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INTRAORAL SCANNERS IN ORTHODONTIC TREATMENT

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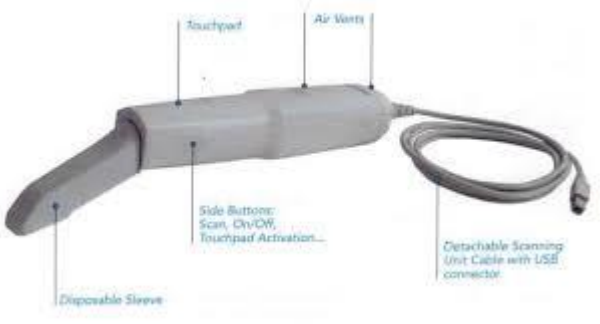
ABSTRACT:

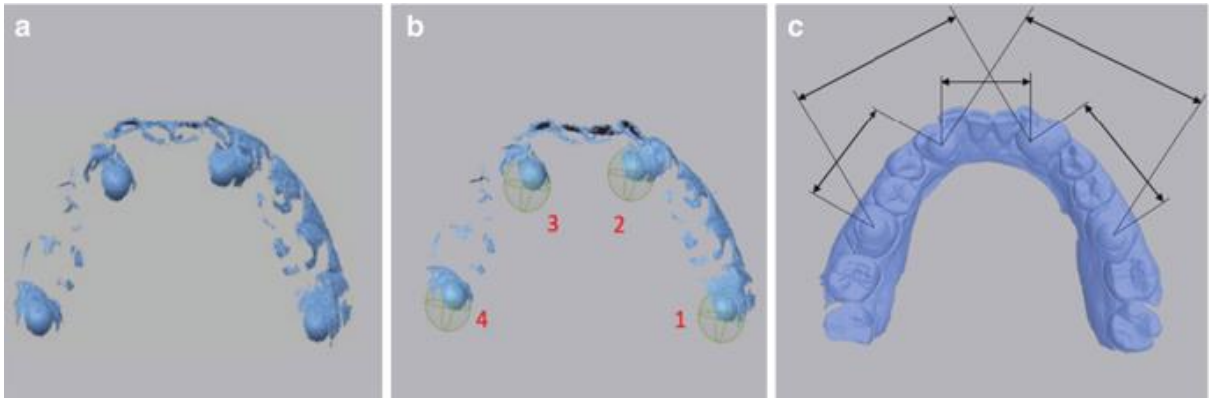
Intraoral scanners (IOS) have revolutionized orthodontic practices by offering non-invasive, efficient, and accurate alternatives to traditional impression methods. By capturing optical impressions of dental arches and surrounding tissues through advanced imaging techniques, IOS enhances diagnostic accuracy, improves patient comfort, and streamlines treatment planning. The evolution of digital scanning technology has led to the development of various scanner models, each with unique features that facilitate the creation of precise 3D digital models of dental structures. These models are crucial for comprehensive treatment planning, enabling orthodontists to visualize outcomes, fabricate customized appliances, and monitor treatment progress. The integration of IOS with near-infrared imaging and cone beam computed tomography further enhances diagnostic capabilities, especially in detecting dental conditions early. Despite the numerous advantages, such as reduced discomfort and faster treatment times, challenges remain, including variability in accuracy and patient perception. Ongoing research is essential to address these challenges and fully integrate IOS into clinical practice, ultimately improving patient outcomes and satisfaction in orthodontic care.

INTRODUCTION :

Intraoral scanners (IOS) are non-invasive devices that capture optical impressions of dental arches and surrounding tissues by projecting light onto them. This technology is transforming orthodontic treatment by enhancing diagnostic accuracy, improving patient experience, and streamlining treatment planning processes.[1] By facilitating precise imaging, IOS has become an invaluable tool in modern orthodontics. When light is projected onto the intraoral surfaces, imaging sensor cameras capture the reflected images and transmit them to specialized software for processing.[2] Orthocad from Częstochowa introduced pioneering software in 1999 that revolutionized orthodontics by enabling scanning of impressions at headquarters, generating digital 3D models for analysis and archiving. Intraoral scanning devices globally have advanced, with digital optical impressions potentially replacing traditional ones. Scanners allow treatment techniques through computer software for aligners or prosthetic restorations.[3] The "Parallel Confocal/Telecentric" method, rooted in confocal microscopy principles, ensures precise imaging. Scanners offer advantages like reduced patient discomfort, time efficiency, streamlined procedures, and simplified data storage, facilitating quick communication. Efficiency in clinical procedures is crucial for patient satisfaction and workflow optimization. As digital technologies evolve, computer-assisted treatments are likely to shape future dental and orthodontic practices[4]. The software constructs a cloud of polygonal mesh points that represent detailed three-dimensional (3D) surface models of the teeth and surrounding tissues. This mesh is then further refined and processed to create a final 3D digital image of the scanned object. The resulting image serves as a digital replica of the intraoral structures, eliminating the need for traditional stone or plaster models. The ability of IOS to differentiate between the optical properties of hard and soft tissues, as well as saliva, aids in standardizing the surfaces that are scanned, enhancing the accuracy of the imaging. The scanned data is typically stored in .stl file format, allowing for easy transfer via digital media to locations around the world.[5] This article aims to provide a comprehensive overview of the role of intraoral scanners in orthodontic treatmen.



