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Intraoral Scanner Technologies

A Project Submitted to
The College of Dentistry, University of Mosul, Department of Prosthodontics in Partial Fulfillment for the Bachelor of Dental Surgery

By

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Certification of the Supervisor

I certify that this project entitled (Intraoral scanner technologies) has been prepared by Khawla *Salim yaseen* under my supervision at the Department of Prosthetic Dentistry, College of Dentistry, University of Mosul in partial fulfillment of the graduation requirements for the Bachelor Degree in Dentistry.

Dr. Ali Salah Alshammari
Lecturer / 4 /2023

Dedication

I would like to dedicate this project research to ***the soul of my father***, ***my mother, my brother***s and ***my sisters***

Khawla

Acknowledgments

First of all, I thank ***Allah*** almighty for inspiring me with power, patience and willingness to perform this work.

I gratefully acknowledge University of Mosul and College of Dentistry for awarding me the opportunity to fulfill my undergraduate study and I am extremely grateful to the Dean of College of Dentistry ***Asst. Prof. Dr. Rayan Salim Hamed*** for his scientific support to the undergraduate students.

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I would like to express my thanks, great pleasure and love to ***my family***. Special word of thanks, appreciation and deep gratitude to whom I love greatly ***my mother, my father*** and ***my brothers and my sisters*** for their emotional support, encouragement and patience throughout the study to overcome the difficulties in my work.

Khawla

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List of Abbreviations

IOS	Intraoral scanner
CAD –CAM	Computer-aided design and computer-aided manufacturing .
3D	three-dimensional.
STL	Standard Tessellation Language.
POI	Point of interest
CBCT	cone beam computed tomography

Introduction

INTRODUCTION:

Edentulism results when one or more teeth are missing, or need removing due to injury or disease. With full edentulism, all teeth are missing; with partial edentulism, one or more teeth are missing. It is restoring the existing edentulous spaces becomes necessary, Prosthetic dentistry provides aesthetic and functional well-being to the patients by restoring the missing tooth. Various prosthodontic options such as fixed or removable partial dentures, implant supported prostheses have been commonly used to tooth restoration**(Silva-Junior *et al*.,2017; Guptam,*et al*.. 2018**).all these option require impressions to duplicate oral to making conditions and tooth morphology is an integral part of prosthetic dentistry. Since the eighteenth century, conventional impression techniques have been used to register the three-dimensional geometry of dental tissues. Nevertheless, volumetric changes of impression materials and expansion of dental stone seem error-prone, and thus the process requires the services of an excellent dental laboratory (Hong-Seok, and Chintal, 2015). The conventional impression-taking method may pose patient discomfortand possibility of deformation which could be affected by the type of impression material (Keating et al.,2008) To overcome these difficulties, impression with IOS (intraoral scanner) was developed for dental practice **.(F. Duret , 1985.) .**

IOS are devices for capturing direct optical impressions in dentistry**(Ting-Shu *et al*., 2015)**Similar to other three-dimensional (3D) scanners, they project a light source (laser, or more recently, structured light) onto the object to be scanned, in this case the dental arches, including prepared teeth and implant scanbodies (i.e .cylinders screwed on the implants, used for transferringthe 3D implant position)(**Zimmermann, *et al*.,2015).**The images of the dentogingival tissues (as well as the implant scanbodies) captured by imaging sensors are processed

by thescanning software, which generates point clouds**. (Imburgia,*etal*. 2017)** . Computer-aided design and computer-aided manufacturing (CAD-CAM) technology in dentistry was introduced for single-unit restorations 30 years ago, and technological advances make it possible to produce complex multi-unit rehabilitations and implant restorations**. (Nedelcu ,*et al*., 2018).**

When the CAD-CAM concept started to be used in prosthetic dental treatments, intraoral scanning concept were introduced in the early 1980s **(Su T,& Sun J. 2015).** Especially with the entry of intraoral scanners into the market, digital impression techniques have shown many innovations and developments; and these developments brought with them easier and reliable manipulations at many stages of treatments**(Logozzo *et al*.,2014).**

Aims of the study

Review of intraoral scanner technologies and compare it with conventional impression material

Chapter One:

Review Of Literature

CHAPTER ONE: REVIEW OF LITERATURE

1-1-Teeth loss :

