Republic of
Ministry of Higher Education
And Scientific Research
University of Baghdad
College of Dentistry

Digital Impression

A project submitted to
The College of Dentistry, University of Baghdad and Department of Prosthodontics in Partial Fulfillment of the requirement for the Bachelor of Dental Surgery

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2023


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Certification of the Supervisor

I certify that this project entitled " **Digital Impression** " was prepared by the fifth-year student **Mohammed Saman Nazar** under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

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DEDICATION

All my success as well as everything I do, I'm honored to dedicate it to my parents, the two people who gave me the values and paved the path for my journey in life. A special feeling of gratitude to my loving parents, whose words of encouragement and push for tenacity ring in my ears.

My father, who pushed me to continue for the better and accompanied me throughout this difficult period and who has always been my inspiration in my work.

My mother, my mentor and role model for the love, and for her generosity in love, knowledge, wisdom and life lessons.

My brothers and sister have never left my side and are very special.

My grandparents for believing in me since day one and granting me the gift of compassion and motivation.

I also dedicate this dissertation to my many friends and family who have supported me throughout the process. I will always appreciate all they have done, for their presence, warmth and endless support.

Acknowledgment

Foremost my gratefulness and appreciation to my **God Allah** almighty for blessing me with passion for this career, preservation to walk this journey and for bestowing me with strength, good health and peace of mind to finish this project.

I would like to express my thanks to **Professor Dr. Raghad Al Hashimi** dean of College of Dentistry, University of Bagdad for his constant support and efforts to improve our educational system and college.

I wish to extend my sincere thanks to Professor **Dr. Abdel-bassit Fathallah** Head of Prosthetic Department for his continuous care and efforts to facilitate the work and completion of this project and requirements.

This project wouldn't have seen the light without the guidance, support and supervision of **Lecturer Dr. Ali Abdulrazzaq**, his scientific advices, insightful comments, immense care and time spent proofreading and following the work is deeply appreciated.

Last but not least I thank everyone who played a role in this work by their provided information, encouragement and enlightening.

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Introduction

Dental Impression defines as a negative imprint of an oral structure used to produce a positive replica of the structure to be used as a permanent record or in the production of a dental restoration or prosthesis. The impression procedure is most significant step **(Deepak, 2017).**

In dentistry, impression was taken with conventional methods for many years and nowadays elastomeric impression materials especially polyvinyl siloxane and polyether are used very reliably in terms of impression accuracy **(Mehl et al, 2009; Seelbach et al, 2013).**

At the beginning of the 1980s, digital impression systems occurred as Werner Mörmann began to think about what could be done to develop one session treatment. He shared this idea with his electronic engineer friend, Marco Brandestini. In this way, it has been started to develop digital impression instruments with optical reading systems **(Mörmann, 2006; Rekow, 2006).**

Digital and conventional impression methods have some advantages and disadvantages compared to each other **(Amin et al, 2017).**

In the conventional impression method, having a greater number of steps increases the possibility of making extra mistakes **(Chochlidakis et al, 2016).**

Digital methods are more preferable in terms of time and preference of clinicians **(Schepke et al, 2015).**

In the digital impression method, the possibility of a problem because of inadequacy of impression details is less than conventional method.

Intraoral scanner (IOS) has less effect on the gag reflex than the impression tray. It is easier to store digital impression. In addition, the other disadvantages of the digital impression method are cost and requirement of extra education for using **(Ahlholm et al, 2018; Mühlemann et al, 2018).**

The intraoral scanner (IOS) is a three-dimensional (3D) device capable of detecting dental impressions, through the first acquisition of a large number of images and then the subsequent processing using dedicated software.

The advent of new technologies in the field of medicine and dentistry is giving improvements that lead the clinicians to have materials and procedures able to improve patients' quality of life. In dentistry, the last digital techniques offer a fully digital computerized workflow that does not include the standard multiple traditional phases.

Aims of the review:

The review aim to:

1- Assessment of digital impression and different systems of it.

2- Showing different techniques and technology.

3- Makes a comparsion between conventional and digital impression according Advantages and disadvantages of both of them, accuracy and effectiveness.

