Review article

The digital era in dentistry: A review

Rishika Dhimole[1], Mithilesh M. Dhamande[2], Seema R. Kambala[2], Priyanka Paul Madhu[3]

[1]Sharad Pawar Dental College and Hospital, Datta Meghe Institute of Higher Education and Research (DMIHER), Sawangi (Meghe), Wardha 442001, Maharashtra, India

[2]Department of Prosthodontics Crown & Bridge, [3]Department of Public Health Dentistry, Sharad Pawar Dental College and Hospital, Datta Meghe Institute of Higher Education and Research (DMIHER), Sawangi (Meghe), Wardha 442001, Maharashtra, India

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Corresponding author: **Rishika Dhimole.** Email: rishikadhimole24@gmail.com

ABSTRACT

In dentistry precisely recording the soft tissue details and adjacent tooth morphology is a critical process. It is quite challenging for the dentist since the oral hard and soft tissue structures show great variations in every patient. Conventional impression materials such as agar, alginate and elastomeric impression materials are used but these impression materials require patient's cooperation during impression taking. These impression materials sometimes cause gagging, irritation and unpleasant taste and smell to the patient. To overcome these drawbacks digital impression and digital scanners are encouraging innovations. They increase the patient's comfort and aids in the accuracy in recording tissue details. The development of new technology in the medical and dental fields is leading to advancements that enable physicians to create treatments and materials that can enhance patients' quality of life. Different IOSs have adopted varied scanning methodologies, which could result in different scanning accuracies. This was done to compare the accuracy of several IOSs and the effects of different variables on the accuracy result. Using 3D scanning technologies, a physical model which is digital three-dimensional computer-aided design (CAD) is transformed. For the design and production of specific parts using additive manufacturing (AM) technologies, this digital output offers several advantages. It is crucial to evaluate the dentistry industry's present level of 3D scanning technology utilization.

Keywords: Intraoral scanners; digital impression; digital technology; CAD-CAM; accuracy.

INTRODUCTION

Dr. Francois Duret's thesis, titled 'Empreinte Optique' (Optical Impression), which was introduced in Lyon, France (1973), was the first to apply CAD/CAM methodology to the dentistry industry. He showcased state-of-the-art CAD/CAM equipment specifically in 1984. This method could create a single-visit dental crown and was demonstrated at the Chicago Midwinter Meeting in 1989 (1,2).

New digital impression technologies are now commercially available, and intraoral digital scanning will soon replace the eagerly expected urge to help sufferers. The process of obtaining dental impressions is one of the most painful experiences for a dental practitioner. The use of gypsum models in prosthodontics, orthodontics and restorative dentistry is not only necessary but also commonly used in these clinical specialties. Every dentist has long wished for the ability to immediately scan the teeth of individuals or even plaster models. Avoiding discomfort, accelerating procedure, better communication between employees and prosthetic laboratories, and minimizing the quantity of space required to retain these models are claimed advantages of this machinery. Advent of cutting-edge production technology, functional restorative materials, and cutting-edge clinical methods nowadays has given rise to the field of 'digital dentistry', which has expanded treatment options and operative methods across all branches of dentistry. The digital workflow entered dentistry in a variety of sectors of application, from treatment planning and designing to the development phases, from implant surgery procedures to the manufacture of specialist prostheses and gadgets produced by CAD/CAM additive and subtractive technology. As a result, workflows that are increasingly focused on digital technology are becoming more prevalent in both clinical procedures and laboratory techniques. Product development experts from several industries Created advanced scanners for dental practices which are more streamlined and develop pictures and restorations with more precision since the first digital impression scanner was introduced. Dental impressions are taken differently now that these goods are being used (1).

The emergence of advanced technology

The first polyether substance made specifically for dental use was impregnum, created by the ESPE company in 1965. Since its introduction in dentistry in the middle of the 1980s, digital impression and scanning technologies have advanced to the extent that some writers can say that in five years, the majority of dental practitioners in the U. S. and Europe will be taking impressions with this technology. Since 1937, the procedures for capturing elastomer impressions and making plaster castings have been widely

employed and nowadays it has been practiced widely (1).