Edentulism refers to the condition of having no teeth. However, the term can be further categorized into partial edentulism and complete edentulism. Partial edentulousness is a dental arch in which one or more but not all natural teeth are missing. Generally, it occurs by caries, periodontal problems, traumatic injuries, impactions, supernumerary teeth, neoplastic and cystic lesions **(Muneeb ,2013).** Some studies have reported caries as the main causative agent for tooth loss . Complete tooth loss or edentulism,is defined as having all natural teeth missing include third molar**(Lakshmi ,2014).**. Both partial and complete edentulism can have significant impacts on an individual's quality of life, including difficulty eating, speaking, and socializing. Treatment options may include dental implants, dentures, or bridges, depending on the individual's needs and preferences **(American College of Prosthodontists,2020).**

1-2 Treatment options for restoring missing teeth:

1-2-1 Removable Dentures :

- Removable partial dental prosthesis (RPDP) The prosthesis that replaces some teeth in a partially edentulous arch and that can be removed from the mouth by the patient. It can be a simple removable partial denture fabricated in acrylic resin called as temporary partial denture. A removable partial denture fabricated in cast metal alloy and acrylic resin is called cast partial denture.
- Removable complete dental prosthesis The prosthesis that replaces the entire dentition and associated structures of maxilla and mandible **(Lakshmi 2014).**

1-2-2.Fixed:

i- Bridge are dental restorations that replace one or more missing teeth. A bridge consists of an artificial tooth or teeth that are attached to adjacent teeth using dental crowns.

ii- Dental implants: Dental implants are artificial tooth roots that are surgically placed into the jawbone. Once the implant has fused with the bone, a crown or other dental restoration is attached to the top of the implant. Dental implants are a long-term solution for tooth loss and have a high success rate.

iii- All-on-4: All-on-4 is a dental implant procedure that replaces all of the teeth in the upper or lower jaw using just four implants. This procedure is a good option for people who have lost most or all of their teeth and want a fixed, permanent**(Lakshmi ,2014).**

(ALL THESE TREATMENT REQUIRE IMPRESSION)

1-3 Impression :

A dental impression is a negative imprint or mold made of teeth and surrounding oral tissues, which is used to create a positive reproduction of the mouth structure. It is commonly used in dentistry to create restorations, such as crowns, bridges, dentures, and orthodontic appliances. The process of making a dental impression involves placing a tray filled with a dental impression material into the patient's mouth and allowing it to set. Once set, the impression is removed and sent to a dental laboratory, where a dental technician uses it to create a custom-fitted restoration or appliance American**.(Dental Association. 2018).**

1-3-1 Type of impression material :

- Alginate: Alginate is a commonly used impression material for making preliminary impressions of the teeth and oral tissues. It is easy to use, relatively inexpensive, and produces good detail. **(Frencken, *et al*.,1997).**
- Polyvinyl siloxane (PVS): is a popular impression material used for making final impressions of the teeth and oral tissues. It has high dimensional stability, excellent detail reproduction, and good tear strength. PVS is available in different viscosities and setting times, making it versatile for a range of impression techniques**. (Craig, and Powers, 2016).**
- Polyether: Polyether is another popular impression material used for making final impressions. It has excellent dimensional stability and tear strength, but it can be more difficult to work with than PVS. Polyether is hydrophilic, meaning it can wet oral tissues better than other impression materials, making it useful in moist environments. **(Donovan, & Chee,2012).**
- Zinc oxide eugenol (ZOE): is a commonly used impression material for making impressions of edentulous (toothless) arches. It has good flow properties, is relatively easy to use, and has a low cost. ZOE sets by a chemical reaction and is not affected by moisture in the mouth. However, it has poor dimensional stability and detail reproduction compared to other impression materials**. (Anusavice,2012).**

1-3-2-Advantage and disadvantage of impression material:

a-Advantages

- Accuracy: High-quality dental impression materials can provide very accurate impressions, allowing for precise fit of restorations such as crowns, bridges, and implants.

- Ease of use: Some impression materials are easier to work with than others, which can help reduce the time and effort required for the impression process.
- Cost-effectiveness: Many impression materials are relatively inexpensive, making them a cost-effective option for dental practices.
- Versatility: Dental impression materials can be used for a variety of applications, including restorative, orthodontic, and prosthetic procedures**. (Wang, 2020).**

b-Disadvantages :

- Sensitivity: Some patients may be sensitive to certain impression materials, which can cause discomfort or allergic reactions.
- Taste and odor: Some impression materials can have an unpleasant taste or odor, which can be unpleasant for patients.
- Setting time: Some impression materials may require a longer setting time, which can be inconvenient for both the patient and the dentist.
- Dimensional stability: Some impression materials may shrink or distort over time, which can lead to inaccuracies in the final restoration**. (Wang, 2020).**

1-3-3 Impression Technique :

There are several techniques used for making dental impressions, including the one-step, two-step, and double-mix techniques:

- One-step impression technique: In this technique, a single impression material is used to record the prepared tooth and surrounding tissues in one step. This technique is simple, quick, and requires fewer materials. One-step impression technique is commonly used for single unit restorations and in situations where there is adequate moisture control. **(Assif, & Aviv,2003)**.