IOS TECHNOLOGIES IN ORTHODONTICS



"Point and stitch" method

Intraoral scanning (IOS) technology has significantly transformed orthodontic practice by offering an efficient and accurate alternative to traditional impression methods. One major advancement is the removal of the need for titanium dioxide powder, which was previously necessary to improve scanner accuracy but often uncomfortable for patients; current IOS technologies can now scan clean and dry dental structures without this powder.[7] However, it posed several issues for patients, including discomfort during the application and the messiness associated with removing it after scanning. Various dental scanning technologies enhance this process: triangulation measures distances using laser technology suitable for capturing data from delicate oral structures; active wavefront sampling employs a 3D-in-motion technique for real-time data modeling, yielding quick and distortion-free results; parallel confocal imaging uses a "point and stitch" method to generate 3D images from laser light reflected off surfaces; and accordion fringe interferometry utilizes dual laser beams to detect distortion patterns and create 3D images.[8] Most modern dental scanners provide acceptable accuracy for both prosthodontics and orthodontics, producing stereolithography (STL) files compatible with laboratory workflows.[9]

Scanner	**Manufacturer**	**Key Features**
iTero Element	Align Technology	- Real-time outcome simulation (Simulator) - Progress assessment for Invisalign patients - Powder-free scanning with direct contact to tooth surfaces - Parallel confocal technology - In-built air flow to demist the lens - Bulky scanner wand for wider view, shorter scan times, and higher accuracy - Disposable sleeve for infection prevention
TRIOS 3 / TRIOS 3 Wireless	3Shape	- Immediate scanning post power-on - Automatically preheated scanner tip - Downsized wand compared to predecessors - Autoclavable wand sleeve - Ultrafast Optical Sectioning technique for optimal speed and accuracy - Wireless wand design for increased flexibility - Built-in treatment simulator and dynamic occlusion recording
Lava C.O.S.	3M	- Active wavefront sampling technology - Remarkable performance comparable to newer scanners - Released in 2008
True Definition	3M	- High accuracy demonstrated in comparative studies - Smallest wand size equivalent to a conventional handpiece - Thin powder layer recommended for superior outcomes - No real-time full-color scans

		- Compatible with various open-source communications (e.g., Incognito, Invisalign)
CEREC Omnicam	Sirona Dentsply	- Based on triangulation imaging method - Video streaming instead of stitching static images - No powder spraying required - Strong reputation in restorative dentistry - Expands feasibility of full jaw scans with related laboratory communication features

BENEFITS OF INTRAORAL SCANNERS IN ORTHODONTICS:

• **Enhanced Accuracy:** Intraoral scanners provide precise measurements and visualizations of dental structures, leading to more accurate diagnosis and treatment planning.
• **Increased Comfort:** Traditional dental impressions often involve uncomfortable materials and procedures. Intraoral scanning is a much more comfortable experience for patients.
• **Faster Treatment:** The digital workflow enabled by intraoral scanners speeds up the treatment process, reducing the number of appointments required.
• **Improved Treatment Visualization:** Orthodontists can use 3D models created from intraoral scans to visualize treatment outcomes and better communicate treatment plans with patients.
• **Advanced Treatment Options:** Intraoral scanners support the development of innovative orthodontic techniques, such as 3D-printed appliances and clear aligners.

APPLICATIONS OF INTRAORAL SCANNERS IN ORTHODONTICS:

• **Diagnostic Records:** Intraoral scans can be used to create accurate diagnostic records, including study models and photographs.
• **Treatment Planning:** Orthodontists can use the digital models to plan treatment, simulate tooth movements, and visualize the expected results.
• **Appliance Fabrication:** Intraoral scans are used to create custom orthodontic appliances, such as braces, retainers, and clear aligners.
• **Monitoring Treatment Progress:** Regular scans can help monitor treatment progress and make necessary adjustments.

ACCURACY OF INTRAORAL SCANNERS IN ORTHODONTICS

The accuracy of intraoral scanners (IOS) in orthodontics has sparked considerable debate, with various studies presenting differing levels of accuracy. While some studies indicate that the Lythos scanner can match the accuracy of conventional impressions, others, such as Duvert et al., argue that IOS may perform lower than conventional materials under optimal conditions.[9] Factors such as intraoral conditions can significantly influence scanning outcomes, with maxillary scans being less accurate than mandibular ones.[10] Recent evaluations of various IOS models have shown that the 3Shape TRIOS often outperforms others, including CEREC, while studies have found no significant differences in precision among most IOS. Accuracy is characterized by two components: trueness (the scanner's ability to replicate actual dimensions) and precision (the reproducibility of measurements).[11] Overall, while IOS shows promise in orthodontics, ongoing research is essential to validate its accuracy and address the challenges encountered in clinical practice.[12]