In orthodontics, technologies such as Cadent IOC/OrthoCAD, Dentsply/ GAC's OrthoPlex, Stratos/OrametrixSureSmile, & EMS RapidForm have been used effectively for several years. Modern CAD-CAM systems may input information directly from models to laboratory equipment that carves ceramic & resin restorations without the necessity of preparation of tooth and convert it into working model, neighboring tooth, or antagonist tooth. Two types of digital systems are there: specialized three-dimensional digital impression systems & CAD/CAM (3D). Instead of plaster models created with these technologies from physical impressions, definitive restorations are constructed from digitally scanned information. They also encourage the patient's comfort, acceptance, and comprehension of the situation. Traditional models need to be physically stored and might chip or break, which requires more office space. On the other hand, digital scans may be permanently stored on hard drives (3).

Intraoral scanning systems

IOS contains a laptop, a camera, and software. Goal is to correctly capture an object's three-dimensional geometry. Standard Tessellation Language is a popular digitized configuration. Another choice is PLY files. Regardless of method of imaging used through IOS (intra oral scanners). After locating POI, software compiles the several photographs and video cameras captured under a light projection (point of interest) (2). There are two strategies in the realm of 3-D reconstruction: light capture and projection. Techniques that are both active and passive, Triangulation is an active technique that projects light from the camera onto an object to simulate the texture and color of tissues using red, white, or blue light. In the passive technique, oral soft and hard structures are dependent on a definitive degree of object quality and are only illuminated by ambient light (3,4).

Various intraoral scanners

1. ITero
2. Fast scan
3. Carestream CS 3500
4. Plan scan
5. Trios
6. Lythos
7. True definition
8. CEREC

iTero

iTero was introduced in 2007 by Cadent, and Align Technology, Inc bought it in 2011. It is based on the idea of confocal parallel scanning microscopy (5). Holding the wand at a 45˚ angulation through gingival border, initiating at the distant part of the left sided mandibular buccal quadrant and progressing mesially, one scans each quadrant while capturing the buccal and occlusal terrain. On the lingual side, the identical process is repeated, beginning with the mandibular left sided lingual quadrant. There are 15 minutes in total (6). New developments: Align Technologies has released several scanners, including:

- iTero HD 2.9
- iTero Element
- iTero Element flex
- iTero Element 2
- iTero Element 5D

It performs rapid digital scans utilizing parallel confocal imaging technology, which records 100,000 laser light points and generates sharp photographs of > 300 focal depths of dental tissue. Only 50 micrometers (50 m) differentiate each of these focal depths. Parallel confocal digital scanner scans every component and prosthesis present in the mouth without applying any materials over the tooth surface. Also efficiently records supra gingival and subgingival margins. Since the cadent ioc scanner employs direct scanning without use of scanning powder, it allows orthodontists and their helpers more feasibility in the clinical applications. Presents extremely precise orthodontic scanning along real-time examining for patients with complete and partial arches, different mouth openings, and adults and adolescents. Additionally, the software architecture of ioc enables data to be exported and linked with other orthocad-compatible tools for managing orthodontic offices. The 3M ESPE Lava COS system is another alternative for digital impressions. This system includes a Central Processing Unit, touch-screen display, and a 13-millimeter-thick scanning machine installed on a movable cart. The camera is equipped with 192 LEDs and 22 lens systems. Active Wavefront Sampling is the technology that was utilized to collect 3D impressions. The ‘3D in Motion’ concept by Lava combines an innovative optical design with real-time model formation, image processing algorithms, and 3D data recording in a video sequence (1). A complicated optical system with many lenses and blue LED cells is included in the scanning device. For precise, high-speed scanning, Lava COS system records 20 3D data sets every sec, and up to 2400 data sets per arch (3).

The Outcome Simulator, a special function of iTero, enables the patient to be shown a virtual Invisalign treatment path. After scanning is finished, the result Simulator may be shown in a matter of minutes. The operator can manipulate the teeth on the screen to show adjustments to the movement arrangement (7).

