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# COMPARISON OF THE ACCURACY AND TIME EFFICIENCY BETWEEN CONVENTIONAL AND TWO DIGITAL SYSTEMS IMPRESSIONS OF SINGLE TOOTH IMPLANT

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# III. Abbreviations and Symbols

**3D:** Three-Dimensional

**ANOVA:** Analysis of variance

**ASTM:** American Society for Testing and Materials.

**CAD:** Computer-aided design.

**CAM:** Computer aided manufacturing.

**CEREC:** Chairside Economical Restoration of Esthetic Ceramics or CEramic REConstruction.

**Lava C.O.S:** Lava Chairside Oral Scanner.

**LSD** : least significant difference

**P:** probability value

**SD:** Standard deviation

**Sig:** significance

**SLA:** Stereolithographic.

**SPSS:** Statistical Package for the Social Sciences

**STL: ST**ereo-**L**ithography or Standard Triangle Language or Standard Tessellation Language.

**µm:** micron

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# 1. ÖZET

Muhammed ALIBRAHIM, Dr. Öğr Üyesi. Umut ASLAN, Protetik Diş Tedavisi Anabilim Dalı

**Tek diş implantlarda konvansiyonel ve iki farklı ölçü sisteminin ölçü netliğinin ve çalışma zamanının karşılaştırılması**

**Amaç**: Son yıllarda, aşırı harap olmuş dişlerin restorasyonu için kullanılan teknikler ve materyaller oldukça gelişmiştir. Bilgisayar destekli dizayn ve bilgisayar destekli üretim (CAD/CAM) teknikleri tüm bu gelişmelere paralel olarak diş hekimliği alanında dönüşüme uğramaktadır. Bu çalışmanın amacı iki farklı ağız içi dijital tarayıcının netliğini ve çalışma zamanını karşılaştırmaktır.

**Materyal ve Metod**: Her birine tek diş kemik seviyesinde Straumann implant uygulanmış 10 hastadan polivinil siloksan (PSV) ile 1 adet konvansiyonel ölçü ve 3'er adet CEREC OC (Sirona Dental Systems, Sirona, Bensheim, Almanya) ve Straumann CARES IOS (Intra oral Scanner, Basel, İsviçre) digital ölçü alındı. Ölçüler için gerekli süre bu evrede hesaplandı. Her metod için gerekli sürelerin ortalama değerleri hesaplandıktan sonra zaman efektifliği değerlendirmesi yapıldı. Konvansiyonel ölçüler üzerinden elde edilen modeller dijital olarak taranarak hassaslık ve doğruluk değerlendirmeleri için referans model olarak kullanıldı. Ölçü dosyaları süperimpose özelliği olan STL dosya tipine çevrildi. (Geomagic Control; Geomagic, Morrisville, USA). Ölçülerin değerlendirilmesi referans modeller ile dijital sistem modeller arasındaki sapmalar karşılaştırıldı.

**Bulgular:** İki system arasında hassaslık ve doğruluk açısından istatistiksel olarak anlamlı bir fark bulunamamıştır ($P>0,05$), fakat çalışma zamanı açısından istatistiksel olarak anlamlı bir fark saptanmıştır ($P<0,05$). CEREC OC grubu çalışma zamanı açısından en düşük ortalama değerleri göstermiştir.

**Sonuç:** Cerec omnican ve Cares tarayıcıları arasında (hassaslık ve doğruluk) bakımından herhangi bir fark görülmemiştir. Cerec sistemi Cares ve geleneksel sistemlerle kıyaslandığında ölçü süresi bakımından diğer sistemlere göre daha verimli olduğu bulunmuştur.

**Anahtar kelimeler**: Intraoral tarama, Implant, Netlik, CAD/CAM

## 2. SUMMARY

Muhammed ALIBRAHIM, Dr. Öğr Üyesi. Umut ASLAN, Department of Prosthodontics

**Comparison of the accuracy and time efficiency between conventional and two digital systems impressions of single tooth implant.**

**Aim**: Over the last decades, the materials and methods for restoring compromised teeth have developed massively, this has been basically seen in the implant dentistry field. Computer-aided design and computer-aided manufacturing (CAD/CAM) techniques and approaches have been converting the dental field in parallel with these progresses. The aim of this in vivo study was to compare the accuracy and time efficiency between two intraoral scanning systems.

**Material and Method**: 10 patients with single tooth bone level implant from Straumann received one conventional impression with polyvinyl siloxane (PVS) (Elite HD+, Zhermack SpA, Italy) and three scans with CEREC OC (Sirona Dental Systems, Sirona, Bensheim, Germany) and Straumann CARES IOS (Intra oral Scanner, Basel, Switzerland). The time required for the impressions was measured at this stage and assessment of time efficiency was exercised after calculating the mean of required time results of every method. After pouring the conventional impressions, the casts made from them were scanned and employed as the reference model to evaluate trueness and precision of intraoral scanning virtual models made by each system. Impression files were converted to STL files and processed and analyzed using (Geomagic Control; Geomagic, Morrisville, USA).