Chapter one

REVIEW OF LITRERATURE

1.1 Digital impression

A relatively new approach employs Computer-Aided Design/ Computer Aided Manufacturing (CAD/CAM) technology to take a digital impression intra orally, fabricate the master model, and design as well as produce the final restoration. This method aims to overcome certain physical limitations of conventional means, such as the dimensional changes of impression materials, the expansion of dental stone, and human errors associated with final restoration fabrication, thus reducing processing time as well as cost **(Miyazaki ,2009)**.

CAD software allows for precise planning of the denture frame components in relation to individual teeth anatomy and the soft tissue of the oral cavity. In addition, it allows continuous control of sections of individual elements of the prosthesis, and hence the control of the planned mechanical parameters, and designing of minimally visible components **(El Khamisy Habib AH,2017), (Malara PA,2015).**

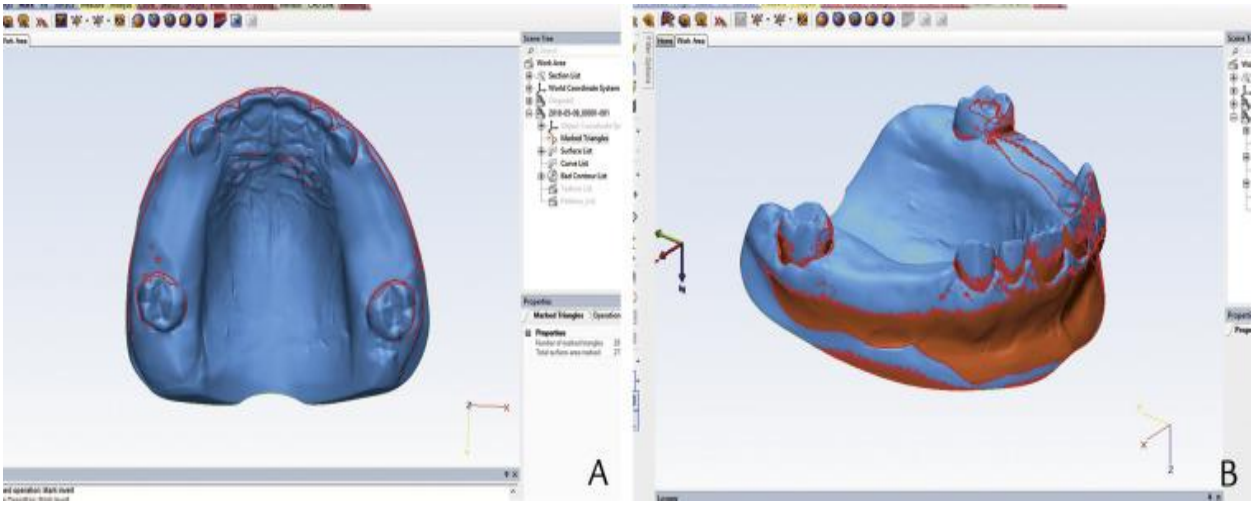

Figure (1-1) A CAD-CAM device for preparing guide planes for removable partial dentures. (Miyazaki T,2009).

The evolution of the CAD/ CAM technology decreases the duration of prosthesis manipulation and provide superior functional and esthetic outcomes. Also changes of the prosthesis volume and/ or shape is reduced or eliminated in this approach compared to the conventional procedures. Thus, the produced prosthesis adheres tightly to the tissue and uniformly transferring loads on it. Furthermore, it permits easy duplication of the denture and manufacture of new one using stored digital data **(Person AS,2009), (Williams RJ,2006)**.