REPRODUCIBILITY

The reproducibility and reliability of intraoral scanners (IOS) have been confirmed in various studies, yielding excellent results. Research by Duvert et al. and Sun et al. indicated that in vivo scanning is comparably reproducible to ex vivo scanning, with only minor differences. Linear measurements showed similar reproducibility levels between conventional and digital models.[9] Previous studies have reported satisfactory to excellent reproducibility for IOS when compared to both in vivo and ex vivo scanning methods. Wiranto et al. found that IOS and cone beam computed tomography (CBCT) scanning of alginate impressions are valid, reliable, and reproducible for obtaining dental measurements for diagnostics.[10] A systematic review by Aragon et al. demonstrated that inter- and intra-arch measurements from digital models derived from intraoral scans are reliable and accurate when compared to conventional impressions.[12] A recent meta-analysis concluded that the accuracy of digital and alginate full-arch impressions is similar, with a 3D deviation of only 0.09 mm, and both techniques showing high precision below 0.1 mm. Furthermore, Wiranto et al. confirmed the validity and reproducibility of IOS and CBCT scanning of alginate impressions.[13] Kirschneck et al. found that while indirect alginate impressions had statistically higher reproducibility than direct digital impressions, all methods proved clinically equivalent for diagnostic purposes when comparing models obtained from the Lythos intraoral scanner, alginate, and polyether.[14]

TREATMENT PLAN

Intraoral scanners, such as the iTero Element 5D, enhance diagnostic capabilities through the utilization of near-infrared imaging (NIRI) technology, which significantly improves the early detection of interproximal caries compared to traditional methods. The integration of cone beam computed tomography (CBCT) with intraoral scanning further enhances comprehensive treatment planning and precision in orthodontic interventions.[15] Patients tend to prefer 3D scans over conventional methods as they offer a better understanding of oral conditions and treatment plans, with intraoral scanning being particularly beneficial for disabled patients by reducing the need for general anesthesia and improving accessibility to orthodontic care.[16] Studies reveal varying precision levels among different intraoral scanners, emphasizing the importance of selecting the appropriate technology for specific clinical scenarios. While intraoral scanners provide substantial benefits, challenges such as accessibility and the need for further research remain, particularly regarding their full replacement of conventional methods in all clinical settings.[17;18]

TIME CONSUMED

Numerous studies have investigated the time required for digital impressions obtained via intraoral scanners compared to conventional impressions, yielding contradictory results. Burhardt et al. found no significant differences in chairside time among groups using alginate, LAVA, and CEREC, with alginate requiring the least time, followed by CEREC and LAVA, which had the longest chairside time. Other studies confirmed that alginate impressions generally require less time than digital impressions.[19] Despite varying reports, many clinicians find digital impressions to be time-efficient, as they can capture a full-arch scan in under three minutes, eliminating the need to pour stone casts and fabricate physical models, making intraoral scanning a valuable tool for orthodontists.[20] However, anatomical variations and limited mouth openings can complicate the process and extend the time required. Scanning time is closely correlated with accuracy, and operators' experience plays a significant role in efficiency. Generally, operators become quicker with experience, although some machines like the iTero may initially have longer scanning times compared to traditional methods, while others like TRIOS may offer advantages for less experienced operators without significant further improvement with additional practice.[22]

PATIENT PERCEPTION

Patients' perceptions of time regarding impression methods, whether conventional or digital, have been extensively studied, indicating that intraoral scanning is generally more comfortable for patients. Although Burhardt et al. found that patients preferred intraoral scanning despite perceiving it as more time-consuming, Burzynski et al. reported that many patients viewed the digital method as faster than anticipated[23]. Despite some negative perceptions about scanning times, patient comfort and cooperation with clinicians significantly influence how time is perceived during procedures.[24] Patients often enjoy following the scanning process and viewing their dental arches digitally, enhancing their experience. The presence of powder during scanning also impacts comfort, with a notable percentage of patients experiencing discomfort related to it.[25] Moreover, the gag reflex, a common concern during dental procedures, is significantly reduced or absent with digital methods, leading to a more pleasant experience in terms of sensory factors like smell, voice, taste, and heat.[26] Therefore, intraoral scanning may be the preferred option for patients with severe gag reflexes. However, existing studies do not adequately consider the consistency and quantity of conventional impression materials or the implications of having to retake impressions due to inaccuracies.[26,27]

CONCLUSION :

As technology continues to advance, intraoral scanners are expected to play an even more significant role in orthodontic treatment. We can anticipate further improvements in scanning accuracy, speed, and integration with other dental technologies. Additionally, the development of artificial intelligence and machine learning may enable automated treatment planning and personalized orthodontic care. In conclusion, intraoral scanners have transformed the orthodontic experience, offering numerous benefits for both patients and orthodontists. Their accuracy, comfort, and efficiency have made them an essential tool in modern dental practice.

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