**Results:** The differences between the two systems regarding trueness and precision were not statistically significant (P>0,05), but statistically significant difference was recognized in the time efficiency (P<0,05). CEREC OC showed the lowest mean values in time measures.

**Conclusions:** There was no deference regarding accuracy (trueness and precision) in comparison between CEREC omnicam and CARES**.** CEREC was found to be superior regarding time efficiency in comparison with CARES and conventional approaches**.**

**Key Words:** Intraoral scanning, Implant, Accuracy, CAD/CAM

# 3. INTRODUCTION AND AIM

Impressions have been used since the end of eighteenth century in the dental field, and still very essential in the practice of dentistry. Throughout the past two centuries, making dental impressions have greatly evolved, including compound, molded wax, synthetic rubbers and reversible and irreversible hydrocolloids. The 20th century showed outstanding advances in technology, and digital impressions came about in the 1980's for use in dentistry. In the decades following till recently, digital impression techniques have been evolving and their uses still broadening. In recent years, interest in digital scanning and three-dimensional imaging has increased greatly. Digital impressions and 3D models used widely in the application of dental field and dental specialties. Uses of digital models for prosthodontics contain analysis of occlusion, appliance design and production, treatment simulation and treatment effects (Kusnoto and Evans, 2002).

The main reason digital impression technology has not been completely used in contemporary practices is the endurance of conventional impression techniques. These methods include hydrocolloid and elastomeric materials, such as alginate, polyether, and polyvinyl siloxane. The advantage of these materials is that they are well accepted, accurate and are generally inexpensive. However, these impressions are not likely preferable by patients and have been presented as disturbing and burdensome (Hacker and Heydecke, 2015).

Additionally, these conventional impression techniques require stocking of raw materials and inventory as well as the need for a space to storage the plaster models. Digital impressions and the 3-dimensional models have huge advantages over plaster models and elastomeric materials, including more efficient storage and retrieval, superior durability, increased diagnostic versatility, decreased processing time and easier transferability (Joffe, 2014).

The most familiar conventional impression materials used for final impressions in implant and fixed prosthodontics are polyether (PE), and polyvinyl siloxane (PVS). These materials show great dimensional stability and accuracy and have been successfully utilized in fixed prosthodontics for years (Christensen, 2008).

## 3.1. Conventional Impression Material

### 3.1.1. Polyvinyl Siloxane

PVS (polyvinyl siloxanes) is one of the most common used impression materials in the field of dentistry; it is proved to guarantee accurate impression of the oral cavity (Vecsei et al., 2016).

Polyvinyl siloxane materials (PVS) are an alteration of the main condensation silicones. It is established from the polydimethyl siloxane polymer, however the presence of varying terminal groups is based on the different curing reactions. These materials are used for dental and implant impressions. It enables capturing highly accurate impressions that resist distortion and tearing while being removed. PVS impressions grant better fitting restorations. This material allows a range of viscosities from light body, which is mostly administered with a syringe, to heavy body and putty materials that often used for bite registration. Depending on the type of restoration and impression needed, various-viscosity PVS materials can be used. Set time differs depending on brand and viscosity, but often ranges between 2 to 5 minutes.

With the development of digital impression technology, the accuracy of the impression and the 3-dimensional digital model has been a major concern. Many studies were made to evaluate the accuracy of 3D models, and showed that they are comparable to plaster models using both angular measurements and linear as well as arch-registration measurements (Fleming and Marinho, 2011).

Digital technologies have fundamentally improved clinical prosthodontics, treatment, enhanced diagnostic and follow-up probabilities. They have innovate conventional prosthetic approaches and enabled completely modern treatment workflows, as well as introducing the concept of the “virtual patient (Fasbinder,2013).

The popularity of digital impression techniques has been increasing in dentistry fields due to the supported evidence of their accuracy. Digital models are appropriate with many laboratories which allows digital communication, quality fabrication of restorations, prostheses and dental appliances. Since the advent of 3-dimensional scanning in dentistry, several dental and prosthodontics companies have started making digital scanners and comprehensive software analysis programs that supply many functions. These functions can ease procedures that were traditionally performed using physical models such as

dental analysis, occlusal setups, and treatment predictions. The digital software innovate new procedures that were not presented with plaster casts, such as allowing visualization of tooth movements, the ability to overlay models and treatment outcomes (Kravitz and Groth, 2014).

There is a changing market of scanners available due to variety of intraoral scanning systems. Digital scanners differ in acquisition techniques as well as in the unit's weight, speed and size. Digital scanners have different methods for the acquisition of intraoral impression, these methods are triangulation, parallel confocal, active wave front sampling, accordion fringe interferometry and three-dimensional in-motion video (Burgess et al., 2013).