- Two-step impression technique: In this technique, two different impression materials are used to make separate impressions of the prepared tooth and the surrounding tissues. The first impression records the tooth preparation, and the second impression records the surrounding tissues and the prepared tooth. This technique provides greater accuracy and detail reproduction. Two-step impression technique is commonly used for multiple unit restorations and in situations where there is inadequate moisture control. **(Kawai, 2003).**
- Double-mix impression technique: In this technique, two different impression materials are used to record the tooth preparation and the surrounding tissues simultaneously. The first material is a wash material that flows into the prepared tooth and surrounding tissues, and the second material is a bulk material that provides support and stability. Double-mix impression technique provides high accuracy and detail reproduction. It is commonly used for complex restorations and in situations where there is inadequate moisture control**. (Srinivasan, & Viswanathan,2012).**

1-4-Intraoral Scanner:

scanners are a type of dental technology used to create digital impressions of a patient's teeth and gums. Here's a brief history of the intraoral scanner:

1-4-1 History of IOS:

In the early 1980s, the first intraoral scanners were developed using a mechanical arm with a small camera attached to it. This allowed for some level of digital scanning, but the images produced were not of high quality. **(Patzelt *et al*.,2014).**

In the mid-1990s, a new type of intraoral scanner was introduced that used laser triangulation to create 3D images of the teeth and gums. This technology was more accurate and produced higher quality images,

but was still limited by the size and weight of the scanner. . **(Patzelt *et al*.,2014).**

In 2000, the first handheld intraoral scanner was introduced. This allowed for greater flexibility and maneuverability, and made it easier for dentists to capture digital impressions of their patients' teeth. . **(Patzelt *et al*.,2014),(Giannobile , 2021).**

improve. New Over the next decade, intraoral scanners continued to evolve and features were added, such as the ability to capture color images and the ability to take video scans. The scanners also became smaller, lighter, and more comfortable for patients to use. In recent years, intraoral scanners have become even, more advanced with the introduction of artificial intelligence and machine learning algorithms that can help to analyze scans and identify potential dental issues . **(Patzelt *et al*.,2014),(Giannobile , 2021).**

1-4-2-Intraoral scanner technologies:

IOS is a medical device composed of a handheld camera (hardware), a computer, and a software. The goal of IOS isto record with precision the three-dimensional geometry of an object. The most widely used digital format is the open STL (Standard Tessellation Language) or locked STL-like (Figure 1(a)). This format is already used in many industrial fields and describes a succession of triangulated surfaces where each triangle is defined by three points and a normal surface (Figure 1(b)). However, other file formats have been developed to record color, transparency, or texture of dentaltissues . Irrespectiveof the type of imaging technology employed by IOS, all cameras require the projection of light that is then recorded as individual images or video and compiled by the softw are after recognition of the POI (points of interest). The first two coordinates (x and y) of each point are evaluated on the image, and

the third coordinate (z) is then calculated depending on the distance to object technologies of each camera, as explained below (Figure 1(c)).