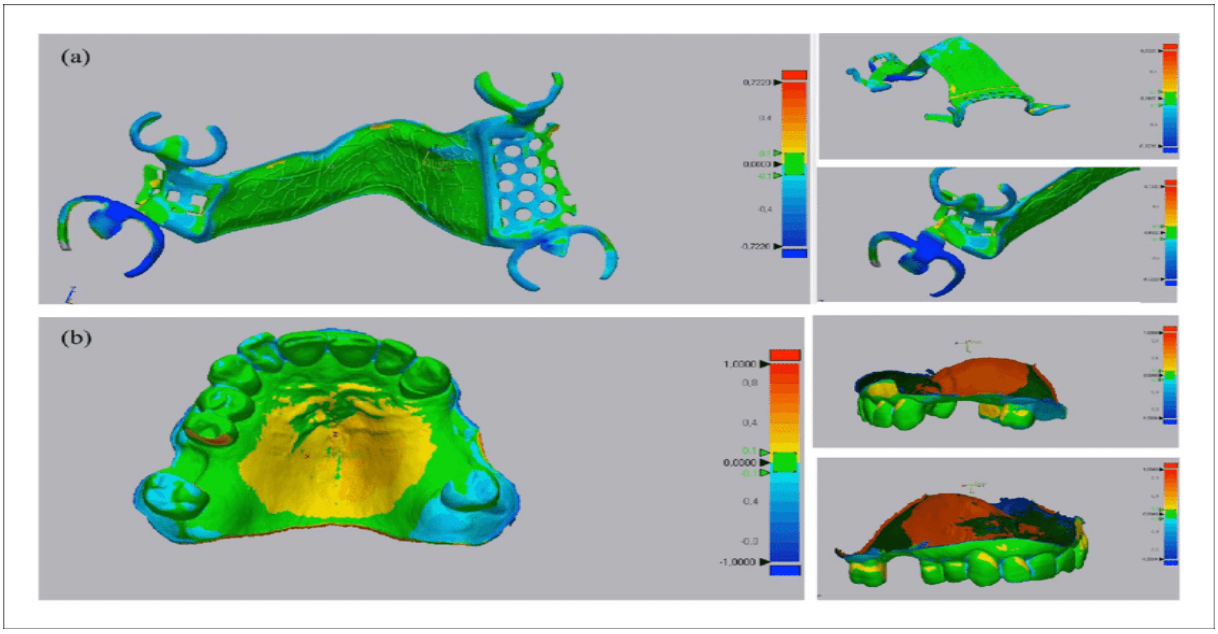

Figure (1-2) (a) 3D deviation of the superimposed digital framework design (CAD) and the metal framework produced (CAM) and (b) 3D deviation colour map of the superimposed digital impression and the printing model. (person As,2009)

1.2 CAD/CAM systems parts

(1) A data acquisition unit, which gathers the information or data from the mouth and then converted into visual or optical impressions which are created directly or indirectly at the same time.

(2) Different softwares, are used for the designing of the final restorations which are secured in optical impressions and prepared for the milling parameters.

(3) A computerized milling system, for the final manufacturing of the restoration with solid blocks of the appropriate restorative material. The first two parts of the system are associated in the CAD phase, while the third one is the CAM phase(Galhano GA,2012).

1.3 Types, Propositions and Features of Different Digital Systems:

The main digital impression systems those are available on the market include CEREC, Lava C.O.S. system, iTero, E4D, and TRIOS. They vary from each other in terms of various features such as working principle, light source, the necessity of powder coat spraying, operative process, and output file format**(Birnbaum NS,2008) , (Rekov ED,2006).**

1.3.1 CEREC System

The CEREC 1 system (Sirona, Bensheim, Germany) was brought to market in 1987 together with the Duret system as the first intraoral digital impression and CAD/CAM device**(Mormann WH,2006)**.The principle of this system is designed with the concept of "triangulation of light," where the intersection of three linear light beams is focused on a certain point in 3D space**(Birnbaum NS, 2009)**. LED blue diode is the light source which will emit visible blue light for the image capturing. The CEREC AC Blue-cam can capture one quadrant of the digital impression within 1 minute and the antagonist in a few seconds. In 2012, the latest and newest CEREC system, CEREC AC Omnicam, was brought to market. Blue-cam can only be applied for a single tooth while Omnicam can be used for a single tooth, quadrant, or full arch. Powder-free scanning and precise 3D images with natural color are the most prominent features of Omnicam. The CEREC system is a closed system, Sirona's supporting CAM devices such as CEREC MC and CEREC In-Lab works on the proprietary format file those contain the digital impression date**(Rohaly J, 2006)**.