CAD/CAM systems provide an intra-oral digital scanning system and they are divided to chairside and milling. Both types of CAD/CAM systems are getting more acceptance by dentists and their patients. Wismeijer et al. (2013) reported that patients significantly favored digital scans comparing to material-based, conventional impression techniques (Fasbinder, 2012).

After the constant proving of the accuracy of digital models and the several advantages they hold over conventional impressions, the recent topic in research is the utilization and acceptance of intraoral scanners in daily dental practice. When deciding how to include an intraoral scanner into practice and what type of scanner to use, a dentist may consider several factors including patient comfort, performance, efficiency, ease of use, features/options, vendor company, portability, compatibilities and cost.

Over the last decades, the materials and methods for restoring compromised teeth have developed massively, this has been basically seen in the implant dentistry field. Implants have been evolved to be the principle of care for a lot of patients with severely compromised or missing teeth. Dentists these days can provide these patients with highly esthetic restorations, likely in a considerable shortened time framework. Consequently, the implant-dental field these days is one of the fastest rising areas in the dentistry field.

The production of customized implant abutments with CAD/CAM technology started on 1998. The CAD/CAM workflow eliminates the potential dimensional inaccuracies of investing, waxing and casting, as well as the later necessity for manipulation after machining, such abutments have the possibility to supply improved peri-implant soft-tissue support, basis to achieve an optimal esthetic outcome (RAMSEY et al., 2012).

Conventional impression approaches with transfer posts integrated with plaster master casts and porcelain fused- metal (PFM) crowns still represent the major standard in the fabricating process for fixed implant-supported restorations( Kapos and Ashy,2009). However, conventional method has technical, economic and patient-related compromises. Complex and Time consuming manufacturing procedures with expensive manpower and equipment, a considerable amount of materials with conflicting characteristics, products loss as well as interference of the treatment procedures during impression making due to gagging, suffocation hazard and taste irritation (Abduo and Lyons, 2013).

It should be taken into account that the initial three dimensional implant position capturing with conventional implant impressions is qualitatively influenced by various factors, including the pattern of impression technique itself, materials used, tray selection, the inherent fit of components, the number and angulation of implants and the operator's skill (Lee and Betensky, 2015).

### 3.2. Digital impression

The three dimensional implant position can be captured digitally by contact-free transfer with the use of intraoral optical scanner. One of the advantageous of intraoral optical scanner is that they can be used chairside for immediate digitization of the patient's oral cavity (Christensen GJ, 2009).

The application of an intraoral optical scanner grants real-time on-screen evaluation of the clinical condition, convenient and patient-friendly treatment concept and the option to proceed with chairside milling (Joda and Bragger, 2015).

Additionally, chairside digitization is more hygienic than the conventional impression-taking method due to the absence of potential infection from saliva and/or blood and the requirement for secondary transfer of the impression tray to the laboratory is needless (Fasbinder, 2010). Afterwards, the scanning data are saved as standard tessellation language (STL) files which can be utilized for computer assisted design and computer-assisted manufacturing (CAD/CAM) of customized abutments, milled models and suprastructures with high-quality materials. Today, digital computer- assisted

technologies grant a streamlined and simplified fabricating of implant prosthetic constructions. (Joda et al., 2016).

### 3.3. Overall Research Design

There are two aspects to this research:
1- Timed Clinical Efficiency.
2- Accuracy

### 3.4. Aim of Study

The aim of this in vivo study is to compare the accuracy (trueness, precision) of a powder-free, continuous imaging impression system (CEREC OC) and Multi- scan Imaging system with powder coating (STRAUMANN CARES IOS) to determine the more accurate system and to quantitatively measure and to compare the differences in time (impression time) required to create clinically acceptable impressions using material-based (polyvinyl siloxane [PVS]) monophasic impression with two chairside digital scanning systems(CEREC OC and STRAUMANN CARES IOS).

### 3.5. Research Hypothesis

The null hypothesis was (1) because of requiring a layer of powder, the inhomogeneous powder thickness may affect the accuracy comparing with powder free system. (2) There will be no difference in the time required to perform clinically acceptable impressions using material-based (polyvinyl siloxane [PVS]) monophasic method and chairside digital scanning techniques.

# 4. General information

## 4.1. CAD CAM Components

CAD/CAM systems consist of three main parts:

1. A data acquisition unit, which gathers the data from the scanned area then transform it to virtual impressions (an optical impression is created during that directly or indirectly).
2. Software for designing virtual restorations depending on the virtual impression and setting up all the milling properties.
3. A computerized milling unit which fabricates restorations with hard blocks that are made of different restoration materials.

The CAD stage is performed with the acquisition unit and the software, while the third part is in charge of the CAM stage (Galhano et al., 2012).