Fast scan

The FastScan was upgraded from the initial design to commercial style & was showing promising outcomes in the beta testing in the dental clinics, according to an announcement made by IOS Technologies in July 2010. Intra oral scanner FastScanTM is currently in its

final stages of development by IOS Technologies. The system's primary competitive edge over rivals is its wand. IOS FastScanTM is the only option that enables camera movement inside the wand. To scan the entire arch, the only requirement is to hold the wand in different positions (buccal, lingual, and occlusal) (6).

Carestream CS 3500

The CS3500 unit uses parallel confocal imaging-derived parallax scanning technology. An inventive light-guidance system facilitates data collection by informing the operator whether an area was successfully scanned so that they can focus on the patient rather than the monitor. It consists of a USB connection which is one of the unique features of this system. The tips of the scanner can be sterilized and used up to 20 times (8). In 2013, Care stream Dental launched the CS 3500. Angulation and depth of the scan can be kept 45 degree and 16 millimeters. The confocal microscopy principle is used. It has a wand, is portable, does not require a trolley, and has a USB port. No additional heat is necessary to keep it from fogging. For both adults and children, there are two different scanning tips (10).

Plan scan

Planscan, developed by E4D Technologies (Richardson,2008), uses the Optical Coherent Tomography concept (8). It uses a highly developed triangulation system, and it rarely requires powdering. At video-rate speed, point-and-stitch reconstruction takes place. Other noteworthy characteristics include heated mirror scanning that is fog-free, active heat, sterile suggestions for infection prevention dissipation for full-arch scanning, software with a movable field of view to enhance the target area, and a mobile design using laptops (10).

Trios

Trios was launched by 3Shape in 2010. It makes use of the confocal microscopy technique (6). It comes in two different forms: This system includes an anti-fog heating element, an autoclavable edge, and an ergonomic seat with portable USB connections to the desktop display. and a TRIOS Cart with internet access, 3D illustration, and a competent screen. The missing areas can be filled automatically (9). Newer systems (10) –

- TRIOS 3 Basic
- TRIOS 3
- TRIOS 4

Lythos

Ormco's Lythos digital scanner was created expressly for use in orthodontics. The Lythos scanner's small size is its most notable quality. It is supported by a chairside delivery unit and only weighs 25 lbs, making it simple to move from one operating room to another or between offices (10).

True Definition

The True Definition system employs cutting-edge three-dimensional visual imaging and has been approved for use with Invisalign at this time. The True Definition solution includes a 22" touchscreen HP desktop, a lightweight wand, a powder dispenser, and a wireless Internet connection for cloud uploads. The 7 oz, compact, ergonomic wand from True Definition resembles a typical dental handpiece and has a pencil grip. It makes use of double-tap activation instead of buttons. The wand is divided into sextants, starting on the occlusal and ending back on the lingual. To ensure at least one tooth overlaps, the same procedure is repeated in the anterior sextant, beginning with the first premolar. Three sweeping passes may scan an entire arch in around five minutes. Reconstruction of the data happens concurrently (10).

CEREC

In 1987, Sirona Dental System released CEREC. It applies the principles of Active Triangulation and Confocal Microscopy (11,12). This system includes-

- *CEREC Omnicam* – It creates full-color, 3D and 2D imprints with full and half-arches. It has a hand piece with a circular camera tube and a small camera tip. The gap between the scanner and the tooth must be between 0 and 15 millimeters (10).
- *CEREC Bluecam* - To capture details, A blue-colored diode with light emission is present. It can be used to scan the entire jaw, a quadrant, or just one tooth region. Instantly the camera is placed over the region of the tooth (10).
- *Apollo DI* - In this software camera is moved 2–20 millimeters above the tooth surface throughout the process (6).

Clinical implications

Nowadays IOS is used in every aspect of modern dentistry. In prosthodontics it is being used for making an impression of a prepared tooth regardless for what purpose the tooth is going to be prepared. Preliminary restorations for fixed bridges, implants, single crowns made of zirconia or lithium disilicate, a framework for FPDs, and inlays, onlays, Obturators, RPDs. They can provide direction to implant positioning. There is not much evidence regarding the accuracy of IOS for long-span prosthesis or fixed full arches, whether they are implant supported or solely removable (10). For Orthodontic purpose diagnosis and treatment planning is the main concern of IOSs. Every day, new digital technologies are being created, and they are proven to produce more precise and effective healthcare outcomes. Dental education must be at the forefront of these developments to produce doctors who are skilled in employing these technologies (10).