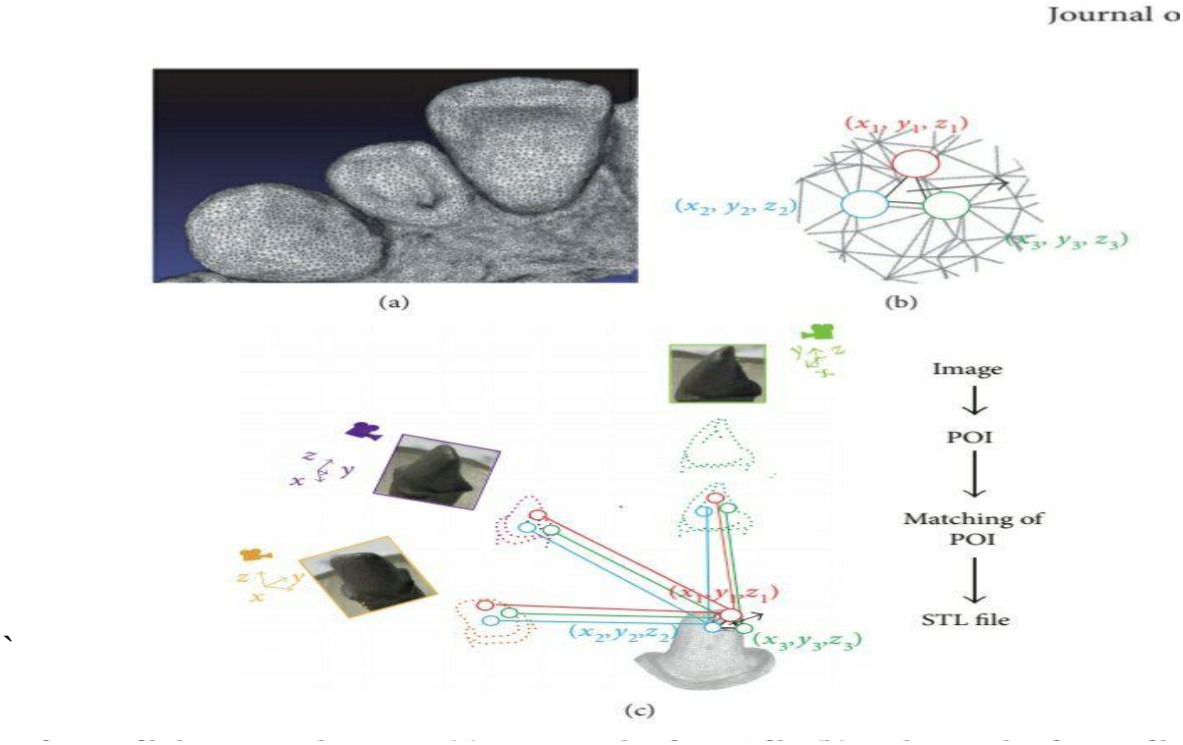

Figure 1-1: Generation of a STL file by intraoral scanner.(Journal of Healthcare Engineering)

1-4-3. Clinical Impact of IOS Technologies

☒ **Handling and Learning**. Recent studies have indicated that the digital impression technique was more comfortable and faster than the current impression technique .**(Gjelvold, 2016.).** Lee and Gallucci have reported that implant impression with IOS using confocal technology was a more efficient technique with shorter preparation and retake time than conventional implant impressions for inexperienced second year dental students **(Lee, and Gallucci, 2013).** In two other clinical studies, IOS using confocal or AWS was significantly preferred over conventional impression; it was more time efficient, comfortable, and patient friendly for implant impression **(Joda, and Brägger,2016).**Each scanner also

includes specific technology and captors that impact size and weight of the scan head **(Zimmermann, *et al*. ,2015).**

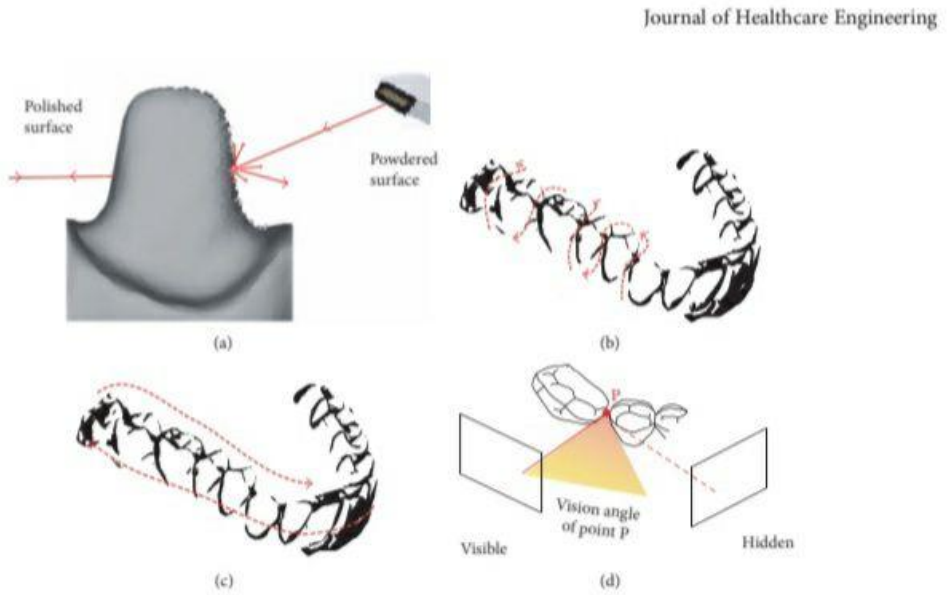

Figure 1-2: Scanning strategies.(Journal of Healthcare Engineering)