## 4.2. Data Acquisition

When gathering data the first step is scanning the abutment and convert the information into 3D digital data which will afterwards help to design and manufacture the CAD/CAM dental restoration (Beuer et al., 2008).

Dental CAD/CAM scanners are categorized in two groups: **laboratory scanners** (which are generally used with conventional impressions and stone models) and **intraoral scanners** (digital impression) (Fuster-Torres et al., 2009).

**Laboratory scanners:** Laboratory scanners acquire information from the plaster model (Miyazaki et al., 2009) or immediately from the impression (according to the system). Fabricating time is considerably reduced after direct scanning of the impression because both pouring and trimming are not required. Still, the procedure of scanning dental impressions is a challenging approach due to the difficulty of reaching deep points inside the impression by the scanner light.

**3shape D700 (Copenhagen, Denmark)**

The D700 3D is a laser scanning device which is part of 3Shape's Dental System 2009. D700 refers to the future generation of scanning technology and the peak of 3Shape's scanning practice. This technique gives indication and treatment options more than any other scanner to get improved clinical results. D700 also provides advanced scanned impression that its quality considered an enormous step in digital dentistry and better productivity upgraded process with outstanding advantages on the long term of investments.

D700 uses a market unique 2-camera setup and 3-axis motion system. This setup improves impression scanning and fasten the D700 scanning of full cast dental plaster models. The advanced technology setup in D700 and its processing speed do not affect the quality of production and guarantees excellent precision in details resolution and dimensions and high quality scanning results. The D700 also offers a lot of unique scan indications including impression scanning, 14 unit bridges, wax-up customized abutment articulated, antagonist model, onlays, inlays, pre-designed model aligned to preparation model implant position, orientation detection, , post & core wax-up and implant bridges for copy milling.

Intraoral scanners collect the data of the prepared teeth and scan bodies directly from the oral cavity, which allows instant designing and manufacturing of the dental reconstruction (Mattiola et al., 1995). Intraoral scanners provide very precise digital impression (Patzelt et al., 2014), this approach helps to reduce dental clinical procedures, obtain the impression and decrease the level of inconvenience and the feeling of gagging for the patient (Christensen, 2009; Logozzo et al., 2014).

### 4.3. CAD/CAM Classification

CAD/CAM systems are classified according to data sharing ability, scanning device and fabricating technique or milling process.

#### 4.3.1. Depending on data sharing capacity

There are two types of CAD/CAM systems according to the data sharing capacity: closed and open. (Correia et al., 2006)

a) Closed systems provide all CAD/CAM steps, including data acquisition, virtual design, and reconstruction manufacture. All the steps are included within the one system. Switching between systems is not applicable.
b) Open systems which permit the implementation of original digital data by other CAD software and CAM machines.

### 4.3.2. Depending on scanning device

There are two types of CAD/CAM systems according to the scanning device:

a) Chairside (In-office): many system alternatives come under this label: just a scanner (e.g. Lava C.O.S), scanner with designing software (e.g. E4D) or all the parts of the CAD/CAM system (scanning device, designing software and milling machine, e.g. CEREC system).
b) Dental laboratory: The impression is captured in the clinic, then the remaining fabricating procedures (designing and milling) will take place in the laboratory. Laboratory should contain the laboratory scanner, designing software and the milling device, or the scanner and the designing software alone (Mantri and Bhasin, 2010).

## 4.4. File Format

The file format created by CAD software is either Standard Triangle Language, Standard Tessellation Language or **St**ereo-**L**ithography files (STL).These files define any surface geometry of three-dimensional objects by triangulation and can be used for computer-assisted design/computer-assisted manufacturing of milled models, customized abutments and implant suprastructures (Joda and Bragger, 2014).

The STL files can be open files or closed files. Open files are original to the CAD software which makes it accessible for other companies to fabricate a restoration with their CAM machine. Closed file formats are only suitable for the milling device of the same company (Mehl et al., 1997); but there is a tendency towards the open file formats in order to make it easily attainable by other companies. Finally, after designing the 3D dental restoration, it is ported to the milling machine in digital format file to be milled and fabricated in order to produce the final dental restoration (Van Noort, 2012).

### 4.5. Work Flow of Producing Dental Restorations

For indirect restorations, there are two approaches to handle the impression of the dental structures using CAD CAM technology, the digital approach and the conventional approach (Miyazaki et al., 2009).

The conventional approach in which the elastomeric silicone impression is taken to form a working model. According to the type of laboratory scanner used, the scan can be performed on the elastomeric silicone impression immediately or on the gypsum model acquired by pouring of the impression (Beuer et al., 2008c). Afterwards, all the information required to design and produce the dental restoration is gained.

The digital approach in which the impression is obtained using an intra oral scanner. After that the software will integrate the scanned area with the opposing dentition on a virtual articulator depending on the digital occlusal record. Then the digital model is divided virtually to produce the working die. Afterwards the acquired information is sent to a lab and articulated STL working model will be prepared. The models preparation procedure during the veneering step of the ceramic framework is a very essential to get an accurate contact points and occlusion (Beuer et al., 2008c).

