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Digital Impression

A Project Submitted to
The College of Dentistry, University of Baghdad, Department Of Conservative Dentistry in Partial Fulfillment for the Bachelor of Dental Surgery

By
Noor Shaban Ali

Supervised by:
Dr. Abeer Ghalib

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Certification of the Supervisor

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

Dr. Abeer Ghalib
Date

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بسم الله الرحمن الرحيم

اللهُ نُورُ السَّمَاوَاتِ وَالأَرْضِ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ الْمِصْبَاحُ فِي زُجَاجَةٍ الزُّجَاجَةُ
كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِن شَجَرَةٍ مُّبَارَكَةٍ زَيْتُونَةٍ لَّا شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ
لَمْ تَمْسَسْهُ نَارٌ نُّورٌ عَلَى نُورٍ يَهْدِي اللهُ لِنُورِهِ مَن يَشَاءُ وَيَضْرِبُ اللهُ الأَمْثَالَ لِلنَّاسِ وَاللهُ
بِكُلِّ شَيْءٍ عَلِيمٌ

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Introduction

Digital impression technology has revolutionized the field of dentistry, providing significant advantages over traditional impression methods. Digital impressions involve the use of specialized equipment that captures a 3D image of the patient's teeth and surrounding tissues. This eliminates the need for messy and uncomfortable impression materials that have been traditionally used in dentistry.

With digital impressions, the captured images can be viewed instantly on a computer screen, allowing for real-time adjustments to be made to the restoration design. This results in more accurate and precise dental restorations, such as crowns, bridges, and veneers. Orthodontic appliances like clear aligners can also be fabricated using digital impressions.

Digital impressions are a faster and more efficient process than traditional impressions, reducing the overall chair-time for patients. They also allow for the elimination of impression retakes, which can be costly and time-consuming.

Digital impressions are highly accurate and have significantly reduced the risk of errors during the impression process. The captured images can be stored and shared electronically, making them easily accessible to other dental professionals involved in the patient's treatment.

Another benefit of digital impressions is that they are more environmentally friendly than traditional impressions. They reduce waste by eliminating the need for impression materials, which can be difficult to dispose of properly.

Digital impression technology is rapidly advancing and has become an integral part of modern dentistry. It has improved the patient experience, reduced the risk of errors, and improved the efficiency and accuracy of the restoration process. As technology continues to advance, it is likely that digital impressions will become even more widely used in dental practices around the world.

Conventional dental impressions are being rapidly replaced by digital impressions made with intraoral scanners (IOS) as a result of the development of digital technology, and they may be completely replaced within the next ten years. Dentistry uses intraoral scanners (IOS) to record direct optical impressions. They use imaging sensors to take pictures of the prepared tooth surfaces and dental arches as a light source is projected onto them.

In order to provide an efficient and economical work flow, many dental laboratories now digitally design their restorations after scanning casts or impressions.

When selecting an IOS, there are numerous factors to take into account.

What is the cost of purchase? (ranges between $20,000 and $40,000).

• Is the scanner small, light, and easy to use? Would it be comfortable for the patients?

• Does it require powder, display images in color, perform chairside milling, or continue the same workfow to computer-aided design/computer-aided manufacturing (CAD/CAM) lab(s)?

• Are there costs involved for image export and storage, upgrades?

• Are there licensing/usage fees (can reach up to $3500/year)?

• Is the scanner compatible with the practice management software, is it portable, is touch screen, and can it be plugged into USB and laptop?

Aims of the study

The aim of this study is to know the advancement in dental technology and the advantages of digital impression over the conventional impression to know what is the best choices on which case.

Chapter one: Review of literature

History

Digital technology was introduced to dentistry by Dr. Duret in the 1970s. In 1987, Dr. Mormann introduced the concept of computer-aided design/computer-aided manufacturing (CAD/CAM) technology. Currently, two types of digital systems are available:

CAD/CAM systems and three-dimensional (3D) digital impression systems (Table 6.1).

Digital impression systems can be further be divided into either direct digitalization (intraoral scanners) or indirect digitalization (extraoral scanners) depending on

the requirement. Intraoral scanners were introduced as stand-alone devices that capture a digital impression and send the fle to a dental laboratory for prosthesis fabrication. They were originally a part of CAD/CAM systems which produce a digital impression of prepared teeth.

1980s: The first computer-aided design and computer-aided manufacturing (CAD/CAM) systems were developed, which used digital imaging technology to capture 3D images of dental impressions.

1990s: The first intraoral scanners were developed, which allowed for the capture of digital impressions directly from the patient's mouth. These scanners used laser technology to capture the 3D images.

Early 2000s: The first commercially available intraoral scanners were introduced, which used light-based technology to capture the 3D images. These scanners were faster and more accurate than the previous laser-based scanners.

2007: The first intraoral scanner with powder-free scanning technology was introduced, which eliminated the need for the application of powder on the patient's teeth before scanning.

2010: The first digital impression systems that utilized mobile devices and cloud computing were introduced, allowing for the capture and sharing of digital impressions on-the-go.

2013: Intraoral scanners with color-capture technology were introduced, allowing for the capture of highly accurate and detailed images of the patient's teeth and surrounding tissues.

2015: The first intraoral scanners with real-time tracking technology were introduced, allowing for the capture of highly accurate and detailed images of the patient's teeth even during movement.

Present day: Digital impression technology continues to advance rapidly, with the development of newer and

more advanced intraoral scanners, software, and manufacturing processes. Its use is becoming increasingly widespread in dental practices around the world.

3. Generation of digital impression

First Generation (1980s): Computer-aided design and computer-aided manufacturing (CAD/CAM) systems were developed to capture 3D images of dental impressions. Examples include the DENTSPLY CEREC system and the Lava Chairside Oral Scanner.

Second Generation (1990s): The first intraoral scanners were introduced, which used laser technology to capture the 3D images of the patient's teeth and surrounding tissues. Examples include the 3M ESPE Lava COS system and the Sirona CEREC system.

Third Generation (Early 2000s): Intraoral scanners with light-based technology were introduced, which were faster and more accurate than the previous laser-based scanners. Examples include the iTero Element scanner and the 3Shape Trios scanner.

Fourth Generation (Late 2000s): Intraoral scanners with powder-free scanning technology were introduced, which eliminated the need for the application of powder on the patient's teeth before scanning. Examples include the 3M ESPE True Definition scanner and the Carestream CS 3600 scanner.

Fifth Generation (2010s): Intraoral scanners with mobile and cloud computing capabilities were introduced, allowing for the capture and sharing of digital impressions on-the-go. Examples include the 3Shape TRIOS Move scanner and the Medit i500 scanner.

Sixth Generation (Mid-2010s): Intraoral scanners with color-capture technology were introduced, allowing for the capture of highly accurate and detailed images of the patient's teeth and surrounding tissues. Examples include the 3M ESPE True Definition scanner and the Align iTero Element scanner.