☒ **Powdering**. Dental tissues present many reflective surfaces, such as enamel crystals or polished surfaces, that could disrupt the matching of POI by the software due to overexposure. To prevent this, practitioners could change the orientation of the camera to increase diffuse light Another strategy to overcome this difficulty employed by some systems is to use cameras with a polarizing filter **. (Burgner, *et al*., 2013).** For other scanners, a 20–40 μm powder coating is required during the digitizing process to reduce reflectivity(Figure 2(a)). Theoretically, the powder thickness could vary between operators and reduce file accuracy, but the software of the IOS is capable of taking an average thickness into account (**da Costa, *et al*.,2010).** Powder-based digital impression has been previously shown to be very accurate for partial impressions **.(Hack and Patzelt, 2015**).However, powder could be relatively uncomfortable for

patients, and additional scanning time has been reported when powder is contaminated with saliva during impression as this requires cleaning is and reapplication of powder .**(Joda, and Brägger, 2016)**

- **Scanning Paths**. Scan path means that the intraoral scanner must be used according to a specific movement to increase accuracy of the virtual model **.(Zimmermann, *et al*. ,2015)** The scanned object should be positioned at the center of an acquisition area to describe an optimal sphere around the object. Practitioners also have to maintain a fluid movement, always preserving a steady distance and the tooth centered during recording. The camera should be held in a range of between 5 and 30mm of the scanned surface depending on the scanners and technologies **(Zimmermann, *et al*. ,2015).** This handling is particularly difficult during the change of axis, such as the passage from posterior to anterior tooth or in case of malposition. Some manufacturers propose guides to avoid practitioners to maintain distance and keep the surrounding tissue out of the field of view of the camera. For IOS using confocal technology, when a scan of the entire arcade is required, different strategies are described by manufacturers. One is a linear movement on all occlusalpalatal surfaces followed by buccal surface (Figure 2(b)). Another procedure consists of making an S sweep on vestibular, occlusal, and lingual faces of each tootsuccessively **(Müller, *et al*., 2016).** (Figure 2(c)). The first strategy seems to limit spatial distortion by finishing the capture at the initial position, and so avoiding an overall one-way error, but linear or rough movement of vestibular scans could be imprecise on interproximal areas. This technical observation leads practitioners to adapt their clinical protocol in difficult areas such as interproximal zones, tooth preparation, high curvatures of central incisive, and change of axis around canines. However, the capture of areas with a steep downward slope, such asthe anterior mandibular area, is often associated with difficultiesin the

treatment of the image . **(Zimmermann, *et al*. ,2015)**. This limitation underlinesthe increasing significance of IOS tracking and software.

- **Tracking and Software**. Sometimes during impression, tracking could be lost which may destabilize the software when distance to the object or scan path is not respected; movement is too fast or too jerky. A scan strategy must be followed beginning, for example, with easy parts (occlusal faces of posterior teeth) so that the software has enough information if tracking is lost. Manufacturers are currently developing different strategies and software algorithms to continue scanning when tracking is lost mainly by recognizing saved geometry of the object. For this, practitioners need to rescan a meaningful area without being stationary to give enough information to the camera and software. The second scan will allow matching the previous POI, and the software will complete this missed area **(Mao, *et al*.,2014).(**Figure 2(d)).

1-4-4-Clinical application of IOS:

IOS are of great utility and are applied in various fields of dentistry, for diagnosis and for fabricating restorations or custom devices in prostheses, surgery and orthodontics **(Rodiger ,*et al*. ,2017).** IOS are in fact used for acquiring 3D models for diagnostic purposes**(Imburgia , *et al*., 2017).** these models can be useful for communicating with the patient**(Goracci , *et al*. ,2016**) . In prostheses, IOS are used to make impressions of preparations of natural teeth **(Goracci , *et al*. ,2016)** for fabricating a wide range of prosthetic restorations: resin inlays/onlays , zirconia copings , zirconia , metal-ceramic and all-ceramic as well as frameworks and fixed partial dentures **(Shembesh ,*et al*., 2016).** have shown that the marginal gap of ceramic single crowns made from intraoral scans is clinically acceptable and similar to that in crowns produced from conventional impressions.The same considerations can be extended to short-span restorations such as fixed partial dentures of three to five

elements **(Shembesh ,*et al*., 2016).**IOS can be successfully used to capture the 3D position of dental implants and to fabricate implant-supported restorations**(Imburgia , *et al*., 2017).** (. The 3D position of the implants capturedwith the IOS is sent to the CAD software, where the scanbodies are coupled with an implant library, and the desired prosthetic restorations can be drawn within minutes; this restoration then can be physically realized by milling through a powerful CAM machine using ceramic materials **(Flügge ,*et al*.,2016)** . At present, implant-supported single crowns **(Flügge ,*et al*.,2016).** bridges and bars can be successfully fabricated from optical impressions. Similar to what the literature has found for natural teeth**(Goracci , *et al*. ,2016)** , the only apparent limitation to the use of IOS in implant prosthodontics is that of long-span restorations on multiple implants **(Amin S, *et al*., 2016)**and from different in vitro studies on trueness and precision, which indicate that conventional impressions are the best solution for these challenging clinical situations**(Imburgia *et al*., 2017).**