1.3.2 Lava C.O.S. system

LavaTM C.O.S. (Lava Chairside Oral Scanner; 3M ESPE, Seefeld, Germany) is an intraoral digital impression device invented in 2006 and brought to market in 2008. The principle on which it works is active wavefront sampling. Single-lens imaging system is used to obtain the 3D data under active wavefront sampling. Three sensors are used to capture clinical images from different angles simultaneously such as to develop surface patches with in focus and out-of-focus data by proprietary image-processing algorithms**(Galhano GA, 2012).**The Lava C.O.S. has the smallest scanner tip—only 13.2- mm wide**(Garg AK, 2008).** In most cases, supporting CAD software and CAM device are used for desiging and manufacturing of data proprietary files exported by Lava C.O.S.

1.3.3 iTero system

Cadent Inc (Carstadt, NJ) introduced iTero to the market in 2007. They work on the principle of parallel confocal imaging, the iTero system captures intraoral images and contours them by laser and visual scanning(**Kachalia PR, 2010)**.Coating of teeth with scanning powder is not recommended in this system, it can capture all the structures in mouth without any use of coating powder. Red laser is used as a light source in this system and further it consists of a host computer, a mouse, a keyboard, a screen, and a scanner.

1.3.4 E4D system

The E4D system was developed by D4D Technologies, LLC (Richardson, TX). It works under the principle of optical coherence tomography and confocal microscopy(**Logozzo S, 2011).**The images are obtained in every angle with the laser technology. The software will compile all the images. The image library can wrap around a precise virtual model in seconds. This system also functions as a powder-free intraoral scanning device. It includes a cart with the design center (computer and monitor), laser scanner head, and a separate milling unit**(Tsitrou EA, 2010).**

1.3.5 TRIOS system

A new type of intraoral digital impression system, TRIOS, was introduced in 2010, by 3Shape (Copenhagen, Denmark) and was presented to market in 2011. This system works under the principle of ultrafast optical sectioning and confocal microscopy**(Logozzo S, 2011)**.They maintain a fixed spatial relation of the scanner and the object being scanned and recognizes variations in focal plane of the pattern over a range of focus plane. Moreover, they have a quick scanning speed of up to 3000 images per second thereby reducing the influence of relative movement between scanner probe and teeth. Similar to the iTero and E4D systems, the TRIOS intraoral scanner is a powder-free device in the scanning process. TRIOS include two parts: TRIOSR Cart and TRIOSR Pod. The TRIOSR Pod is having a handheld scanner which offers better flexibility and mobility, so due to its simple construction it is compatible with other computers and iPad also(**Persson AS, 2009).**

A B

Figure (1-3): (A) iTero system, (B) TRIOS system.

(Persson AS, 2009)

1.4 Digital scanner:

A digital scanner is a non-contact measuring device that records and reconstructs three-dimensional (3D) surfaces or volumes. It consists of an optical acquisition system in association with 3D reconstruction software **(Lo Russo et al, 2018)**.

• IOS is a medical device composed of a handheld camera (hardware), a computer, and software. The goal of IOS is to record with precision the three dimensional geometry of an object. The most widely used digital format is the open STL or locked STL- like **(Raphaël Richert et al., 2017)**.

• The IOS devices use an advance optical surface scanning technology that are similarly to a camera using the sensors measure light reflection times from various texture through processes to capture the object three dimensionally instead of simply capturing lights and colors in the camera. The information is then captured by the 3D software that uses specific alignment algorithms to allow for registration of the object. **Fig (1.4)**

Mobile and record directly in the mouth

• Extra-oral scanners (EOS) are used to digitize impressions/models in laboratories.

• Facial scanners can be used for recording aesthetic lines or extra-oral defects in maxillofacial prosthetics **(Lo Russo et al, 2019).**

Figure (1-4): Intra-oral Scanner Device **(Logozzo et al., 2011).**

1.4.1 Digital Intraoral Scanner Technique

The digital impression of edentulous jaws is described by a certain technical difficulty, thus adequate clinical training is required **(Lo Russo and Salamini, 2018).**

In the past, the use of intraoral scanners was not recommended to perform the impression of edentulous jaws due to alleged feasibility and accuracy limits **(Mangano et al., 2017).**

Many articles showed that digital impressions of edentulous jaws are feasible and predictable. **(Lo Russo et al., 2019; Chebib et al., 2019)**