Seventh Generation (Late 2010s): Intraoral scanners with real-time tracking technology were introduced, allowing for the capture of highly accurate and detailed images of the patient's teeth even during movement. Examples include the CEREC Omnicam scanner and the Medit i700 scanner.

4. Digital Impression Systems Technologies

Several imaging methods, such as a laser or video, are used by intraoral scanning systems to create their 3D images. Certain imaging systems, like CEREC, rely on the triangulation technique, which involves reflecting a light source off an item. Accuracy when scanning curved surfaces, especially those that reflect light unevenly, such teeth with amalgam fillings, is limited by light triangulation. As a result, some systems require the use of titanium dioxide powder as a contrast medium, whereas others do not, in order to fix the problem of light triangulation.

Several light source technologies are used by current systems, such as laser, structured (striped), or LED illumination.

Systems for transferring digital impression data utilizing IOS can be categorized in a variety of ways. The IOS is referred to as an open system if it enables the direct export of the digital impression via source file formats like STL (Standard Tessellation Language, or "send-to-lab"), PLY (Polygon File Format), and OBJ (Object File Format) to various laboratory units, providing the desired flexibility [5], and a closed system if it does not.

Open platforms give professionals the flexibility to collaborate with many labs and maximize the return on their investment. The STL fle format lacks representation of color or texture but is straightforward and compact, speeding up processing. The OBJ and PLY formats, on the other hand, can store attributes like color and texture and benefit from more advanced 3D printers.

In a closed syste

m, the manufacturing company receives the digital imprints in exchange for a fee. The benefit is that it offers security and a single location for distribution because the same manufacturer is responsible for the data's configuration, collecting, and manipulation. Some scanners merely permit data capture, which is then transported to the lab for additional processing and production. The patient can have a dental restoration in a single appointment thanks to scanners that, in addition to acquisition, have the ability to mill or print the same day.

Several types of scanners may use varying data gathering techniques, image transfer, tracking algorithms, and scanner head sizes, but every scan creates a digital representation of the patient's dentition.

5. The benefits of digital impressions

Digital impressions have the benefit of not requiring any materials for

making an impression, improving patient comfort [6, 7], and causing little to no gagging. Because the positive image of dental preparation is visible on the computer screen, castings are avoided, and modifications are simpler. In addition, the rubber dam may be utilized with digital imprints, can be stored more easily, and, most crucially, can be delivered the same day as digital scanning utilizing CAD/CAM technology. Similar benefits include not requiring temporization or retraction-cord packaging.

Also, it makes it possible for patients and dental technicians to communicate more effectively. Scanners can record the teeth that have been prepped, the nearby teeth, and even the entire arch. It is also possible to perform opposing arch scans and simulate movements using a virtual articulator [8].

6. Negative Aspects of Digital Impression

There is a learning curve with any fresh technology, and inexperienced users could need more time to shoot the digital pictures. Additional drawbacks of IOS include its high initial investment cost and inability to detect subgingivally prepared edges of teeth.

7. Digital Impressions and iOS Clinical Indications and Contraindications

In prosthodontics, single tooth crowns, endodontic crowns, resin onlays and inlays, veneers, fxed partial dentures, detachable partial denture frameworks, implant bridge post and cores, temporary restorations, and digital smile design can all be designed and milled using digital impressions. Long-span fixed partial dentures, long-span fixed partial dentures supported by implants, and full removable dentures are contraindicated.

They can be utilized in orthodontics for diagnosis, treatment planning, the creation of retainers, bespoke devices, and orthodontic aligners. Moreover, they can be utilized in guided implant surgery.

General contraindications include the patient's inability to remain still and limited access to the area, such as when the intraoral scanner's head is too large or there are tongue or orthodontic appliance interferences [9]. Before scanning, bleeding must be under control in order to get a good image.

8. Accuracy of Intraoral Scanners

Currently, a variety of IOSs are used by dentists (Figs. 6.1 and 6.2), which has led researchers to start examining the literature on the usage of these devices [10]. The crucial question is if the computerized dental models that were developed are accurate.

is comparable to that of dental plaster models when derived from an IOS [11]. The device's accuracy includes "trueness" (the degree of agreement between the experimental dataset and the real object) and "precision" (the degree of agreement between various scans made by the same scanner). (Table 6.2). Studies looking at the accuracy of scans have an essential constraint in that they are conducted in vitro, as it has been noted that intraoral circumstances can affect their accuracy [9].

Figure 1: Intraoral scanning in process (Courtesy Dr. Tariq Saadi)

The scanning of a dentate arch by laboratory and IOS ranged between 17 and 378 m, according to a comprehensive study [13] looking at the mean accuracy of digital technologies, including intraoral tissues. The minimum accuracy for prepared teeth was 23 m, but when the entire arch was scanned, it was 60 m.

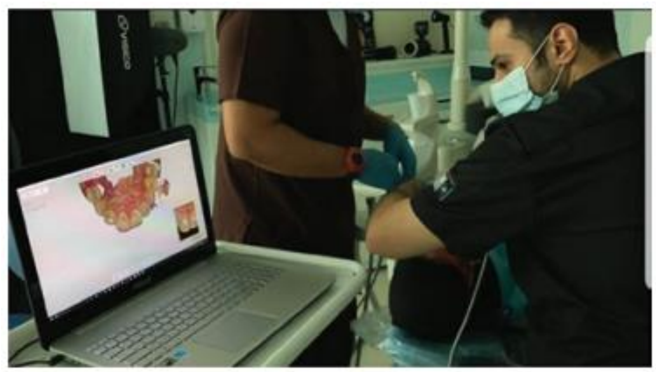

Figure 2 Viewing of scanned image (Courtesy of Dr. Tariq Saadi)

Digital implant scanning had an accuracy of 19–112 m, while scanning of single tooth preparations indicated a range of 20–40 m. For entirely edentulous arches alone, accuracy ranged from 44 to 591 m, while it ranged from 30 to 220 m for partially and completely edentulous arches. The review's authors came to the conclusion that while specific digital technologies are accurate today, scanning edentulous arches is still difficult [13]. Similar comments from other researchers suggested that this was caused by the tissues' movement and the absence of landmarks to serve as a reference in edentulous arches [14]. Generally, the various IOS systems produce a range of results [15].

9 A Comparison of Intraoral and Extraoral Scanner Accuracy

Many studies have demonstrated that intraoral scanners (IOS) are more accurate than extraoral scanners (EOS) [9, 16–18]. It has been suggested that saliva and close spacing within the mouth may worsen scan errors. It's crucial to remember that in addition to errors produced during digitization, EOS can also encounter errors during the processes of impression taking, gypsum modeling, or SLA polyurethane model-making [19]. This is because constructing a repair involves many processes.

10. Often Used Commercial Intraoral Scanning Systems (Table 6.3)

The following intraoral scanners are listed without any sort of ranking.