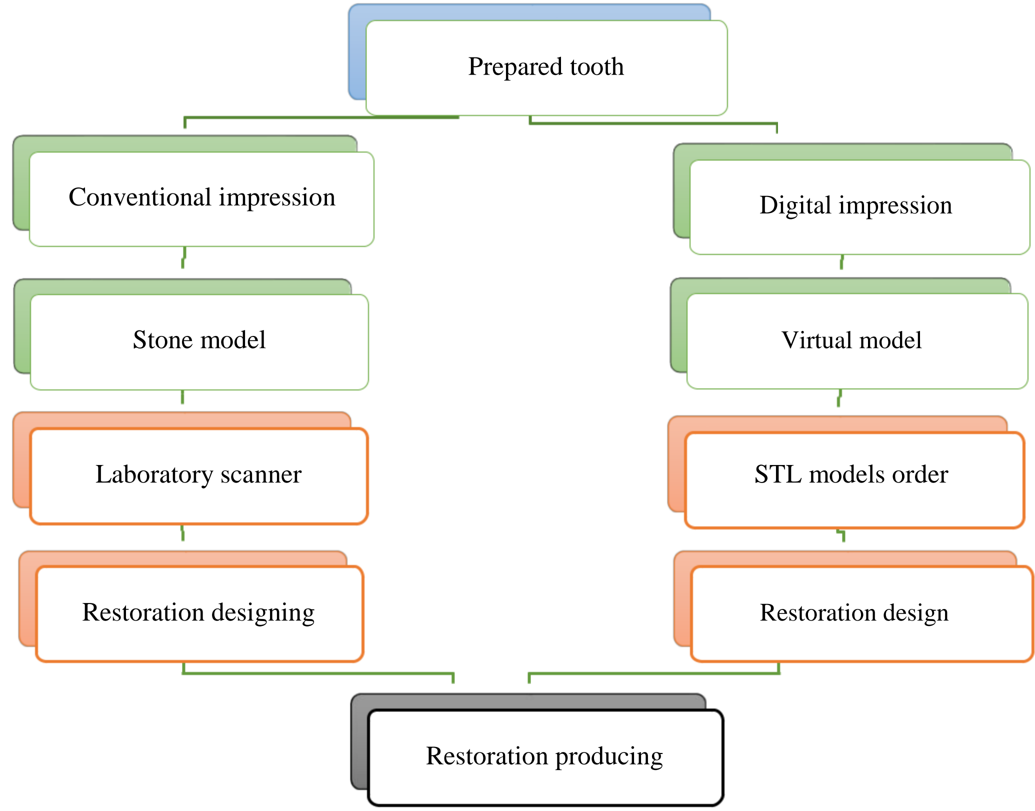


**Figure 4.1.** Work flow (conventional and digital) for fabricating a dental restoration with CAD/CAM technology.

### 4.6. Accuracy of Intraoral Digital Impression

Accuracy consists of trueness and precision (ISO 5725-1). Precision refers to how repetitive scans match each other, thus the scanner with higher precision indicates a more repeatable and regular scan. Trueness indicates how different are the scanned measurement from the real dimensions of the scanned structures. Therefore, the scanner with high trueness means that the scanner provide a matching or close outcome to the real dimensions of the scanned structure.

**Figure 4.2.** Components of accuracy **Figure 4.3.** Accuracy explained graphically

Most manufacturers do not publish the accuracy results of their devices and do not refer to the method they used to measure it (Vlaar and van Zel, 2006); the accuracy is generally determined after the device is presented in the following researches and studies. Standards quality of the company plays a great role in defining the accuracy of the dental scanners. Superior manufacturer's scanners use a high quality fabricating equipment and materials. Moving the device from one place to another affect the hardware and scanning accuracy, thus scanners have to be examined after they are transported. Some systems offer scanners with a calibration device which offers more precision than the scanner precision ability.

The size of the scanner affect the precision. Bigger scanners generally offer improved results due to their steadiness and their automated parts which limit potential movement and individual error while scanning the object (Hollenbeck et al., 2012).

Accuracy is a prime aspect in function and aesthetics of indirect restorations. The fit of implant-supported dental restorations has been debated comprehensively in the literature. In contrast to natural teeth, osseointegrated implants cannot compensate for minor inaccuracies of the prostheses, as they are practically immobile. Their sensory discrimination is more limited than for teeth (Boldt and Knapp, 2012).

Accurately fitting implant-supported prostheses is a necessity which increased with the use of stiff and prone to cracking materials (e.g. ceramics) and screw-retained restorations to splint multiple implants with fixed partial dentures (FPD).