At present, only a few studies have addressed the use of IOS for fabricating partially **(Mansour , *et al*., 2016)** and completely, removable prostheses; in particular, this last application still presents some issues due to the absence of reference points and the impossibility of registering soft tissue dynamics. However, IOS can be successfully used for digital smile design applications , post and core fabrication**(Lee JH.*et al* ,2014)** and for fabricating obturators, in complex cases **(Chalmers , *et al* ,2016)** .Dentogingival model scanning can be superimposed onto files from (CBCT) too, via specific software to create a virtual model of the patient . This model is used for planning the positioning of the implants and to draw one or more surgical stents useful for placing the fixtures in a guided manner.**(Rodiger ,*et al*. ,2017).**

1-4-5-Advantages and Disadvantages of IOS:

A-advantages:

- **Less patient discomfort** :

the conventional physical impressions can cause momentary discomfort for the patient due to theinconvenience and hardship stemming from the materials positioned on impression trays**(Imburgia , *et al*., 2017).** Some patients (e.g. patients with strong gag reflex, or children) appear not to tolerate the classic procedure **(Zimmermann M, *et al*., 2015)** . For such patients, replacing conventional impression materials with light is an advantage optical impression is therefore appreciated **.(Christensen ,2008)** . optical impression eliminates the need for materials and impression trays, which are often unwelcome to the patient.(**Joda ,*et al*., 2016**).Patients tend to prefer optical impressions rather than conventional impressions.

- **Time efficiency:**

Several studies have shown that optical impressions are time efficient, as they en able reduction of the working times (and therefore costs) when compared to conventional impressions **(Goracci , *et al*. ,2016 ; Joda ,*et al*., 2016**). Despite the recent technological advancements in IOS,with the latest devices introduced in the market enabling the capture of a full-arch scan in less than 3 min, it does not appear that the major differences in time efficiency stem from the act of making an impression itself (a fullarch scan may take 3–5 min, similar to that required for conventional impressions), but rather from the time saved afterwards, during all subsequent steps **(Goracci , *et al*. ,2016 ; Joda ,*et al*., 2016).** In fact, with optical impressions, there is no need to pour stone casts and obtain physical plaster models**(Joda ,*et al*., 2016).** it is possible to e-mail

the 3D virtual models(proprietary or. STL files) of the patient directly to the dental laboratory without the need to deliver anything via courier or regular mail. This enables the saving of a considerable amount of time and money during the working year(**Imburgia , *et al*., 2017).**

- **Simplified procedures for the clinician** :

the use of IOS may confer further clinical advantages, simplifying impression-making in complex cases, for example in the presence of multiple implants or severe undercuts that may render the detection of a conventional impression difficult and insidious**(Marti ,*et al*., 2017).** Moreover, if the clinician is not satisfied with some of the details of the recorded optical impression ,they may delete them and recapture the impression without having to repeat the entire procedure; this aspect is time-saving **.(Marti ,*et al*., 2017).**

- **No more plaster casts**

For the clinician, optical impression allows the skipping of an otherwise unavoidable step physical impressions and subsequent casting of gypsum models) with a time-saving effect .The elimination of conventional impression materials translates into direct savings for the clinician, with reduced consumables costs(**Imburgia , *et al*., 2017).**

- **Better communication with the dental technician:**

With IOS, the clinician and the dental technician can assess the quality of the impression in real-time**(Imburgia *et al*., 2017).** immediately after the scan has been performed, the dentist can e-mail it to the laboratory, and the technician can check it accurately**.(Marti ,*et al*., 2017).** If the dental technician is not convinced of the quality of the received optical impression, he/she can immediately request that the clinician make another one without any loss of time and without having to call the patient for a second appointment**(Imburgia , *et al*., 2017).** This

aspect simplifies and strengthens communication between the dentist and dental technician**.(Imburgia , *et al*., 2017).**