10.1 CEREC (invented in 1980 by Dr. Werner Mörmann and Dr. Marco Brandestini at the University of Zurich in Switzerland.)

By introducing the CEREC 1 unit (Sirona Dental Systems GmbH, Bensheim, Germany) in 1983, Prof. Mörmann invented the idea of in-office CAD/CAM [20].

`Early in 2000, the CEREC 3 Redcam scanner, which employed infrared light to scan objects and required an even layer of opaque powder to take a 3D

Figure 3 Different CEREC systems (Courtesy "Dentsply Sirona")

image of the preparation, the antagonist, as well as functional registration, increased software capabilities from 2D to 3D imaging.

In 2009, Bluecam—which uses blue light with a shorter wavelength and requires only a tiny covering of powder—became commercially accessible. The camera was held in front of the tooth in its newest mode, which automatically recorded images and resulted in significantly quicker image acquisition. Bluecam created a 3D model by combining multiple separate pictures.

The first Sirona CAD system without powder, Omnicam was released in 2012. Unlike Bluecam, Omnicam uses continuous picture capture to create a 3D model, enabling colorful full-arch and half-arch scans.

The most latest CEREC IOS is Primescan. Its many benefits include its ability to scan up to a depth of 20 mm, touchscreen, powder-free, ability to scan refective surfaces, ability to scan color photo-realistically, giving shade detection, preventing fogging, speed (performs a full arch scan of upper and lower jaw, bite registration, and model calculation in about 50-180 s), ability to be cleaned with wipes and autoclavable, ability to be dried heat sterilized, and availability of single-use sleeves and mirror Design features are also included in Primescan software. The comparisons between the various CEREC systems available are shown in Figure 6.3.

10.2 Midmark Mobile True Definition Scanner. (introduced in 2018)

The Midmark Mobile True Defnition Scanner, a portable intraoral scanner that runs on a tablet, was acquired by Midmark in 2019 and was formerly known as the 3 MTM True Defnition Scanner (Fig. 6.4).

Instead of a laser, it employs video scanning technology, but it still needs a thin layer of scanning spray to capture the image. It produces STL fles and is an open system, thus feld calibrations are not necessary. Before needing to recharge, two complete arch scans or four quadrant scans can be completed. The console as a whole weights 2.75 kg, and the wand and cord together weigh 253 g. Wand measures 254 mm in length and 16.2 mm in width.

Acquisition Procedure Trinocular is a stereo-exclusive 3D in motion reconstruction technique with a 20 image triplets per second capture rate. For the following, its typical upload and processing times are: (a) Quadrant: 2-min acquisition (upper/lower/ buccal bite) 30 minutes (assuming 10 Mbps observed upload performance from off-site Wi-Fi); (b) Whole arch: 6-min acquisition (upper/lower/3 bite scans) 90 minutes (presuming 10 Mbps measured upload performance from offce Wi-Fi).

Crowns, bridges, inlays, onlays, veneers, partials, clear aligners, mouth guards, orthodontic products, and models may all be made with the Midmark Mobile True Defnition Scanner.

10.3 Trios®4 Scanner (introduced in 2019)

This IOS (3shape, Copenhagen, Denmark) has a touch screen, creates DCM and STL files, makes colored images without the need of powder, and has an open format (Fig. 6.5). It weighs 375 g if the battery is included and 345 g if it is wired. Its dimensions are 42 mm 274 mm. It has an LED light source, a specific tip for interproximal caries diagnosis utilizing infrared scanning, which is still under development, and smart tips with quick heat technology. Each of the three rechargeable batteries included with the Trios®4 wireless allows for 45 minutes of continuous scanning. Depending on battery level, it takes about 2-4 hours to fully recharge, and its wireless range is up to 5 meters.

Figure 4 Midmark MobileTrue Defnition Scanner (Courtesy "Midmark"

Figure 5 (a) Trios 4 scanner (Courtesy "3Shape"). (b) Normal imaging/capturing digital impression. (c) Caries detection functionality via built-in fuorescence technology. (d) Full arch scan, TRIOS Move Plus scanner (Courtesy Dr. Ahmad, Institute of Digital Dentistry, NZ)

A variety of frameworks and restorations, including crowns, bridges, inlays, onlays, veneers, implants, three-unit implant bridges, posts, and cores, can be designed using the 3Shape CAD program.

The most recent iteration of 3Shape's ergonomic cart, Trios Move+, has a 15.6-inch full HD touch screen that is even bigger, a 36% larger work surface than the previous models, and a USB 2.0 port at the rear of the screen for the import and export of scans (Fig. 6.6)

Figure 6: Trios Move + (Courtesy "3Shape")

10.4 iTero Element 5D (introduced in 2018 by Align Technology,)

It is available as a laptop configuration or a wheeled stand (Figs. 6.7 and 6.8). Together with white or 850 nm LED emissions, the wand also generates red laser light (680 nm Class 1).

Figure 7: iTero Element 5D (Adapted from iTero.com)

The wand measures 346 mm in length, 50 mm in width, and 68 mm in depth. It weighs 470 g. (without cable). Using iTero time-lapse technology, it concurrently records 3D, intraoral color, and near-infrared images and allows comparison over time.

Figure 8: iTero element 5D scanner in use (Courtesy Dr. Ahmad, Institute of Digital Dentistry, NZ)

Being an open system, iTero is compatible with software that accepts STL images and includes an interactive user interface. You must pay a subscription fee to utilize it. In restoration procedures involving crowns, FPDs, veneers, implants, aligners, and retainers, it is helpful.

10.5 Planmeca PlanScan® (introduced in 2015)

Planscan can be connected to a PC or integrated into a Planmeca dental device. There are color and grayscale scanning choices for the scans of the lower and upper arches in occlusion, which can be exported as open STL and PLY files. The four accessible scanning options are grayscale standard, landscape, portrait, and color.

Figure 9: PlanScan® Scanner (Courtesy Planmeca)

They can be autoclaved, feature anti-fogging technology, and offer either a frewire 800 or thunderbolt cable interface (via adapter). Blue laser serves as its light source, and projected pattern triangulation serves as its scanning method. Its measurements are 48 x 53 x 276 mm, and its weight is 544 g (scanner with tip). In Fig. 6.9, the scanner is seen.

10.6 EmeraldTM (introduced in 2017 by Dentsply Sirona,)

This IOS can be integrated into a Planmeca dental device or connected to a PC, just like the aforementioned scanners (Fig. 6.10). Lower and upper arches in occlusion are scanned, and the results are produced as open STL and PLY files. It scans in real color and has standard and slimline autoclavable scanning tips. The autoclavable "cariosity tip" uses projected pattern triangulation as its scanning method, has antifogging technology, and uses red, green, and blue lasers as its light source to detect caries. Its measurements are 41 x 45 x 249 mm and its weight is 235 g (scanner with tip).

