Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies *NLM ID: 101716117*

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Indian Citation Index (ICI) Index Copernicus value = 100

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Review Article

Intraoral Scanner in Dentistry: A Comprehensive Review

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ABSTRACT:
Intraoral scanners (IOS) have revolutionized the field of dentistry by providing digital impressions with enhanced accuracy, efficiency, and patient comfort. This comprehensive review explores the evolution, technology, applications, clinical outcomes, and future perspectives of intraoral scanning. Emphasizing their role in restorative dentistry, orthodontics, and periodontal assessments, the paper discusses the comparative advantages over traditional impressions, including reduced chair time and minimized patient discomfort. Additionally, the review addresses limitations such as cost, technology adoption barriers, and the learning curve for practitioners. The findings underscore IOS's transformative potential in modern dental practice, paving the way for further innovations and improved patient outcomes.
Keywords: Intraoral scanners, IOS, Application

Received: 22 November, 2024 Accepted: 25 December, 2024

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This article may be cited as: Kaushik K, Bhatt S, Gupta RY, Patadiya HH, Luthra A, K Ananya R. Intraoral Scanner in Dentistry: A Comprehensive Review. J Adv Med Dent Scie Res 2025; 13(1):57-61.

INTRODUCTION

Intraoral scanners have emerged as a pivotal technological advancement in dentistry, enabling the capture of highly detailed digital impressions of teeth and soft tissue. Unlike traditional impression techniques, which often rely on cumbersome materials and can be uncomfortable for patients, IOS offers a more streamlined, efficient, and user-friendly approach to dental diagnostics and treatment planning. The transition from analog to digital workflows has not only enhanced the accuracy of impressions but has also significantly improved the integration of various dental technologies, including computer-aided design and manufacturing (CAD/CAM).[1]

The utilization of IOS spans various disciplines in dentistry, including restorative dentistry, orthodontics, and implantology. Within restorative dentistry, precise digital impressions facilitate the creation of crowns, bridges, and dentures, while in orthodontics, IOS provides accurate data for treatment planning and monitoring. Furthermore, the integration of IOS with 3D printing and milling technologies has expanded the possibilities for custom dental appliances and orthodontic devices.[2,3]

Despite the many advantages, the adoption of intraoral scanning technology faces challenges, including high initial costs, variability in scanner performance, and varying levels of practitioner proficiency. Moreover, some clinicians and patients remain skeptical about transitioning from traditional methods to digital impressions.

This review aims to provide a comprehensive overview of intraoral scanners, focusing on their technological evolution, clinical applications, advantages, and limitations to facilitate the understanding and integration of IOS in contemporary dental practices.

Components and Technology of Intraoral Scanner: Intraoral scanners represent a significant technological advancement in dentistry, designed to capture highly detailed 3D images of a patient's oral cavity. These devices facilitate the creation of digital impressions, which are used in various dental applications such as restorations, orthodontics, and implants. The detailed mechanism of intraoral scanners involves several key components and processes, which work in concert to ensure precise and accurate digital models of the oral environment.[1-3]

Key Components and Technologies

1. **Optics and Light Projection:** At the heart of most intraoral scanners is a sophisticated system of optics and light projection. The scanner typically emits structured light, which is a pattern of light (such as grids, stripes, or dots) projected onto the teeth and gums. This light is then distorted based on the contours and textures of the surfaces it contacts.
2. **Imaging Sensors:** High-resolution imaging sensors (e.g., CMOS sensors) capture the distortion of the light patterns as they bounce off the oral surfaces. These sensors are extremely sensitive and capable of capturing a large number of data points very quickly.
3. **Scanning Tip:** The scanner's tip is designed for maneuverability within the patient's mouth. It houses the optics and sensors and is often compact to access difficult areas. Some tips are also equipped with anti-fogging mechanisms to ensure clear imaging.
4. **Software Algorithms:** The captured data is processed by sophisticated software algorithms. These algorithms analyze the distortions in the light patterns, converting them into precise 3D coordinates that represent the scanned surfaces of the teeth and gums.
5. **Data Stitching:** To create a complete model, the software stitches together multiple images taken from different angles. Algorithms identify overlapping areas in the images and merge them to form a seamless digital model. This stitching process is crucial for maintaining accuracy and continuity in the final 3D representation.