❖ **Better communication with patients** :

with optical impressions, patients feel more involved in their treatment and it is possible to establish more effective communication with them; this emotional involvement may have a positive impact on the overall treatment, for example, by improving patient compliance to oral hygiene. In addition, patients are interested in the technology and mention it to their acquaintances and friends, raising their consideration of dental centres equipped with these modern technologies. Indirectly, IOS has become a very powerful advertising and marketing tool **(Imburgia , *et al*., 2017).**

B-Disadvantages:

☒ **Learning curve**:

Subjects with a greater affinity for the world of technology and computers (e.g. young dentists) will find it very easy to adopt IOS in their practice .older.clinicians with less experience and passion for technological innovations could find using the devices and related software more complex for **(Marti ,*et al*., 2017).**

☒ **Difficulty detecting deep margin lines of prepared teeth**

One of the most frequent problems encountered with IOS and with optical impressions is difficulty in detecting deep marginal lines on prepared teeth or in the case of bleeding **(Imburgia *et al*.,2017).** In some cases, in fact, and especially in aesthetic areas where it is important for the clinician to place the prosthetic margins subgingivally, it may be more difficult for the light to correctly detect the entire finishing line**(Imburgia , *et al*., 2017).** In fact, unlike the conventional impression materials, light cannot physically detach the gum and therefore cannot register ‘non-visible’ areas. Similar problems can also occur in the event of bleeding, as

blood may obscure the prosthetic margins**(Marti ,*et al*., 2017**).Despite this, with the proper attention and speed (the gingival sulcus tends to close immediately after the retraction cord is removed) and the appropriate strategies for highlighting the preparation line (insertion of a single or double retraction cord), and avoiding bleeding (excellent oral hygiene and provisionals with correct emergency profile), it is possible for the clinician to detect a good optical impression even in difficult contexts**(Aragón ML, *et al*., 2016).**

☒ **Purchasing and managing costs**

Depending on the model, the cost of purchasing an IOS may be between 15.000 and 35.000 euros. Over the last few years, manufacturers have released many new models on the market ,and the growth in supply should be accompanied by a reduction in purchase costs**(Imburgia , *et al*., 2017).** . Regardless, the purchase cost of a high-end, last-generation IOS should be cushioned over the year by integrating the device into the clinical workflow across the various dental disciplines(prosthodontics, orthodontics, implant surgery**)(Imburgia *et al*., 2017).** .One important aspect to consider is additional managing costs related to upgrades of the reconstruction software. Different manufacturing companies have different policies in this regard, and it is important for the clinician to be fully informed of the annual management costs and fees, where present, before purchasing an IOS(**Imburgia , *et al*., 2017).** .

1-4-6-Type of IOS:

- TRIOS intraoral scanner: The TRIOS intraoral scanner uses a high-speed camera to capture 3D images of the teeth and soft tissues in the oral cavity. The scanner is designed to capture high-resolution images quickly and accurately, making it an ideal tool for digital impressions, implant

planning, and orthodontic treatment planning**. (Zimmermann, *et al*.,2015).**

- iTero intraoral scanner: it uses a combination of laser and optical scanning technology to capture high-resolution 3D images of the teeth and soft tissues. The scanner is designed to capture accurate and precise digital impressions for a variety of dental restorations, including crowns, bridges, and orthodontic appliances**. (Rhe,2018).**
- CEREC intraoral scanner: it uses a high-speed camera to capture 3D images of the teeth and soft tissues in the oral cavity. The scanner is designed to capture accurate and precise digital impressions for a variety of dental restorations, including crowns, bridges, and veneers. The scanner is also capable of designing and milling restorations in-office, providing a same-day restoration option for patients. **(Zimmermann, *et al*., 2015).**
- Shape TRIOS 4 intraoral scanner: it uses a high-speed camera and advanced scanning technology to capture high-resolution 3D images of the teeth and soft tissues in the oral cavity. The scanner is designed to capture accurate and precise digital impressions for a variety of dental restorations, including crowns, bridges, and implant restorations. The scanner also features an integrated intraoral camera and shade measurement tool, providing a comprehensive digital solution for restorative dentistry. **(Ender, & Mehl,.2018.)**.
- Medit i500: is an intraoral scanner developed by Medit. It uses high-speed imaging and video streaming to capture accurate and detailed images of the teeth and surrounding tissues. The Medit i500 is designed to be lightweight and ergonomic, making it easy for clinicians to use. **(Hamza,*et al*., 2020).**

1-5-Evolution of Dentai CAD/CAM :