Figure 10: Emerald™ Scanner (Courtesy Planmeca)

The cable interface is USB A type connection on the laptop

and USB C type connection on the scanner. All cables are designed to transmit data

via USB 3.0.

Indications: Inlays/onlays, veneers, crowns, bridges, full arches, scan bodies, models, and impressions.

10.7 EmeraldTM S

A skilled user may scan a full arch with this improved version of EmeraldTM in much under a minute (Fig. 6.11). It has every attribute of the EmeraldTM.

There are several indications, including inlays/onlays, veneers, crowns, bridges, entire arches, scan bodies, models, and impressions. Planmeca intraoral scanners assist the various workfows of a number of disciplines, including prosthodontics, orthodontics, and implantology, and feature built-in design functions.

Figure 11: Emerald™ S Scanner (Courtesy Planmeca)

10.7.1 Carestream Health, Rochester, New York, Carestream CS 3700® (ntroduced in 2019 by Carestream Health,)

After Carestream 3500, this is the most recent IOS for Carestream Dentistry (Fig. 6.12). It has a weight of 316 g (without the cable and power box), can record full color HD 3D images, and employs amber, blue, and green LEDs for light. It has a high-speed USB 2.0 connection to the computer, and it acquires data using active triangulation and bidirectional reflectance distribution function technology with smart shade matching. It scans in true color in both 2D and 3D images as well as multilayer shade information without the need for contrast media, has a scan speed of 30 seconds for single-arch scans (according to in vitro testing), and 10

Figure 12: (a) Carestream CS 3700® automatically detects the enamel color of the scan area to help identify the correct position for restorative outcomes (Adapted from Carestream Dental LLC). (b) Intraoral imaging of Carestream CS 3700®

frames per second (fps) with fields of vision. 13 X 13 mm, 13 × 7 mm (posterior tip) (posterior tip)

The scanner comes with built-in design tools. Crowns, inlays, onlays, bridges, dentures, sleep apnea devices, orthodontic appliances, surgical guides, and implant-supported restorations are examples of indications.

10.7.2 Medit i500 (introduced in 2018 by Medit,)

One of the more recent IOS versions is this one. These are open systems for integrated CAD/CAM work, powderless, and competitively priced (Fig. 6.13). The tip measures 18 mm by 152 mm and has a single button for operation. The whole length of the handpiece is 266 mm, and it weighs 276 g. Its imaging technique is 3D motion video technology with full color streaming capture, and it has a high resolution. With two high-speed cameras and a clever scan-detecting algorithm, it has good accuracy for single crown [21] and supports USB 3.0 data transmission.

Figure 13: Medit i500 scanner (Courtesy Dr. Ahmad, Institute of Digital Dentistry, NZ)

10.7.3 Virtuo Vivo (Dental Wings)

These IOS have removable, autoclavable sleeves, a pen grip handle, and an ergonomic design (Fig. 6.14). The wand barely weights 213 g, making it lightweight. It makes use of motion control technology, including gesture and voice controls, to enable touch-free screen manipulation. A touchscreen is also included. The hand piece includes an incorporated air mouse feature. It makes advantage of multiscan imaging, which simultaneously takes data from numerous angles. It contains two 3D scanners' worth of power in one wand, real-world color, a light on the wand, and an auditory indication that confirms the data. It has subscription fees and built-in design features..Fig. 6.15 shows images captured with different IOS

Figure 14: Virtuo vivo scanner (Reproduced with permission from Dental wings)

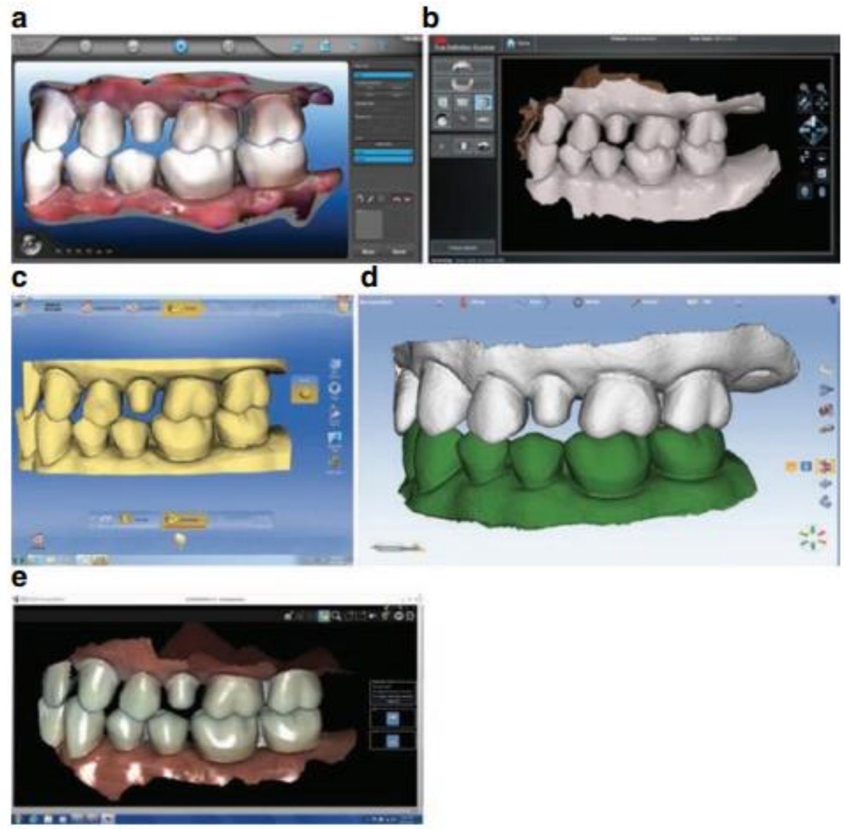

Figure 15: Captured screenshots of a partial arch digital impression done with the iTero (a), the 3 M True Defnition Scanner (b), the CEREC AC with Bluecam (c), the PlanScan (d), and the CareStream CS 3500 (e). (Reproduced with permission from John Wiley and Sons)

Table1. comparison between intraoral scanner generations

Scanner	Technology	System	Contrast medium required (powder)	User interface	Weight (approx.) Wand tip (approx.)
CEREC Bluecam	Visible blue light	Closed	Yes	Simple and intuitive, compact tool bars, menus, use of mouse	280 g 22 mm × 17 mm
CEREC Omnicam	Continuous 3D color capture	Closed	No	Simple and intuitive, compact tool bars, menus, use of mouse	15 mm × 15 mm
CEREC Primescan	Blue laser	Open	No	Touch-enabled and intuitive user interface	10 mm × 11 mm
3 M true definition	Video scanning	Open	Yes (light)	Touch screen tablet	200 g 14.4 mm × 16.2 mm
3Shape Trios	Confocal microscopy	Open	No	Touch screen	1 kg
Align iTero element	Parallel confocal laser scanning	Open	No	Interactive	470 g 50 mm × 68 mm
Planmeca PlanScan	Blue laser projected pattern triangulation	PlanScan and other open systems	No	Cable interface, icons, mouse	544 g 48 mm × 53 mm
Emerald TM	Blue laser projected pattern triangulation	Open	No	Cable interface	235 g 41 mm × 45 mm
Carestream	LED of amber, blue, and green with active triangulation	Carestream solutions and other open systems	No	Cable interface	316 g 13 mm × 13 mm
Medit i500	Continuous video capture	Open	No	Cable interface	276 g 18 mm × 152 mm
Dental wings Virtuo vivo	Multiscan imaging	Open	No	Touch screen Integrated voice and gesture control	213 g

11. Evaluation of Traditional vs. Digital Impressions

The majority of the studies in their systematic review and meta-analysis were study found that using digital impression techniques rather than traditional impression procedures improved the marginal and internal ft of fxed restorations [1].