Scanning Process

1. **Preparation:** The oral cavity is cleaned and dried to ensure optimal imaging conditions. Any reflective materials, such as metal crowns, may be treated with a matting agent to reduce glare.
2. **Initial Scan:** The dentist or dental assistant positions the scanner tip inside the mouth and begins the scanning process. The scanner emits structured light patterns onto the surfaces of the teeth and gums, which are then captured by the imaging sensors.
3. **Data Capture:** The scanner moves methodically over the target areas, continuously capturing data points. Modern scanners can capture thousands of images per second, significantly reducing the time required for a complete scan.
4. **Real-Time Feedback:** Many intraoral scanners provide real-time visual feedback on a connected monitor, displaying the developing 3D model as the scan progresses. This feature allows the operator to identify and correct any missed areas immediately.
5. **Post-Processing:** After capturing the necessary data, the software processes it to refine the 3D model. This involves cleaning up noise, aligning data points, and ensuring the accuracy of the final digital impression.
6. **Model Export:** The finalized 3D model can be exported in standard digital formats (such as STL) for various applications. It can be used to design and manufacture dental restorations, orthodontic appliances, or surgical guides.

In conclusion, intraoral scanners utilize advanced optics, high-resolution imaging sensors, and powerful software algorithms to capture detailed 3D images of the oral cavity. This technology enhances the accuracy, efficiency, and patient comfort in the creation of dental impressions, signifying a leap forward in modern dental care.

VARIOUS APPLICATION OF INTRAORAL SCANNER

Intraoral Scanner in Prosthodontics: In prosthodontics, intraoral scanners (IOS) are transformative tools, significantly enhancing precision and patient comfort. Traditional methods involving physical impressions can be cumbersome and prone to errors like air bubbles and material distortions. IOS technology bypasses these issues by capturing highly accurate digital impressions of the oral cavity. This digital data allows for the precise fabrication of crowns, bridges, and dentures. It minimizes fitting issues and reduces the number of adjustment appointments, leading to increased patient satisfaction. Furthermore, the digital impressions can be quickly shared with dental labs, expediting the overall workflow. The scanner’s high-resolution images enable prosthodontists to assess the oral structure thoroughly, ensuring that all restorations fit seamlessly with the patient’s natural anatomy. This digital approach not only enhances clinical outcomes but also fosters better dentist-patient communication, as the images can easily be used for patient education and to illustrate the need for specific treatments.[3,4]

Intraoral Scanner in Implantology: In the realm of implantology, intraoral scanners are indispensable. They provide a non-intrusive and highly precise method for capturing the three-dimensional topography of the patient's oral cavity, which is essential for successful implant placement. The digital impressions generated by the IOS help in the creation of accurate surgical guides and custom abutments,

facilitating the precise placement of implants. This precision reduces the risk of complications and enhances the longevity and success rate of the implants. Moreover, intraoral scanning allows for better preoperative planning by integrating the digital data into implant planning software. This integration aids in visualizing the bone structure and optimizing the implant position for functional and esthetic outcomes. Enhanced accuracy in capturing soft tissue details also helps in achieving optimal restorative outcomes, ensuring that implants not only function effectively but also appear natural. [3,4]

Intraoral Scanner in Endodontics: In endodontics, intraoral scanners offer notable benefits, particularly in diagnostics and treatment planning. The high-resolution imaging capability of IOS helps in the detailed visualization of tooth morphology and any existing pathology. This is critical when diagnosing complex cases like fractured teeth or subtle root canal anatomy variations. Digital impressions taken with IOS are particularly useful in fabricating custom-fit endodontic access guides, which enhance the accuracy of access cavity preparations. This precision reduces the risk of procedural errors such as perforations. Additionally, the scanner aids in creating post and core restorations by ensuring that the post channels are accurately captured, thus improving the fit and longevity of the restorations. The ability to document and share digital data enhances interdisciplinary communication, allowing endodontists to collaborate more efficiently with other dental specialists for comprehensive patient care.[1,5]