Due to a build-up of errors and mistakes in each clinical and laboratory step, a certain amount of inaccuracy is inevitable. Many methods have been offered to estimate the

passive fit of restorations, however, none of them can be depended on solely. Consequently, various approaches to improve the fit of the implant-supported restorations has been offered (Wee et al., 1999).

The accuracy of digital impression for various clinical applications is debatable, even though many studies revealed that conventional and digital impressions propose restorations of equal value. The conventional linear distance measurement is limited to certain geometric formats. To evaluate the accuracy of impression materials, the clinical condition should be ideal. Thus, the accuracy of digital casts should be assessed by superimposing the impression on the original geometry (DeLong, 2003.). However, in clinical practice the measurement of the original master of the intraoral surface is indefinite. One method is to put one impression as the reference and compare all the other impression techniques to the reference. However, this reduces the ability to identify impression deviations since the source of these deviation may be produced by faults in the master scan or the digital impression. Due to these limitations, the accuracy of digital impressions has been generally investigated in small geometrical forms and regions of the dental arch (Luthardt and Loos, 2005).

Scanning larger areas demands merging of several single images, which causes a gradual distortion and therefore greater inaccuracy of the subsequent dataset. This is proven by assessment of full arch scans which still show greater inaccuracies of datasets from intraoral scanning systems comparing to resulting data from the conventional method (Ender and Mehl, 2013). Moreover, the scanning strategy appears to effect the accuracy of the subsequent datasets when full arches are captured. Due to these realities, the utilization of intraoral scanning in the daily practice is generally limited to short spans of the dental arch and is applicable to form small areas of the jaw or single-tooth reconstructions (Luthardt, 2005).

### 4.7. Scan Speed and Productivity

Scan speed is one of the decisive factors for scanners, the speed will impact the productivity of the dental laboratory and finalizing the process. In case of precision, there is no specific standards to compare between scanners and no studies has been published by the manufacturers to compare the scanners with their marketing claims. It is presumed that scanning duration takes from 30 seconds to few minutes (Hollenbeck et al., 2012).

The scan speed factor is not the only indicator of the productivity of the scanner. A total workflow needs to be examined, starting from induction of the operation, scanning, designing and fabricating the restoration with the milling device. When multiple systems are compared according to this criteria, a huge differences will be accomplished as result. Generally, total automated systems need less time to process the scanning operation by the device. As previously mentioned, this will reduce the complications caused by clinicians. The adjustments needed for manually run systems will consume a lot of time (camera brightness, die position, etc.). The CAD software will also reduce the types of restoration that will be manufactured. Thus, it is more sufficient to get the scanner (CAM software) and the milling device (CAD software) from the same company as the developer can set more adjustments and provide more ideal and efficient workflow (Hollenbeck et al., 2012).

### 4.8. Increased Clinical Efficiency

The clinical time associated with chair-side digital scanning systems mostly plays significant role in the adoption of this new technology. These days a few information concerning the learning curve and efficiency of the digital scanning techniques is presented and specific technologies in particular. Farah and Brown (2009), used the 3M ESPE LAVA C.O.S. after a two-day training sessions set by representatives of the company. The first day was an informational, including practice scanning on typodonts and staff members. The second day patients were scheduled for onlay, crown, and bridge procedures. The researchers estimated the Net Impression time (defined as the time needed to mix the material, load the tray, setting time, take an opposing impression and a bite registration) to be 9 minutes and for Total Impression time (defined as Net Impression time plus the time required for assistant set-up and suitable tray selection) to be 13 minutes. The digital scan times displayed a decrease in time (more efficiency) as operators took additional scans and became more experienced. After 15-20 scans operators were able to achieve between 4 - 5 minutes of Net Scan time, a 50% timesaving comparing to the conventional method. Total Scan time was reduced after 20 attempts as the staff and operators worked more efficiently together.

An in vitro study assessing the implant impressions and time effectiveness found out that digital impressions need fewer time than the conventional method, using an elastomeric material (Lee SJ, 2013).

Digital technologies offer a lot of profits. In vitro studies, IOS was reported to be more time efficient comparing with conventional impression methods for single implants. In addition, it eliminates the possibility of dimensional variations of the impression material and any interference between different materials throughout the manufacturing process.

The evolution of CAD/CAM technologies offered improvements for processing all-ceramic materials and the treatment models. The chairside concept and the delivery of an indirect ceramic reconstructions in single session was presented on 1980 (Mormann and Lutz, 1987) and considerably improved the time efficiency in the field of dentistry (Mormann, 2006).

Capturing an accurate dental impression is considered to be one of the most delicate and major time-consuming procedures in dental field. During this process, it is important to guarantee the capturing of the intraoral condition as precise as possible, knowing that faults and imprecisions could have far reaching outcomes for the quality and the fit of the final reconstruction. Even though a lot enhancements in material features had been made (for example, reduced setting time and better taste), making the impression still considered to be time consuming for the dentist and bothering procedure for the patient. Balkenhol and colleagues proved that the working times for the tested elastomeric impression materials were longer than those the manufacturing companies submitted. With the evolving of computer-aided design/computer aided manufacturing (CAD/CAM) technologies and the development of intraoral scanning devices during the past 20 years, substitutions to conventional impression making exist (Lutz, 1987).