Also, they came to the conclusion that digital die-produced restorations had less internal and marginal disagreement than polyurethane stereolithography apparatus (SLA) dies.

Recently, employing current technology, reduced variance for short span repairs was seen.

IOS provides lower deviations than conventional impressions when it comes to long-span restorations, however this is not true for all cases [2, 3]. As a result, a recent systematic study looking into the accuracy of digital impressions in fxed prosthodontics came to the conclusion that traditional impressions made with high-precision impression materials demonstrated superior accuracy than digital impressions [4].

Table 2: comparison between digital impression and conventional impression:

Digital impressions	CAD-CAM (Chairside)
A scanner wand is used intraorally to record a digital image of the preparation	Chairside CAD/CAM systems include both a scanner and a mill for fabricating a restoration. With these systems, clinicians can scan, design, and mill a full-contour restoration in-office
These can be reviewed instantly, and changes made. Practitioner can even re-scan the image if needed	This system offers methods and tools to modify the restoration, such as adjusting contacts, height, color, and occlusion
The data file is electronically transmitted to the dental laboratory or the manufacturing company (open or closed system) along with a prescription	As opposed to electronically sending the data to the laboratory, *computer-aided design (CAD)* can be done and completed chairside. The file is sent to an in-office milling machine, for *computer-aided manufacturing (CAM)* for the final prosthesis. The finished restoration can be cemented during the same appointment
Significantly lower cost than CAD CAM system	Higher economics than a scanner alone, and require training for the entire staff
Any type of restoration can be created using a digital impression, from all ceramic crowns to gold inlays	Final prosthesis is milled from a ceramic or composite block

CLINICAL REPORT

A 43-year-old healthy man was referred for a restorative consultation. His chief complaint was large clinical diastemas between his maxillary anterior teeth, 7-10 (Figure 16).

Figure 16: .Pretreatment frontal view of maxillary anterior teeth.

Also, the patient was not satisfied with the color and shape of his natural teeth. A comprehensive oral examination and a full-mouth radiographic series were completed. It was determined the patient had a low caries risk with no active dental caries or signs of periodontal disease. Medical history was reviewed and revealed no contraindication for elective dental treatment. Treatment plan options were discussed with the patient to include vital whitening therapy followed by either direct resin-composite bonding or laminate ceramic veneers. After careful consideration by the patient, vital whitening therapy followed by laminate ceramic veneers was selected as the treatment of choice. Minor soft tissue crown lengthening was recommended to the patient before veneer preparations to correct slight tissue asymmetry. The patient declined surgical intervention because he has a low smile line that would not affect the social or esthetic outcomes of his treatment. Vital whitening provides the operator with the opportunity to use a translucent glass ceramic, allowing the stump shade to control the final color. Porcelain laminate veneers are considered a conservative treatment with predictable clinical results.10,13 Initial diagnostic impressions were taken for treatment planning using irreversible hydrocolloid impression material (Jeltrate Fast Set, Dentsply Caulk, Milford, DE, USA) and poured with type III dental stone (Buff Stone, Whip Mix Corp, Louisville, KY, USA). Casts were articulated on a semi adjustable articulator (Model 2240, Whip Mix Corp) with a face-bow transfer (Model 8645, Whip Mix Corp). A diagnostic wax-up was completed by the laboratory for patient presentation of proposed shape and contour of final laminate ceramic veneers and provisional stent fabrication (Figure 17).

Figure 17: Diagnostic wax-up of maxillary anterior teeth mounted in semiadjustable articulator.

Teeth whitening treatment started with an athome whitening kit using 15% carbamide peroxide (Opalescence PF 15%, Ultradent Corp, South Jordan, UT, USA) overnight daily for six weeks. The patient's initial tooth shade was Vita A3.5. Preparations were started for laminate ceramic veneers after achieving an acceptable shade (Vita A1) and waiting 14 days post whitening for oxygen free-radical dissipation and possible color regression (Figure 18).

Figure 18: Frontal view of maxillary anterior teeth after preparation for ceramic veneers.

The maxillary anterior teeth were prepared with a butt-joint margin on the lingual surfaces, 1.5-mm reduction of the incisal edges and 0.3-mm (gingival) to 0.8-mm (incisal) reduction on facial surfaces using a round-ended diamond cutting instrument (Brasseler USA, Savannah, GA, USA) and a reduction guide (Figure 18). Soft tissue management and marginal exposure was performed using a single-cord technique (#0 Ultrapak, Ultradent Inc) . A CAD digital impression of the prepared maxillary teeth and a CAD digital scan of the opposing mandibular teeth were taken following application of the spray contrast medium (Lava COS, 3M ESPE, St Paul, MN, USA). A closedjaw record was then taken with the same intraoral digital scanner using the spray contrast media (Figure 19). The CAD software (Lava COS, 3M ESPE) overlapped the digital information obtained from the previously acquired maxillary and mandibular scans with the closed-bite scan to form a virtual bite registration and articulation. The completed CAD data were sent electronically to the scan center at a local commercial dental laboratory to mark the laminate veneer margins and perform a virtual ditching process for marginal design and fabrication (Figure 20). Provisional veneers were virtually designed (Figure 21) using CAD/CAM design software (Dental Wings Inc, Montreal, QC, Canada). The provisional veneers were designed to be splinted for better retention and subsequently milled from polymethyl-methacrylate (PMMA) Vita A1 blocks within a custom milling center (Figure 22a,b). The provisional veneers were tried intraorally for marginal integrity, functionality, occlusion, esthetics, and patient satisfaction. They were temporarily cemented using an acid-etch point technique (midfacial) and bonded with flowable resin composite (Vita A1). Excess composite was removed and polymerized with a VALO Broadband LED Curing Light (Ultradent Corp) on standard setting. The occlusion was checked and adjusted. The provisional veneers were reevaluated after a few weeks following the patient's evaluation of form, function, and esthetics. The patient requested modifications that were performed and communicated to the dental laboratory.