On the other hand the same studies showed that optical scanners are not suitable to capture areas of high mobility tissue zone, that are usually considered the basic determinant in the retention of complete denture **(Preti and Gassino; 2007; Marino et al., 2014).**

The differences between the two types of impressions (conventional and IOS) in those areas are related to two reasons: Firstly the specific software implementations in the scanner delete automatically areas that not steady over time. Current IOS focuses on capturing tissues that remain immobile, thus the software algorithm automatically removes scans of mobile tissue such as the tongue, vestibule, mobile areas of the palate as well as retractors or similar dental instruments **(Hack et al., 2020).**

Secondly, when an important part of peripheral sealing zone is impressed, those areas will be different from those registered by the impression materials. This is because the scanner does not determine any pressure to the tissue compared to conventional impression materials **(Hack et al., 2020).**

Digital scanning of edentulous ridges:

Presents three recording challenges:

1- The lack of anatomical landmarks.

2- The functional borders.

3- The posterior palatal seal. **(Tasaka et al,2019)**

Borders stretching are the most difficult area to record with digital scanning. **(Chebib et al, 2019**).Proposed to match conventionally registered functional borders with the original digital scanning. Other authors proposed mobilizing soft tissues with a finger or a mirror to record their position. **(Goodacre et al, 2018)**

Concerning the posterior palatal seal, the anterior and posterior vibrating line on the soft palate could be delineated by using an indelible pencil or small spots of light-polymerized gingival barrier material before scanning. The accuracy of digital scanners is sensitive to other factors such as learning curve, brightness during scanning, presence of saliva or scanning strategy. Each IOS requires specific settings and training. **(Ender et al. 2013)**

1.5 The procedure for a digital impression:

It is initiated after meticulous examination and treatment planning.

It is performed as follows:

• An intraoral or extra oral scanning of the patient's arches is performed. Intraoral scanning is performed with an intraoral scanner, thereby, eliminating the requirement of a physical impression. This includes several scans of both arches requiring about 3– 17 min. The scans are then joined by the software resulting in a full-mouth image.

• Alternatively, impressions materials are used to make impressions, which are then scanned directly with an extra oral digital scanner or made into master casts and then scanned. In general, bench top scanning of the cast models achieves comparable accuracy regardless of the type of dental stone used.

• Extra oral scanning of either the impressions or the stone-model scans can both provide adequate precision, although, digitalized the impressions present considerably better dimensional accuracy than stone models **(Lima JM et al, 2014).**

• The scanner generates a stereo lithographic file (STL) of the master cast that is imported into the designing software **(Lima JM et al, 2014)**

1.6 Advantages and disadvantages with digital impression:

The advantages of digital impressions are:

1. Enhanced patient comfort and simplicity.

2. Eliminates the possibility of errors like air bubbles incorporated while making impressions, displacement of the tray, and deflection of the tray during insertion, inadequate use of impression material, insufficient use of impression adhesive, or distortion of impressions during disinfection.

3. Reduces the risk of contamination and eliminates the need to disinfect the impression.

4. Storage of conventional models require additional office space, may even break or chip when physically stored, whereas digital scans can be stored on hard disks indefinitely.

5. The most significant advantage for dentist and dental lab technicians in using digital technology is the elimination of many lab procedures like pouring cast and shrinkage of conventional impressions materials **(Birnbaum NS etal, 2008)**.

The disadvantages include:

1. The lack of knowledge among dentists and dental technicians.

2. It is a new concept and not known by all.

3. The equipment is sophisticated, but newer versions are simplified but require training and practice to use the newer technique.

4. The cost of equipment is high. (Kim SY etal, 2013).

Moreover, Loos et al. found that covering preparations with metal oxide powder prior to scanning alters the geometry of the surface and that may compromise the internal fit of the restoration(Loos R,2005).