CAD software is utilized for image alteration and restoration design in manufacturing. Still, CAM software is used for the actual manufacturing process, allowing for a fully automated process. Scan, design, and milling systems are available in various combinations for dentistry. These range from complete scanning, designing, and milling systems to systems that perform certain activities, such as digital scanning only, exclusively designing restorative materials, or exclusively milling restorative materials, to systems that perform all of these duties Digital impression systems are computer-based cameras or scanners that capture digital images of the teeth and soft tissues and analogue models and impressions and save them to the hard drive of a computer. To alter photos and maintain patient information, digital impression management software is employed. Creating a digital impression of prepared teeth was only possible as part of larger in-office CAD/CAM systems, but these devices are now available as independent units**.(V. Pereverzyev,2022).**

Chapter two:

Discussion and Comment

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DISCUSSION AND COMMENT

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The world is progressing day by day, and everything is progressing to make life easier and more efficient. When we talk about dentistry, there are many innovations every coming day, and digital dentistry is one of these innovations and gifts to dentistry. The uses of digital dentistry is increase in all branches. digital dentistry has transformed the way dentists diagnose and treat dental problems. one example for digital dentistry is intraoral scanner .IOS is a device that uses optical or laser scanning technology to create a digital 3D image of the teeth and surrounding tissues**.(Zimmermann, *et al,* 2015)**.IOS offer several benefits to both dental practitioners and patients, including less patient discomfort]. Some patients (e.g. patients with strong gag reflex, or children) appear not to tolerate the classic procedure**(Zimmermann M, *et al*., 2015)** . For such patients, replacing conventional impression materials with light is an advantage;optical impression is therefore appreciated **(Christensen ,2008).** the use of IOS may confer further clinical advantages, simplifying impression-making .in complex cases**.(Marti ,*et al*., 2017).**Another advantage is better communication with patients Optical impression is a powerful tool for patient communication and marketing . **(Imburgia , *et al*., 2017).** It also offer better communication with the dental technician With IOS, the clinician and the dental technician can assess the quality of the impression in real-time**(Imburgia , *et al*., 2017).** . In fact, immediately after the scan has been performed, the dentist can e-mail it to the laboratory, and the technician can check it accurately **(Marti ,*et al*., 2017).**

The use of IOS time saved**:** Several studies have shown that optical impressions are time-efficient, as they enable reduction of the working times when compared to conventional impression**.(Joda ,*et al*., 2016)** . with optical impressions, it is possible to e-mail the 3D virtual models(proprietary or. STL files) of the patient directly to the dental laboratory without the need to deliver anything via courier or regular mail**(Imburgia , *et al*., 2017).**

In the other hand there are some disadvantages for IOS include Difficulty detecting deep margin lines of prepared teeth One of the most frequent problems encountered with IOS and with optical impressions is difficulty in detecting deep marginal lines on prepared teeth or in the case of bleeding . In some cases, in fact, and especially in aesthetic areas where it is important for the clinician to place the prosthetic margins subgingivally, it may be more difficult for the light to correctly detect the entire finishing line**(Marti ,*et al*., 2017).** Similar problems can also occur in the event of bleeding, as blood may obscure the prosthetic margins**(Marti ,*et al*., 2017).**

After we reviewed the advantage and disadvantage of IOS ,we can say.while IOS have many benefits, they do require a significant investment However, many dental practices are finding that the benefits outweigh the initial investment, and that using intraoral scanners can improve patient satisfaction and overall practice efficiency.

But we cannot completely abandon the use of impression material in dentistry because some important reasons like cost, training , and some limitation like bleeding ,long span and limitation mouth opening also difficulty of use of IOS in remote and poor area ,but in the future, we expect that manufacturers will continue to develop their products and overcome their flaws. And the IOS become more popular and cheaper and there is IOS in each dental clinic.

Chapter Three:

Conclusions And Suggestions

CHAPTER THREE:

CONCLUSIONS AND SUGGESTIONS

3-1 Conclusions:

intraoral scanner technology is a valuable tool in modern dentistry that have been found to provide faster, more accurate, and more comfortable digital impressions compared to traditional methods. They have also been shown to improve clinical outcomes, reduce chair side time, and increase patient satisfaction.

Despite the presence of some difficulties which makes us prefer using traditional impression in some cases. but if we overcome these difficulties in the future. Traditional impression will be a thing of the past.

3-2 Suggestions:

An understanding of the IOS technology is necessary for any practitioner in dentistry to have a successful clinical strategy during the scanning of prepared teeth.

Future developments will focus on integration with artificial intelligence to make IOS more intuitive and accurate, further opening the door to all those looking to go digital.

IOS was superior in terms of patient preference and time reduction.

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