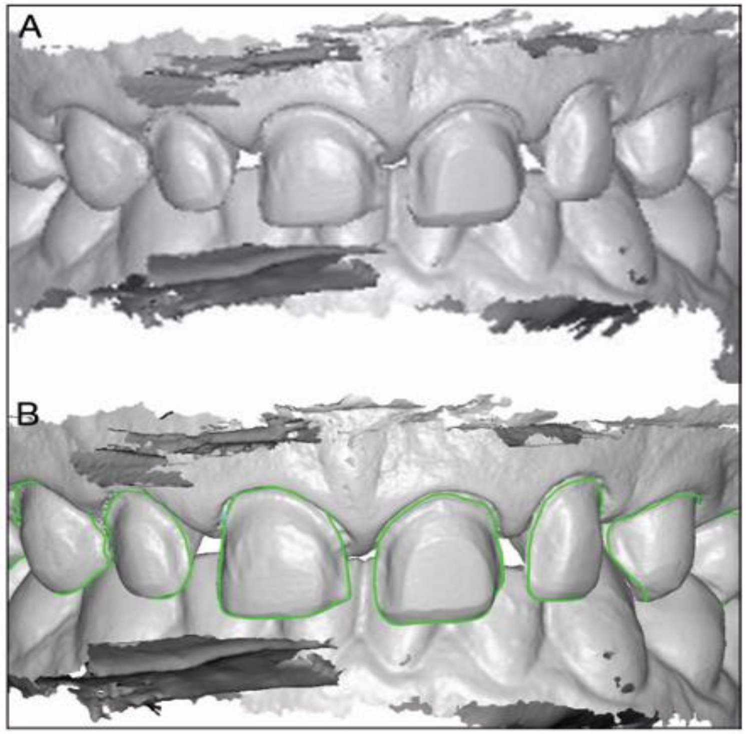

Figure 19: (a):Digital impression and(b):marked finishing margins.

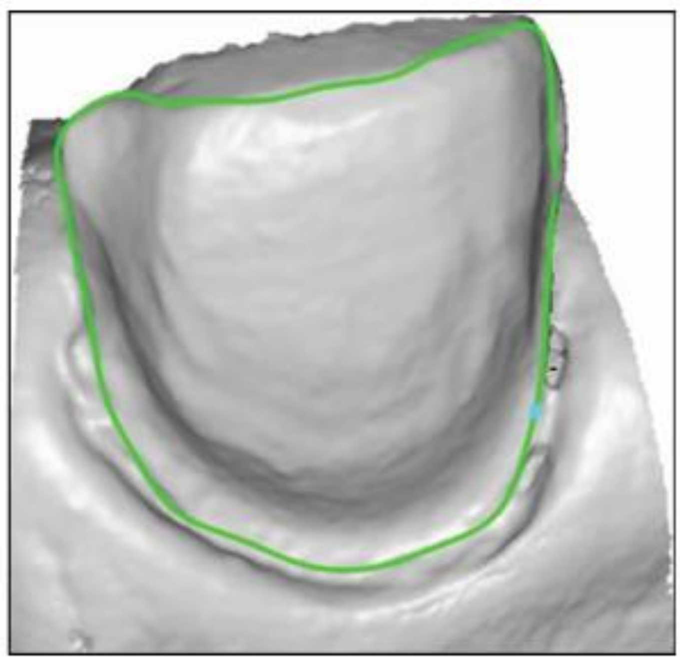
Figure 20: .Margin selection and die trim.

The definitive laminate veneer designs were modified and milled from low translucency IPS e.max (Vita A1) milling blocks (Ivoclar-Vivadent, Amherst, NY, USA) at a remote milling center. At the insertion appointment, marginal adaptation, restoration fit, interproximal contacts, and occlusion were verified individually and collectively using a translucent try-in paste (RelyX Veneer Kit, 3M ESPE).

Figure 22: Virtual design of connected provisional veneers before milling.

Minor adjustments to the interproximal contacts were made using a fine diamond bur (Brasseler USA) and were polished using a chairside ceramic polishing kit (Brasseler USA). After final approval by the patient, all internal bonding surfaces of the laminate veneers were etched with 10% hydrofluoric acid for 25 seconds and silanated (Ceramic Silane, 3M ESPE). The laminate veneers were cemented one at a time using a translucent light-cure resin cement (RelyX Veneer, 3M ESPE) following manufacturer recommendations. All excess cement was removed from margins and cured using a VALO Broadband LED Curing Light

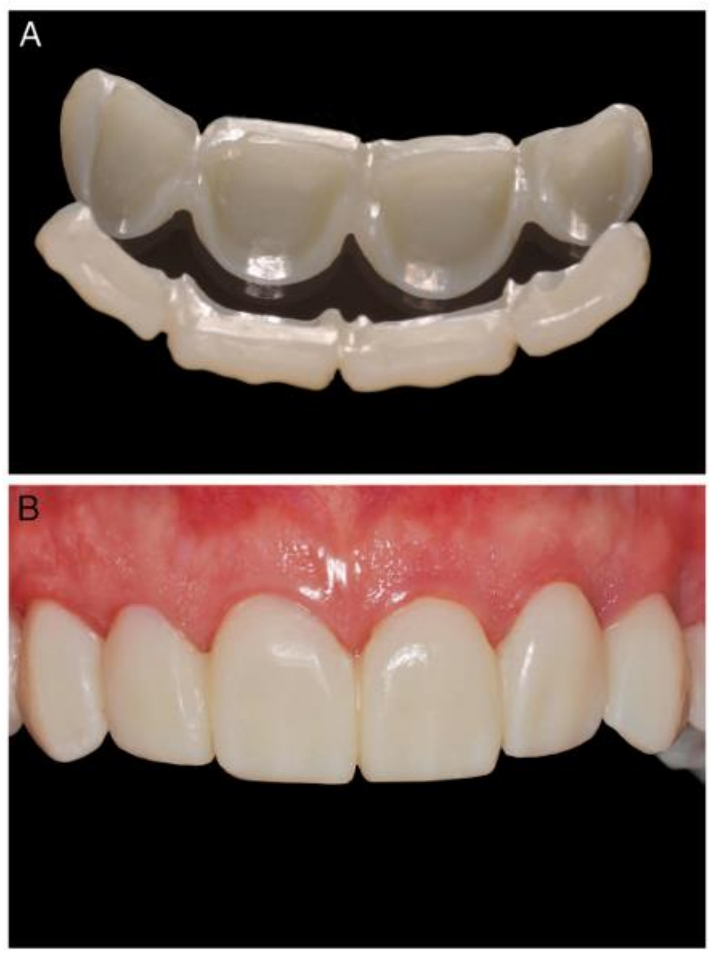

Figure 21: (a):provisional PMMA veneers and(b):PMMA veneers cemented as along-term provisional.