On the other hand, Ender et al. stated that digital impressions by direct intraoral scanning circumvents the need to take a conventional impression and pour up a stone model, eliminating two of the steps that may influence the accuracy and precision of the final restoration(**Ender A,2003).**

1.7 Rapid prototyping technologies (RP):

Rapid prototyping, also known as layered manufacturing, is the collective term for various processing technologies that fabricate precise 3 dimensional (3D) models directly from computerized three-dimensional (3D) data in a short time using layer by layer building technique **(Limma JM,2014),(Sun J,2012).**

1.6.1 Rapid prototyping technologies (RP) include:

- **Stereolithography (SLA)**
- **Selective laser melting (SLM)**
- **Selective laser sintering (SLS)**
- **Selective deposition modeling**
- **Fused deposition molding (FDM)**
- **3D printing and direct inkjet printing.**

Figure (1-5): Stereolithography 3D printer

(Limma JM,2014)

1.8 Digital versus conventional impression

Digital impressions have several advantages over traditional impressions **(Su TS, Sun J, 2016)**. They are very beneficial today as a boon to both the dentists and laboratory technicians by enabling them to achieve greater accuracy in any restorative procedures. Shortly, it will be more likely to be a regular dental office procedure, as it benefits dentists, patients, and laboratory technicians. Digital impressions from the patient's perspective save time and is a lot less messy than the traditional technique**(Yuzbasioglu E, 2014)**. The difficulty of scanning the distal part in the digital impression and requirement of titanium oxide powder spray for contrast (such as CEREC Bluecam systems) are some disadvantages of the digital system. In addition, the other disadvantages of the digital impression method are cost and requirement of extra education for using. Dental students learn the conventional impression method in the dentistry education. It is also necessary to be informed the students about the technological innovations such as digital impression systems and how to apply them in their professional life.

1.8.1 Accuracy

According to the International Organization for Standardization (ISO), accuracy is evaluated in terms of trueness and precision .

Trueness is defined as the measurement bias or systematic error between the reference object and the target object. **Precision** is defined as the random error (reproducibility) between the objects when the process is repeated. In previous studies, for full-arch models, it has been reported that the trueness and precision of conventional impressions, evaluated from stone casts, were 20–55 μm and 13–61 μm, respectively . On the other hand, it has been reported that the trueness and

precision of digital impressions obtained using an intraoral scanner were 40–59 μm and 31–60 μm, respectively.

The evaluation of trueness showed that digital impressions obtained using an intraoral scanner with a large scanning head had significantly lower deviation than the conventional impressions. Similarly, the evaluation of precision showed that digital impressions obtained using an intraoral scanner with a small scanning head had significantly higher deviation than the conventional impressions.

The results suggested that the accuracy of digital impressions for a partially edentulous ridge is superior to conventional impressions in terms of trueness, but inferior to conventional impressions in terms of precision, and that accuracy can be improved by increasing the scanning head size **(Malaguti G, 2017).**

1.8.2 Time and appointments

Digital impression may reduce the number of clinical appointments required and the chair time and can simplify laboratory procedures. The overall treatment time for the conventional impression technique was longer than that for the digital impression technique. Digital impressions tend to reduce repeat visits and retreatment, while increasing treatment effectiveness **(Beuer F, 2008).**

In the digital impression method, preparation time included entering the patient's information into system, the stages of describing how the intraoral scanner should be held during the scanning. The digital impression time included the time from the beginning of the intraoral scanning to the end of the scanning. Total taking impression time was the total duration of these.

1.8.3 The effectiveness and clinical outcomes

The effectiveness and outcomes of the conventional impression technique was evaluated by measuring the total treatment time, including the individual steps :

A) tray selection

B) adhesive application

C) upper/lower impression

D) bite registration.

The effectiveness and clinical outcomes of the digital impression technique were evaluated by measuring the total treatment time, including the individual steps:

A) entering patient information (including name, last name, date of birth) B) laboratory prescription

C) upper/lower scan

D) bite scan.

The mean overall treatment times were statistically significantly different ($p < 0.001$), and comparison of the mean impression times indicated a statistically significant difference ($p < 0.001$).

The mean tray selection time for the conventional impression technique and the mean time for entering patient information for the digital impression technique were not statistically significant ($p > 0.05$).

The mean adhesive application time for the conventional impression technique was statistically significantly different ($p < 0.001$) from the mean time for entering the laboratory prescription time for the digital impression technique.

The difference between the mean bite registration time for the conventional technique and the mean bite scan time for the digital technique was statistically significant ($p < 0.001$).