### 4.9. CAD/CAM Systems

The major intraoral digital impression scanners that are available on the market today include CEREC, STRAUMANN CARES IOS, Lava C.O.S. system, and iTero. They are different from each other in key structures like light source, output file format, the need for powder coat spraying and working standard operative process.

### 4.10. Review Of The Literature

Diverse chair-side digital scanning systems have been presented to the dental market, each one has unique scanning characteristics, clinical and milling operation protocols.

Ting-Shu and Jian, (2014) presented a comprehensive and thorough overview of the five major commercial digital scanning systems currently available:

1. CEREC (Sirona Dental Systems Inc, Long Island City, NY, USA)
2. iTero (Align Technology Inc, San Jose, CA, USA)
3. True Definition (3M ESPE, St. Paul, MN, USA),
4. LAVA C.O.S. (3M ESPE, St. Paul, MN, USA)
5. E4D (Planmeca, Helsinki, Finland).

Although each system has its own scanning and data processing technologies, they share a lot of qualities and features. Digital scanning systems offer an enormous clinical efficiency and reported as comfortable and convenient to patients, especially those with former unpleasant experiences with material-based impression methods. Furthermore, the effective use of these systems takes patience and time to overcome the operator learning curve similar to any new technology (Farah and Brown, 2009)

#### 4.10.1. CEREC system

The first commercially obtainable computer-assisted design/computer-assisted manufacture (CAD/CAM) system for the in-office manufacture of coronal dental reconstructions was introduced in 1985 (CEREC, Sirona Dental Systems St. Paul, MN, USA). The fourth generation of CEREC and the most widespread system is known as **CEREC AC Bluecam** which captures images with a visible blue light emerged from a LED blue diode which is the light source. The CEREC AC Bluecam can record single quadrant of the digital impression within 1 minute and the opposing in a few seconds.

The most advanced CEREC system, **CEREC AC Omnicam**, was presented to the market in 2012. The Omnicam technique of recording is continuous imaging, color video speed scanning system. It employs active triangulation and releases white light to capture surfaces, and is relying on video technology that measure and captures the anatomy and color of the oral surface with a wide focal depth camera (Patzelt, 2013).

Unlike the Bluecam which records as a single image obtaining, Omnicam has consecutive data obtaining system that creates a 3D model and can be utilized for several indications, a single tooth, sextant, or full arch. On the other hand, Bluecam is only used for a single tooth or quadrant. The unique Omnicam features are the powder-free scanning and accurate 3D images with natural colors. The powder-free feature is particularly beneficial for large areas scanning (Birnbaum et al., 2009).

### 4.10.2. Straumann Cares IOS system

The intra oral scanner of this system works depending on the novel 3D capture technology which called multi- scan imaging, the tremendously consolidated Straumann Cares intraoral scanner permits dentists immediate and easy digital impressions capturing. This system also has one of the smallest handpieces offered in the market. It provides convenient, seamless and comfortable navigation due to the sound and gesture control feature. The handpiece of this scanner contains shining ring and voice signals that give a sign when the scanning data has been successfully recorded.

IOS has a gesture command wave to avoid the usual touchscreen monitors. This technology allows touch-free control of the software while the clinician is wearing sterile gloves. IOS captures a single unit in 20 seconds and a quadrant in two minutes. In addition, the IOS system has an open files format that allows exporting files of 3D data to other CAD/CAM systems.

### Scanning procedure

During the procedure of digital scanning, the clinician holds the scanner and direct the camera wand towards the targeted area. The tip of the camera should be a few millimeters far from the scanned area or just slightly touch the surface (Galhano et al., 2012). The clinician should slide the camera tip over the required area in one direction and gently shift it to form the sequential imaging into a 3D model. This smooth procedure can guarantee a deep and prominent scanning. One of the important features is the stop feature in which the dentist can pause and resume the scan at any time.

To ensure that the captured images are stable and accurate, a new technology of shake detection has been developed and provided for many systems to eliminate any potential incorrect imaging caused by shaking or trembling of the clinician's hand (Galhano et al., 2012).

When the scanning procedure is completed, the scanned area and the preparation will be shown on the screen and can be examined from any desired angle. The virtual die will be trimmed on the model and the finishing line is highlighted by the dentist on the die image. Afterwards, a CAD system offers an optimal restoration design and allows the dentist to make modifications if needed using many on-screen tools. When the desired design of the restoration is completed, the dentist will place a block of ceramic or composite material with the suitable shade in the milling machine to start fabricating the physical restoration.

