to virtually review a previous scanning session.

Its effectiveness and ease of use are further improved by incorporating 3D scan-in-motion video sequencing, high-speed cameras, and the scan replay function. These features make it an attractive choice for dental professionals seeking a reliable and cost-effective intraoral scanning solution.

With its affordability, speed, and precision, the Medit i500 (fig 5) intraoral scanner presents a practical option for dental professionals looking to adopt digital impression technology in their practice.

Fig 5. Medit i500 intraoral scanner

Carestream CS 3700

The CS 3700 is quick, intuitive, and clear to use. While it isn't the quickest product available, it performs far better than the CS 3600, which was its predecessor. The company claims it to be 20% faster.

The CS 3700 is a user-friendly, well-designed, and lightweight device. One of the smallest scanners available is the scanner itself.

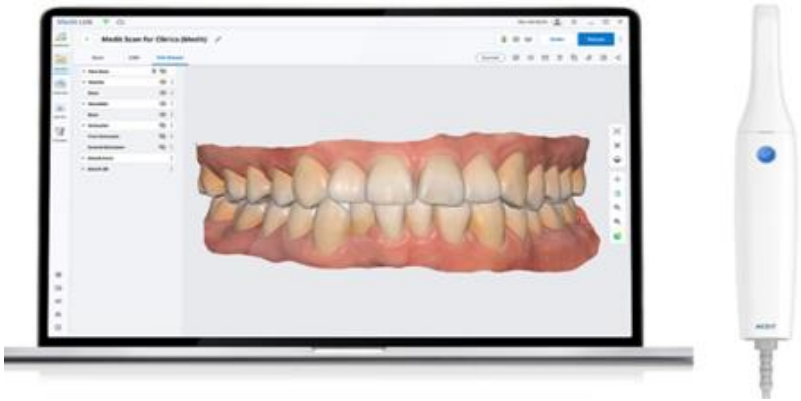

Fig 6. Carestream CS 3700 intraoral scanner

3M True Definition Scanner

An intraoral scanning tool called the 3M True Definition Scanner was created by 3M ESPE, a branch of 3M Company. It provides an alternative to conventional impression materials by being made to take digital imprints of patients' teeth and oral anatomy.

Fig 7. 3M True Definition Scanner

Primescan

High-precision 3D scans may be obtained with Primescan(fig 8) thanks to its sophisticated scanning technology.

- Rapidity and Accuracy – It's renowned for its unparalleled performance and accurate full-jaw scans.
- Powder-Free Scanning – Primescan(fig 8) , like the CEREC Omnicam(fig 9) , allows for powder-free scanning.
- Colour Recording – Primescan(fig 8) produces a thorough visual depiction by taking colour recordings of the tooth structures.
- Clinical Flexibility – The scanner's design allows for clinical flexibility, which makes it appropriate for a range of dental uses, such as prosthetic and restorative dentistry.11

Fig 8. Primescan intraoral scanner

CEREC Omnicam

One unique characteristic is its capacity to capture intraoral coating-free scans of gingiva and real tooth material. This simplifies the scanning procedure and lowers the learning curve by doing away with the necessity for a powder coating stage.

- Shade Detection: This feature helps to objectively support the restoration shade selection process by analysing each tooth's shade based on the intraoral scan.
- Ergonomic Design: The CEREC Omnicam's (fig 9) ergonomic and user-friendly features make it simple to operate, thanks to its lightweight design and ergonomics.
- Versatility: The scanner offers a wide range of applications, including aligner treatment, and enables practitioners to assess tooth colour in the CEREC software.

Fig 9. CEREC Omnicam intraoral scanner

FUTURE OUTLOOK

The incorporation of machine learning, particularly deep learning, has further expanded IOS capabilities, especially in image segmentation, with the potential to significantly enhance their functionality. However, challenges persist, including the integration of IOS technology in large dental institutions, maintaining scanning accuracy in edentulous areas and full-arch implant cases, and the need for further improvements in diagnostic precision[24].

CONCLUSION

Intraoral scanners have revolutionized orthodontics by enhancing diagnostic accuracy, improving patient comfort, and streamlining clinical workflows. As technology continues to advance , IOSs are expected to play an increasingly vital role in digital dentistry, offering new possibilities for treatment planning and patient care.

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