Intraoral Scanner in Orthodontics: In orthodontics, intraoral scanners revolutionize the workflow from diagnosis to treatment monitoring. Traditional orthodontic impressions are often uncomfortable for patients, especially children, and can be imprecise. In contrast, IOS provides highly accurate digital models of the dental arches in a fraction of the time. These models are integral for planning treatments such as braces or clear aligners. Aligners, in particular, rely on the precision of digital impressions to fit correctly and apply the necessary forces to move teeth efficiently. The scanners facilitate better patient engagement, as clinicians can show digital simulations of the proposed treatment outcomes. Frequent digital scans during treatment allow for precise monitoring of tooth movement, making adjustments when needed to ensure the treatment is progressing as planned. The reduced need for physical storage of models and the ease of sharing digital data with orthodontic labs streamline the entire treatment process, resulting in higher efficiency and improved patient experiences.[6,7]

Intraoral Scanner in Pedodontics: Intraoral scanners offer substantial advantages in pedodontics, primarily by improving the overall experience for young patients. Traditional impression techniques can be uncomfortable for children, often resulting in anxiety and non-cooperation. Intraoral scanners minimize discomfort by eliminating the need for messy impression materials and bulky trays. The process is quick and non-invasive, which helps in gaining the trust and compliance of pediatric patients. The high-speed scanning capabilities capture detailed digital images of the teeth and gums within minutes, reducing chair time significantly.

Additionally, the accuracy of intraoral scanners plays a crucial role in pediatric dentistry. Accurate digital impressions ensure precise fit for various prosthetics, orthodontic appliances, and space maintainers. This precision is critical as poorly fitting devices can cause discomfort and hinder oral development. Moreover, digital impressions reduce the need for repeat visits and unnecessary adjustments, making treatment more efficient. The detailed 3D images also assist in early diagnosis and intervention of dental issues such as caries, malocclusion, and developmental anomalies, facilitating timely and appropriate treatment plans.

From a practitioner's perspective, the use of intraoral scanners integrates well with digital workflows, allowing for seamless communication with dental labs, and expedited fabrication processes. This not only enhances the practice’s efficiency but also aligns with the modern, tech-savvy expectations of younger generations and their parents, thereby improving patient satisfaction and retention.[8]

Intraoral Scanner in Periodontics: The application of intraoral scanners in periodontics is transformative, particularly in the precise diagnosis and tracking of periodontal diseases. Traditional methods of measuring periodontal pockets and gingival contours can be cumbersome and less accurate. Intraoral scanners, however, provide high-definition, three-dimensional images that allow periodontists to assess gum health meticulously. By capturing detailed surface scans, clinicians can measure pocket depths, detect gingival recession, and monitor tissue healing with unparalleled precision.

Furthermore, these scanners streamline the treatment planning process. Accurate digital models facilitate the design and execution of periodontal treatments such as guided tissue regeneration, crown lengthening procedures, and grafting. The integration with other digital dental tools enables the creation of surgical guides, enhancing the precision of periodontal surgeries, and improving patient outcomes. The ability to monitor healing and tissue response over time with digital records ensures a more dynamic and responsive approach to patient care.

Intraoral scanners also enhance patient education and engagement in periodontics. Patients can visually understand their periodontal conditions through 3D representations, fostering a clearer understanding of their diagnosis and the necessity of treatment. This visual aid significantly improves patient compliance and motivation, as they can literally see the

improvements in their oral health over successive visits.[4,5]

Intraoral Scanner in Oral Diagnosis and Patient Education: In the realm of oral diagnosis, intraoral scanners revolutionize the process by providing highly accurate and detailed digital images of the oral cavity. Traditional diagnostic methods often involve a combination of x-rays, photographic images, and manual examinations, which can sometimes miss subtle abnormalities. Intraoral scanners, however, offer a non-invasive, comprehensive view of the teeth, gums, and surrounding structures, ensuring no detail goes unnoticed. This precision is particularly beneficial in detecting early signs of dental caries, fractures, occlusal issues, and other pathological conditions.