Clinical advantages

The largest advantage of digital technology for dental lab personnel and dentists is the eradication of many chemical processes. Faulty treatment and manufacturing time is no longer an issue in the practice due to elimination of some clinical procedures. Procedures like curing the impression material, investment materials, and shrinkage of traditional ceramic materials. They play a major role in orthodontics and orthognathic surgeries. Silicone materials & bite wax to take check bite impressions (centric occlusion) has been used in the past. There is not any material which has been placed between both the arches' digitized impressions. It greatly minimizes chances of a poor interaction (3).

The emergence of IOS in dental practice there will be minimum possibilities of mistake brought on by air bubbles Breakage of the impressions, shifting of the impression tray, deviation of the tray, insufficient IMs during mixing, inadequate adhesive for the impressions, or deformed impressions because of subpar disinfection procedures (11).

Disadvantages

Learning curve

To the older clinicians due to lack of knowledge and poor experience with computer technology Learning Curve adaptation for IOS is difficult. It's also worth noting that there's a discussion about which scanning technology is superior to another, as the manufacturer offered minimal information (12).

Sub-gingival margin detection

The IOS scanning was inconclusive in detecting deep gingival margins and it is also troublesome in detecting the prosthetic margins if the patient has bleeding as it obscured the margins (12). IOS cannot compensate for soft tissue margin displacement and is unable to record mobile and flexible intraoral structures (13).

Cost-sensitive

Even after the advent of numerous new models, IOS's initial buying expenses are rather expensive. Additional management costs, such as software upgrades, were also involved. Aside from the lab technicians must also be knowledgeable with digital workflow (13, 15).

DISCUSSION

This review of the literature argued for an analysis of the current state of digital impression accuracy in implantology, focusing on many factors that may affect it, the extent or tilt of the implant, the imaging procedure, the configuration, and material of ISBs, and the IOS device being used (14).

The usage of digital models in orthodontics has proven to be a successful practice and may become the standard way to handle digital models in this area of dentistry in the future. This is comparable to, for instance, implantology and oral and OMFS areas where digitized pictures from CBCT are integrated in the specialized program for three-dimensional outline & execution of cyber procedures (15-17). Digital scanning does not require orthodontists or their helpers to learn any new processes or procedures to incorporate it into regular practice. In terms of duration and objectives, consultations for obtaining orthodontic records essentially stay the same, with the bonus of much higher patient satisfaction (3,18,19). The expenditure may initially appear expensive. However, from an operator's perspective, over the medium term, digital impressions assure economic viability. Like direct digital intraoral radiography, the potential for lower operational material costs and the capacity to monitor the procedure's quality in real time reduce the frequency of follow-up visits and, as a result, chair time (20-23).

CONCLUSION

IOS provides several benefits over conventional impression techniques, including increased practice efficiency, reduced visit frequency, and improved patient and operator comfort. Keeping its obvious advantages in mind, IOSs will likely replace traditional oral procedures soon. In addition, these devices may be utilized in implantology for guided surgery & orthodontics. Fixed prosthodontics uses these devices to produce virtual models for a range of various prosthetic restorations. According to patient satisfaction surveys, the introduction of new technologies results in an improvement of services in the field of dental medicine. Prices for patients' accessibility are excellent. Patient satisfaction was high despite the short turnaround time for restoration production. Whether the development of new technologies in dental medicine has an aesthetic quality has been questioned. These tools are simple to use and dramatically reduce the amount of time needed to create prosthetic work.

Although this technology for dental therapy is developing quickly, this method's application is not keeping up with the rate of technical innovation. To combine the tried-and-true approach of employing elastic materials to the conventional technique and to bypass all restrictions of pouring through hydrated calcium sulfate, A computer-based device could use the impression directly and convert it as the first step in the computerized procedure. Limitations are described as, lack of proof that this largely digital approach using the digitalization of new impression materials is accurate, nevertheless, when compared to the widely used indirect digitalization method of gypsum castings.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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