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INTRA ORAL SCANNERS-PAST, PRESENT AND BEYOND: A REVIEW ARTICLE

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ABSTRACT

From traditional dental impressions to the contemporary era of digital precision, the evolution of intraoral scanning reflects a paradigm shift in dental diagnostics and treatment planning. In recent years, there's been a remarkable surge in the variety of optical intraoral scanners dentists can choose from. The market has expanded significantly, giving dental professionals more options than ever before when selecting this essential technology for their practices.The intraoral scanners that are present: the TRIOS Classic, the TRIOS 3Mono Intraoral Scanner, the LAVA C.O.S., the CEREC Omnicam, the iOC intraoral scanner, the CS3600 Carestream, the iTero Element intraoral scan and the Lythos. With exciting innovations and broader applications in orthodontics, intraoral scanning systems are revolutionizing dentistry. These clever devices capture 3D digital impressions by projecting light onto teeth and implants, promising a bright future for dental care.We explore the technological milestones that paved the way for today's sophisticated scanners, examining their pivotal role in enhancing accuracy, efficiency, and patient experience. This abstract delves into the transformative journey of intraoral scanners, spanning their historical roots, current applications, and the exciting prospects shaping their future. Looking ahead, we anticipate the integration of artificial intelligence, improved ergonomics, and broader applications, heralding a promising future where intraoral scanners continue to redefine oral healthcare standards.

❖ INTRODUCTION

Modern tech has transformed dentistry, moving diagnosis and treatment from 2D to 3D approaches, revolutionizing private practice. Tech that we can actually use in our everyday lives enables effective and convenient information storage, retrieval, and sharing while satisfying the requirements of multiple-doctor practices, multiple practice locations, and growing patient volumes.[1]

These handheld scanners can make detailed 3D digital models of your teeth and gums, basically creating a virtual version of your entire mouth that dentists can examine from any angle.[2,3]

Just like other 3D scanning technology, intraoral scanners work by projecting either laser light or the newer structured light onto the teeth, gums, and special transfer cylinders attached to dental implants. These cylinders, called scanbodies, are crucial for accurately capturing the precise position of implants in the patient's mouth.

The scanner's imaging sensors capture these illuminated surfaces, while sophisticated software processes the data into dense point clouds. The software then connects these points with tiny triangles, creating a detailed 3D digital mesh of the patient's mouth.[4] The result is a virtual model that completely replaces the traditional plaster casts dentists have relied on for decades – offering the same clinical information in a more versatile digital format.[5]

Future dental practices will likely routinely use digital dental arch scanning. This article reviews current orthodontic scanners, focusing on data acquisition technologies, scanner features, and related clinical software.

❖ HISTORICAL REVIEW

Dr. Francois Duret made dental history in 1973 when he introduced the game-changing concept of computer-aided design and manufacturing to dentistry, becoming the first to envision this technology's potential for transforming dental care in France. The Chairside Economical Restoration of Aesthetic Ceramics (CEREC®) system, a digital impression prototype, was later introduced by Sirona Dental Systems for restorative dentistry in 1987.

CEREC 1 (Siemens, Munich, Germany) used infrared camera and optical powder on the teeth to create a virtual model. Technological advancements in computing hardware and software have revolutionized dental practices, leading to widespread replacement of conventional alginate and polyvinyl siloxane (PVS) impression methods across numerous dental and orthodontic facilities. Modern techniques now enable the creation of precisely fitting dental restorations without powder application in most clinical scenarios.

Accurately fitted final dental restorations can now be produced without powder usage in the majority of cases.

One of the first innovations in the CAD/CAM dental field was the CEREC system. Despite exhibiting certain scanning and milling quality limitations, this technology represented the pinnacle of innovation during its era, with no competitive alternatives emerging until 2008. At that time, the Cadent iTero digital impression system—originally launched in 2006—announced its capability to perform comprehensive full-arch intraoral scanning. After acquiring Cadent shortly after, in 2011, Align Technology incorporated iTero into its data transmission system for Invisalign treatment. Digital impression technology continues to evolve rapidly, with innovative intraoral scanning devices consistently being adopted by dental practices worldwide.

❖ **Why Turn to Digital**

The majority of clinical practitioners, especially those who are more accustomed to traditional impression techniques, most likely ask this as their main query. Much like when digital cameras and digital radiography films were initially used in dentistry, the majority of practitioners voice concerns.