For patient education, intraoral scanners are invaluable. The visual nature of the scanned images means that dentists can show patients exactly what is happening in their mouths. This direct visualization helps in conveying complex dental issues in an understandable way. For example, explaining the progression of dental caries or the impact of misaligned teeth on overall oral health becomes more tangible when patients can see the exact areas of concern in a 3D model. This visual approach not only enhances understanding but also fosters a greater sense of urgency and commitment to oral care.[5]

Additionally, intraoral scanners support comprehensive treatment planning. Digital impressions can be easily shared with specialists or used to simulate treatment outcomes, providing a clear roadmap for both the patient and the dental team. This collaborative approach ensures that all parties are well-informed and aligned on treatment goals. For ongoing patient education, these digital records serve as a powerful tool to track oral health changes over time, allowing for continuous monitoring and timely intervention when needed. This proactive stance significantly enhances patient outcomes and satisfaction.[1-3]

Factors influencing the precision of IOS:[4]

1. **Scanning Software:** The ease with which the software is handled plays a crucial role.
2. **Scanner Technology:** This pertains to the resolutions and image quality delivered by the scanning technology.
3. **Powder Material Application:** The thickness of the powder material applied to the scanning site can potentially distort the actual surface thickness being scanned.
4. **Presence of Saliva and Blood:** The clarity of scanning is adversely affected by the presence of saliva and blood.
5. **Soft Tissue Movement and Limited space:** Challenges arise in achieving accurate scanner constrained space

Advantages and Limitations of Intraoral Scanner: Intraoral scanners offer several advantages in dentistry, such as improved patient comfort, increased accuracy, and enhanced efficiency. They eliminate the need for traditional impression materials, reducing patient discomfort and gag reflex. Scanners provide highly detailed digital impressions, which can lead to better-fitting restorations and less room for error. Additionally, the digital workflow streamlines the process, allowing for quicker turnaround times and better collaboration with dental labs. However, limitations exist, including the high initial cost of the equipment, the need for specialized training, and potential challenges with scanning certain anatomies or materials. Furthermore, software compatibility issues may arise, and practitioners need to stay updated with evolving technology to maximize benefits.[8-10]

Future Prospectives: The future of intraoral scanners looks promising, with advances in technology expected to enhance their capabilities and integration into dental practices. As scanning resolution improves, the accuracy of digital impressions will increase, leading to better treatment outcomes. The development of artificial intelligence and machine learning algorithms may streamline the scanning process, enabling faster and more efficient data analysis. Additionally, the integration of intraoral scanners with other digital technologies, such as 3D printing and virtual reality, will create more holistic and efficient workflows in restorative and orthodontic dentistry.

Moreover, as costs decrease and accessibility increases, more dental practices will adopt intraoral scanners, making them commonplace in routine dental care. This widespread use could lead to the standardization of digital workflows across the industry, improving collaboration between dentists and dental laboratories. The potential for real-time communication and data sharing could also enhance patient engagement and treatment planning. Overall, the future of intraoral scanners promises to transform dental practices, improve patient experiences, and optimize treatment efficiency.

CONCLUSION

In conclusion, intraoral scanners represent a significant advancement in dentistry, revolutionizing the way dental impressions are taken and utilized. Their ability to provide accurate, comfortable, and efficient digital impressions enhances patient experience and outcomes while streamlining workflows for dental practitioners. As technology continues to evolve, the integration of intraoral scanners with other digital tools will likely further improve treatment planning and execution. Despite some limitations, the benefits they offer make them an essential tool in modern dentistry, paving the way for enhanced diagnostic capabilities and more effective

restoration processes. Embracing this technology will ultimately contribute to the future of dental care, fostering better patient-provider interactions and optimizing clinical results.

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