The results indicate that the efficiency outcomes of the digital impression technique were higher than that of the conventional impression technique, with respect to treatment time taken up and the perceptions of the subjects**(Ashtiani RE , 2018).**

1.8.4 Patient preferences

Digital impression was the preferred choice. **Benic GI et al**., stated that both the impression techniques were equally acceptable .

Preference for digital impression is another indication that today's patients have more concern on comfort. This is because the digital impressions are associated with reduced invasiveness. Unacceptable conventional impressions require remaking of entire impression. However, with digital impression technique missing and unacceptable areas can be corrected by a segmental rescanning. This reduces working time and increases patient comfort**(Burhardt L, 2016).**

1.8.5 Operator's Preferences

The digital impressions were preferred by the operator . Operator centered outcome were measured for digital and conventional impressions by assessing working time, operator perception and procedure difficulty. Assessment was done using VAS and questionnaires reported that digital impressions require reduced time .The work flow of digital impression technique took reduced time. Even though when a remaking was necessary, the time required for rescan of the digital impression was significantly less. Rescans were done mainly due to the difficulty

in scanning the interproximal contact areas and in areas of reflection from light source **(Gjelvold, 2016).**

Operator perception was measured on the level of difficulty in performing the procedure and was significantly lower for the digital impression technique. Manipulation and learning curve for the intra- oral scanner were less and they seem to be more user-friendly. Operators perceived that missing and unacceptable area can be corrected more easily with digital impressions while the conventional technique demanded remaking of entire impression **(Gjelvold B, 2016).**

1.8.6 Dental students

Students were more familiar with the conventional method before taking the impression. This situation is thought to be due to the fact that the students took conventional impression in the prosthetic courses at the preclinical laboratory while they did not take digital impression. They knew digital impression only as a theoretical course.

Students found the digital method easier than conventional method in the study of Lee and Gallucci **(Lee SJ, 2013).**

Open vs. Closed Architecture:

Digital impression systems can be grouped into two categories based on data files created during scanning: open and closed architecture. Open-architecture files are STL files. These types of files can be used in any software design for final restoration fabrication and are not dependent on the manufacturer. With open-architecture systems; dentists, can work with different laboratories and capitalize on their investments. Open architecture creates more business opportunities for laboratories that are capable of customizing the configurations. The laboratory can become an outsourcing partner for other laboratories or choose to assimilate with newer CAD software**(Fasbinder D.J, 2011).**

In Closed-system architecture, same manufacturer does data collection and manipulation of data modules. The CAD and CAM configurations are controlled by a single company, which is aware of the performance capacity and specifications of the milling unit and is able to adapt the CAD and CAM software accordingly. Closed-architecture systems are ideal for laboratories that do not want to indulge in all newer technologies and software from each different manufacturer. The production process from scanning, designing to milling is done by a single manufacturer**(Brown C, 2011).**

Reasons for choosing the digital impression:

1. It is faster and more accurate.

2. Easy.

3. comfortable, accurate and gives more details.

4. Digital impression easier & give more details & more comfortable for patient and dentist.

5. no gag reflex.

6. More presice and provides 3d imaging and better view of all the oral structures.

7. Less discomfort.

8. no pain.

9. digital impressions can increase productivity and efficiency and provide a high degree of accuracy.

10. lesser or no shrinkage, lesser failures, easily tolerated by the patient, could be saved and no need for repeating nor secondary impression.

11. more quickly And can transfer to computer without the need of plaster models cast .

12. It more convenient.

13. does not require manipulation of sensitive impression materials.

Chapter Two

Conclusion

2.1 Conclusion

In conventional impression method, having a greater number of steps increases the possibility of making extra mistakes. Standardization of the milling stage in the digital impression method and less step numbers reduce the possibility of mistakes and improves adaptability. Digital methods are more preferable in terms of time and preference of clinicians.

In the digital impression method, the possibility of a problem because of inadequency of impression details is less than conventional method. Even if there are fewer scanned places in the digital impression, only the missing areas can be scanned without making reimpression. Intraoral camera has less effect on the gag reflex than the impression tray. It is easier to store digital impression. The students took digital impression in a shorter time compared to the conventional method.

Chapter three

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