For many years, plaster casts have been the gold standard for dentition analysis and possess a substantial and well-documented legacy as a standard component of dental recordkeeping. However, plaster models have a number of drawbacks, such as the need for physical storage space, labour-intensive work, fragility, degradation,and issues with possible loss during transfer.[6] Over the past decade, digital study models have emerged as a game-changer in dentistry, offering a practical and efficient alternative to traditional plaster casts. Digital intraoral scanners offer significant advantages through more efficient and accurate impression techniques that require less time and effort while generating minimal waste and generally reducing expenses.7 Additional orthodontic benefits include immediate accessibility, streamlined electronic data transmission, and substantially reduced storage requirements.8

Digital models can be incorporated into digital records, radiographs, digital photos, clinical notes, and a variety of patient management systems. It is possible to virtually manipulate digital models in order to segment and examine particular teeth, arch shape, crowding or spacing, and malocclusion type. Bolton discrepancy, transverse distances, tooth size, arch length, overjet, overbite, and other measurements are attainable. The user can perform bracket placement, indirect bonding, simulate a suggested treatment plan, and obtain a digital diagnostic setup.[9]

❖ **Whats Behind the Tech—THE PRINCIPLES OF IMAGE**

The primary element determining scanner effectiveness is the initial component (specifically, the imaging technology).The mostly widely utilized principles in IOS development are listed below.

1.Confocal Laser Scanner Microscopy (CLSM)

This produces extraordinarily detailed visualizations with superior depth discrimination capability. Three-dimensional representations are created by gradually collecting visual information through individual points, sequential lines, or concurrent multipoint acquisition which is then computationally constructed, removing any requirement for eyepiece viewing[10] .This sophisticated microscopic technique yields virtual cross-sectional views of specimens at multiple depth levels, providing exceptional clarity and differentiation throughout all three spatial dimensions. Selective filtering lowers glare and light from background information. [11]

2. Optical triangulation

Optical triangulation precisely measures object distances without physical contact, achieving accuracy within ranges spanning from millimeters down to microns[12]. Triangulation sensors are ideal for capturing high-speed data while analyzing delicate, soft, or moist objects to prevent unwanted contact. The system comprises a lens, a laser light source, and a linear light-sensitive sensor[13].

The laser beam illuminates a specific location on the specimen, creating a light spot image across the sensor array. Distance calculation between sensor and surface is determined by analyzing the captured spot's position in conjunction with baseline angles and length parameters. Triangulation sensors are often used to monitor vibrations, tire measurements during high-speed rotations, and safety mechanisms in automatic doors.[12,14]

3. Accordion Fringe Interferometry (AFI)

Accordion fringe interferometry (AFI) represents an innovative linear interferometric technique that generally produces three-dimensional projections[13]. AFI offers highest precision in laser fringe projection, swiftly digitizing 3D forms with great accuracy from point clouds. AFI employs dual-source laser illumination to highlight object surfaces while utilizing a charge-coupled device (CCD) camera to document the curvature characteristics of peripheral boundaries.

[15] AFI can evaluate more surface coatings, textures, and finishes than structured light due to its lower sensitivity to ambient light. [16]

4. Active Wavefront Sampling (3D-in-motion video recording)

Active wavefront sampling (AWS) represents a three-dimensional surface imaging methodology that employs a singular optical pathway and imaging device to acquire depth-related data [17]. he optical wavefront traversing through the lens system undergoes sampling at multiple non-axial positions, with individual images captured and measured at each designated location. The distance to the camera can be calculated by rotating the target feature picture [18].

❖ **Scanning systems**

Here, we go over a few scanners among the dozens of new iOSs available on the market according on their stated performance, clinical reputation, and market appeal.

iTero Element – Align Tech

iTero® uses confocal laser scanning imaging. Apparatus emits 100,000 red laser light beams in tandem, which go via a focusing optic and a probing face before reaching the teeth. Then, using analog-to-digital converters, the reflected light is converted into digital data. The wand can rest directly on the teeth during scanning because the system's scanning capacity eliminates the need to coat the teeth in powder. It also features in-built air flow to demist the lens. However, the scanner wand is comparatively bulkier than those found in more recent scanners. One drawback is that, in contrast to other systems, the iTero® camera requires a color wheel to be connected to the acquisition unit, which makes the scanner head bigger and bulkier.[22]

The iTero® mobile cart includes a central processing unit, a spacious work surface with a touchscreen display, a wireless mouse, a wireless foot pedal, an integrated keyboard, and a scanning wand.[23]In addition to rendering scans in both traditional stone and true-color models, the intraoral scanner provides both continuous scanning and click-to-capture modes, as well as voice and visual control options. Orthodontic digital images are obtained by systematically scanning the upper and lower quadrants in sequence. [24]

Lava C.O.S. – 3M
Although it was released in 2008, this vintage intraoral scanner still performs admirably for its time because to 3M's use of active wavefront sampling technology, which keeps it on par with more recent models.[25]

True Definition, 3M ESPE
The True Definition scanner produced by 3M inherited and improved on the specialties of Lava C.O.S. Mobile True Definition is the newer portable option launched in 2016, with the same hardware/software as the original True Definition.