(Ultradent Corp) on standard setting. The final delivered veneers can be seen in Figure 23.

Figure 23: After cementation of lithium disilicate ceramic veneers.

Upon completion of the bonding process, an irreversible hydrocolloid impression (Jeltrate Fast Set, Dentsply Caulk) was taken of the maxillary arch and poured with type III dental stone (Buff Stone, Whip Mix Corp). The stone model was used to fabricate a vacuum-formed, clear bite guard (SofTray Classic Sheets, 0.08 inches, Ultradent Corp) for nocturnal use by the patient. The patient was instructed on home care and hygiene and was placed on a recall system at six-month intervals. A one-year follow-up was completed.

Chapter two: Discussion

Summary of Evidence It was possible to conduct an analysis of the treated topic, once the individual reviewer results and the conclusions of the investigated articles were extrapolated. In this section, evaluating the synthesis of the individual articles conclusions, benefits or disservices of each methodic can be summarized as follows. Recently, Cave and Keys performed a systemic review about the working time of the two impressions technique. They concluded that the digital impression technique in reducing anxiety and nausea could be considered more comfortable for the patients than a conventional impression technique.

However, the topic is still highly debated in the recent literature and Chandran et al. explained how the digital impressions are superior to a conventional one, without any statistically significant differences, based on assessment of accuracy, patient preference and operator preference. Iin a RCT, Zitzmann et al.

Analyzed both digital and conventional using difficulty on different impression techniques. No experienced dental student found a digital tool easier than conventional impression techniques. According to Zeltner et al., no significant differences were found between conventional or digital workflow in prosthodontic. Authors showed how a conventional workflow can facilitate the better manufacture of occlusal regions. Moreover, centralized milling production provided better results than chairside milling. Sailer et al. in their RCT showed how digital techniques could improve chair time and how participants prefer no powder-need digital techniques for digital scans. Cappare et al. evaluated how digital workflows provide accuracy and predictability. It is a reliable alternative for full arch rehabilitations with a marginal fit precision. Sakornwimon et al. found that conventional and digital techniques present no differences on crowns marginal gap but patients' satisfaction is higher with the "digital way". Joda et al. demonstrated, on a dentist and dental students' group, how digital scanning is more efficient than conventional techniques for single implant or single quadrant impression.

Also, they demonstrated a high level of acceptance by operators. Joda et Bragger showed how, based on their findings, that patients preferred digital technique, particularly because of their efficiency in terms of time. Gjelvold et al. concluded that the digital technique was more efficient and convenient than an analogical, conventional one. According to Gherlone et al, it is possible to realize full-arch rehabilitation, with a satisfactory accuracy way, using digital instruments. Benic et al. Demonstrated how a conventional impression technique was more time-effective than digital, and no statistical differences were found with respect to patient discomfort. Boeddinghaus et al. [28] concluded that the digital intraoral impression could be considered a valid alternative to conventional one. Yilmax in his research documented the "time" perception of the patients. The digital advent in the field of dental impression technique reduces the number of appointments and allows the formation of a soft tissue emergence profile, similar to that of the definitive crown. Adifferent point of view is underlined by Runkel et al. In a paper published in 2019 authors underlined that despite the rapid advancement of the computer-aided technology for dental therapy purposes, the implementation of this technique is not as fast as its technical development. Yuzbasioglu et al. demonstrated how digital methods for impressions in dentistry could be more time-efficient and preferred by patients. Some studies, therefore, consider the digital impression as optimal with regard to the economy of the time and there fore financial of the medical office. However, some studies, are inconsistent in this topic and, as can be seen, it is not a significant parameter.

Some studies in the literature report the problem of impression infection management, and the management of the latter over time, in the dental laboratory, the impression material stability during time [17], or material working phase and mixing issues. This is an issue that does not exist in the case of optical impressions. As far as quality is concerned, the latter did not show statistically significant parameters. [18,19,20, 21]

Digital equipment is starting to be used in the medical field, and above all in the dental field, it is now possible to have a completely digital workflow.[22,23,24,25]

Ortensi et al. recently demonstrated how the application of new materials and digital techniques must guarantee a predictability of the final goal from the beginning to the end of treatment. The possibility of showing the patients the planning treatment as well as the avoiding analogue impression technique is highly appreciated by the patients.[26] (Fig. 24 , Fig. 25)

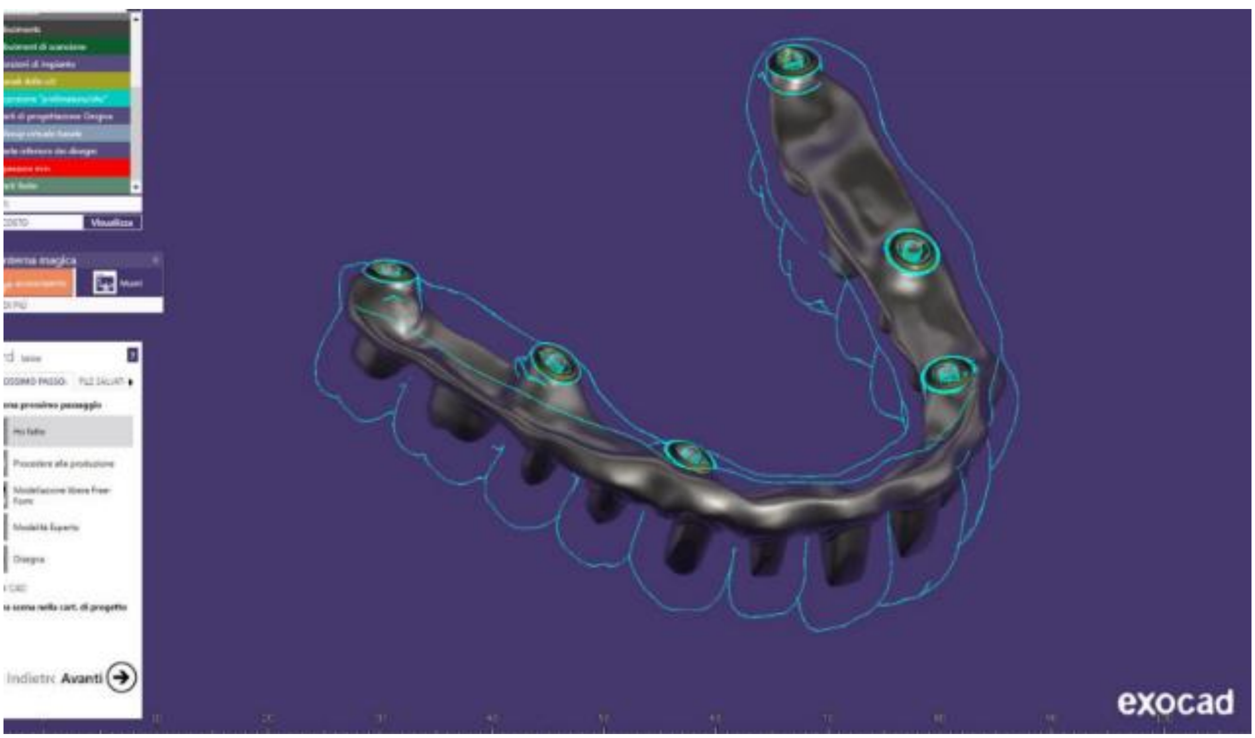

Figure 24: Sample of computers planning and realization of prosthodontics structure before starting the treatment over patients