"3M ESPE named this scanning technique '3D-in-Motion Video Technology.'[26] To measure defocus blur diameter, the system employs a rotating aperture element that is placed off-center within the optical setup—in either the imaging or illumination pathway. Prior to beginning the scanning process, the user needs to dry the complete arch and apply a light coating of powder to facilitate the scanner's recognition of reference points. Video imagery is captured at 20 frames per second, and a complete full-mouth scan, including bite registration, takes approximately 5 to 8 minutes. Immediately after completing the scanning process, 3D digital models become accessible for treatment planning, analysis, enhanced measurements, superimposition, and setup review.

TRIOS 3 / TRIOS 3 Wireless – 3Shape
In December 2010, the TRIOS® intraoral scanning solution was unveiled by 3Shape (Copenhagen, Denmark). The device has a fast scan rate and works on the basis of confocal microscopy [27]. TRIOS 3 uses the Ultrafast Optical Sectioning technique, based on the confocal laser principle. The final 3D digital imprint is generated by combining hundreds to thousands of 3D images, each corresponding to different time points and positions of the lighting pattern's focal plane. In addition to offering scans in either a normal noncolor pattern or enhanced natural hues, the high-definition camera has tooth shade measurement. The scanning wand features an auto-clavable tip, an anti-fog heater, and does not require powder. A complete oral scan takes about five minutes.

CEREC Omnicam – Sirona Dentsply
In the CAD/CAM sector, the CEREC system has the longest history. Omnicam differs from the original Bluecam based on the triangulation imaging technique. [28] Rather than stitching together static photos, Omnicam uses video streaming. This iteration of CEREC also does not require powder spraying before to scanning.

Due to its many associated laboratory communication features, the CEREC system has established a solid reputation in restorative dentistry. orthodontic so that it would be simple to reach even the furthest teeth. The scanning wand's disposable sleeve covering for simple infection protection is another special feature.

Which IOS system is better?
Every intraoral scanning technology is unique in its ability to capture various substrates, such as soft tissue, restorations, dentin, enamel, and prostheses. Intraoral collection of metal and other shiny materials might be challenging. The powder approach, which creates surface homogeneity, is the ideal way to increase scanning accuracy. The presence of edentulous areas is another clinical circumstance that may make accuracy less reliable. Due of apparent anatomical landmarks, it is challenging to obtain precise digital impressions in the toothless area. [29]

According to the study, PlanScan was unable to demonstrate trueness across different substrates, while the Emerald scanner revealed precision differences between the substrates. In another comparative study on trueness, Mangano F. et al. assessed scanners and found that the iTero Elements 5D® delivered the best results, while DWIO exhibited the lowest trueness.

WHAT'S NEXT?
Digital workflow is the first step in an impending revolution in modern dentistry.

Workflow for Digital Orthodontics
This subject has recently been covered in a number of conferences and publications on digital dentistry. [29,30,31] and The digital orthodontic workflow starts with the initial consultation and lasts through the phases of follow-up and retention (Table 1).

Through this workflow, support from various suppliers enhances the treatment modalities. A few diligent orthodontists, like Simon et al., have even attempted to create expander appliances in a novel way.[29,32] These illustrations are merely the beginning of incorporating iOSs into routine tasks. There are high hopes for the development of new 3D printing materials (like NextDent) and printers that can create hybrid materials in the future.

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Table 1: Digital Orthodontic Flow

Initial Consultation	Diagnosis	Treatment Plan	Treatment	Retention
Digital records (photos, X-ray/cone-beam computed tomography, intraoral scanning)	Analysis (radiographs, scan data)	- Virtual setup -Surgical treatment simulation	- Indirect bonding - Clear aligners - Customized brackets Appliances	-Retainers - Outcome, follow-up comparison

CONCLUSION

In conclusion, intraoral scanners have undergone a remarkable evolution, transitioning from cumbersome, niche technologies of the past to the sleek, user-friendly, and increasingly indispensable tools we see in dental practices today. Their present impact is undeniable, streamlining workflows, enhancing diagnostic capabilities, improving patient comfort and engagement, and ultimately contributing to more predictable and aesthetically pleasing treatment outcomes.

Looking beyond the present, the future of intraoral scanning holds immense promise. We can anticipate further advancements in speed, accuracy, and affordability, making them even more accessible to a wider range of practitioners. Integration with artificial intelligence for automated diagnostics and treatment planning, enhanced capabilities for capturing dynamic occlusal information and soft tissue details, and seamless connectivity with other digital dentistry technologies will likely define the next generation of scanners. As the digital revolution in dentistry continues to accelerate, intraoral scanners are poised to remain at the forefront, driving innovation and shaping a future where digital workflows are the standard, ultimately leading to improved patient care and a more efficient and precise dental profession.

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