A, digital diagnosis, and therapeutic programming, with a digital plane preview, should be the future for clinicians and prosthodontics practitioners. The traditional

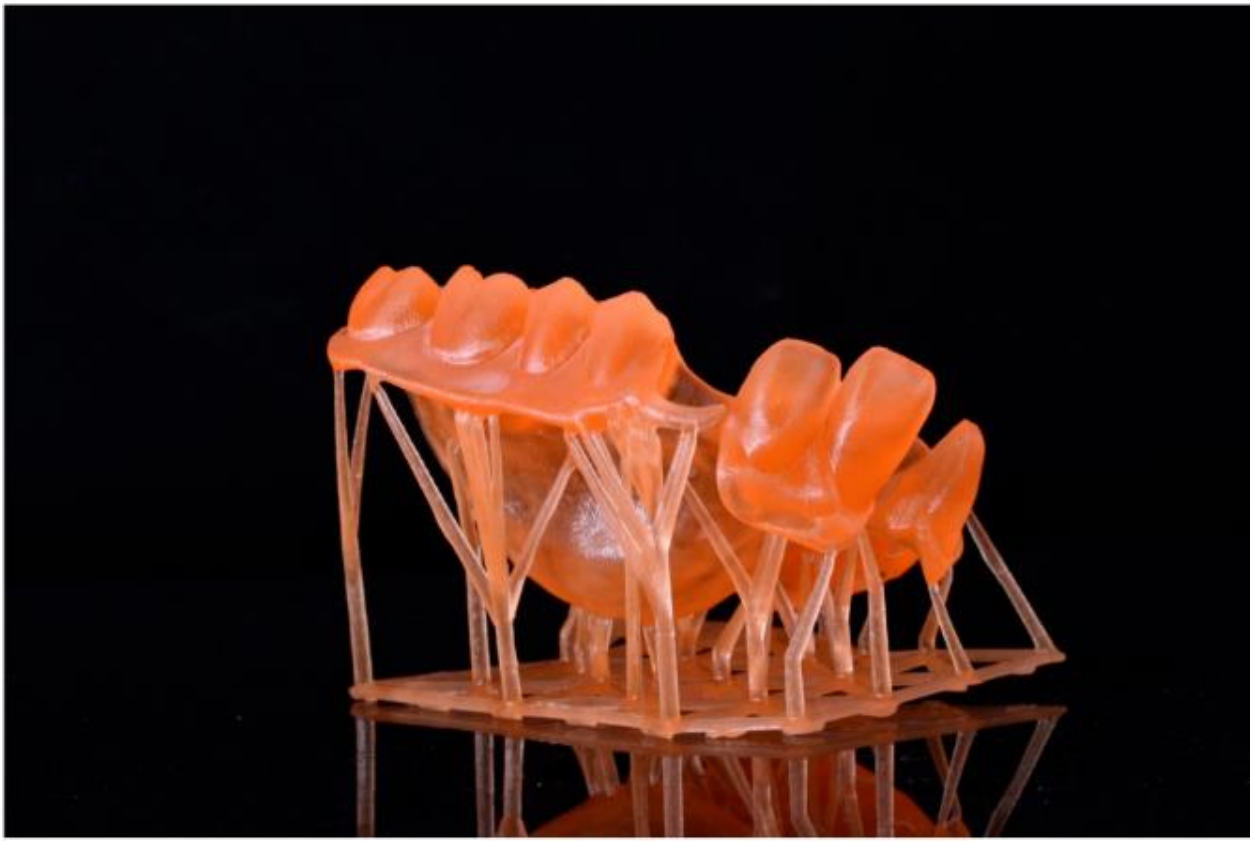

Figure 25: Sample of new devices like 3D printing for having dental threedimensional model.

Impression technique is based on a copy of the oral situation, with acquisition materials and subsequent casting in plaster. Instead, the plaster, used later, will show a dimensional expansion. It should be noted that the impression procedure is at the origin of the manufacture of the product, and therefore, potential errors introduced in this phase will affect the rest of the work. In the case of implant prostheses, a failure to adapt the scaffolding will generate stress on the implants, which will affect the bone interface, causing failure in some cases. Prosthetic complications, such as loosening of the screw or its fracture, could also be related to inadequate insertion of the prosthesis. However, no technique has proved to be effective. Impressions on implants have shown good accuracy. With an impression system, the data through the intraoral scanner could be transmitted through files to the laboratory for the manufacture of a definitive prosthesis. It is also known that implants, in response to bone compression, show only a range of motion of 3–5 µm in the axial direction and 10–50 µm in the horizontal direction.

An intraoral scanner could overcome some errors associated with taking the traditional impression and in production, such as the fact that it communicates with the laboratory directly through a virtual world avoiding errors in preserving the impression. In the literature, there are reports regarding the digital impression technique on dental implants, but most deal with fabrications of customized anatomical abutments and zirconia prostheses. All definitive prostheses, with the different cemented, screwed methods, require accuracy in the bar-implant connection. The scanner copies the implant fixture exactly in the mouth like traditional impressions. Once the image is captured and registered by an intraoral scanner, the CAD software through algorithms could precisely position the implant in the virtual model. In addition, the new technological developments of the optical impression provide the digital creation of a model through analogues, as the traditional laboratory technique requires. Registration errors, however minimal, occur during the acquisition procedures, arising from the length of the arch. When comparing intraoral scanners in whole arch acquisition procedures, the acquisition width should be considered to consider the errors that can be encountered. Once the scan has taken place and the data has been acquired, the software processes every single data to create a virtual 3D model, then the CAD builds the resin model from the collected data.

Chapter three: Conclusion

According to the obtained results in this systematic review, it is certainly possible to say that digital techniques represent a valid alternative in the field of dentistry. The optical impression system compared to the analogue one with the impression materials has a comparable result. Moreover, it is necessary to remember how dentists appeared more distrustful in difficulty, compared with dentistry students. Furthermore, patients have a better perception of the use of digital rather than conventional impressions. The total work time for the impression taking would appear to be lower with digital techniques, but despite this, the data is still not significant. The authors recommend the use of intraoral scanners, which from the formation of a virtual image creates an accurate physical model that gives efficiency to the dental structure and makes the work lighter. This improved way of working should benefit the dentist, the laboratory and the patient.

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