This kind of intraoral scanner is used for onlays, single crowns, inlays, veneers and implant-supported FDPs. In cases of implant supported restorations, the prepared abutment can be directly scanned (Galhano et al., 2012), or a scan body placed on the implant can also be scanned. The scan body is a plastic coping used to get the 3D capturing of the implant position; the body has markers to ease the process (Patel N, 2010).

# 5. MATERIAL AND METHOD

## 5.1. Material

### 5.1.1. Patient selection and inclusion criteria

This project was approved by the Ethics Committee of Marmara University in Istanbul, Turkey (Application No:2017-99). All of the volunteers who understood the study and were willing to participate in signed the consent form and were recruited for the study.

### 5.1.2. Inclusion criteria

Volunteers are patients who seek treatment at the faculty of dentistry of Marmara University.

Every patient has at least single tooth bone level implant from Straumann

Good oral hygiene.

No temporomandibular joint disease.

Aged at least eighteen years

Intact hard and soft tissues.

### 5.1.3. Exclusion criteria

Patients with soft tissue lesions and postoperative scars on thepalate.

Advanced periodontitis affecting gingival recession.

Obvious teeth mobility (mobility degree higher than 1).

## Procedure

We conducted the study with 10 patients, each with single tooth bone level implant from Straumann and already had their healing caps placed

Every patient took 1 conventional impression with PSV and 6 scans with CEREC and Strumann digital systems – 3 each –.

The time required for conventional and digital impressions was measured at this stage.

Assessment of time effeciency was excercised after calculating the mean of required time results of every method

The poured conventional impressions were scanned with 3shape D 700 scanner and employed as refrence model

Impression files were converted to STL files then superimposed

Assessment of precision followed by comparing the deviation of digital systems virtual models with the reference ones

**5.1.4. Overview of the products and instruments used in the study**

CEREC Omnicam (OC; Sirona Dental Systems, Sirona, Bensheim,Germany)

Straumann CARES IOS (Intra oral Scanner, Basel, Switzerland)

Dentaco Scan Liquid titanium dioxide powder ( Essen - Germany)

Zetaplus poly-vinyl siloxane ( Zhermack, Italy)

Impresept disinfectant ( 3M ESPE, Seefeld, Germany)

Vel-Mix™ Die Stone scannable Type IV dental stone ( California, USA)

3Shape D700 laboratory scanner ( Copenhagen, Denmark )

Geomagic Control inspection software ( Geomagic, Morrisville, USA)

Cerec Omnicam scanbody(Sirona Dental Systems, Sirona, Bensheim,

screw-retained monotype scanbody (Straumann Bone Level RC, Institut Straumann AG, Basel, Switzerland)

## 5.2. Method

### 5.2.1. Digital impressions

Two intraoral scanning systems were evaluated in the study: CEREC Omnicam (OC; Sirona Dental Systems, Sirona, Bensheim, Germany); Straumann CARES IOS (Intra oral Scanner, Basel, Switzerland), and for every patient one sextant was scanned and the scanning were timed.

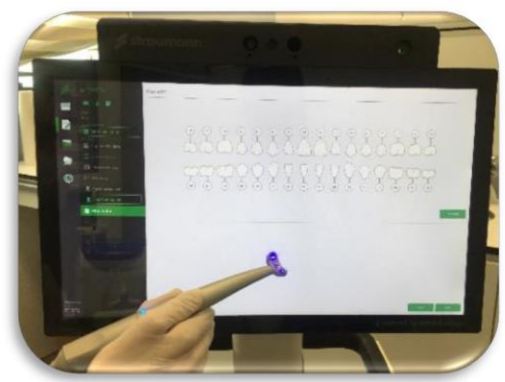

**Figure 5.1.** CARES scanner

**Figure 5.2.** CEREC scanner

The scan procedure was performed following the manufacturer's guidelines, in which saliva was removed by both air syringe and cotton rolls, and buccal or labial mucosa were pulled by cheek and lip retractor to avoid the negative effects of intraoral surroundings as much as possible. The camera of the scanner was aimed towards the captured surface. The camera tip was 5-10 millimeters far from the scan body or the tooth. The camera head was slid over the scanned area in a one direction mildly to generate the succeeding data into a 3D model. This procedure was then repeated two times, thus every patient had three digital impressions for each jaw for each system. To standardize the procedure, all scans was executed according to the manufacturers' guideline by one dentist who trained himself to use each device.

A scan body (Straumann Bone Level RC) for Cares and (Sirona Dental Systems) for Cerec was used to digitally transfer the implant location.

‘Scan bodies’ (scannable impression copings used in implant restoration) are cylindrical and moderately narrow, permitting the wand tip easy access to all critical spaces. During the performance of digital scanning, some difficulties were countered while acquiring data in the interproximal margins, it was challenging to bring within the focal distance of the wand tip.

**Figure 5.3.** Scanning with CARES

As the CEREC system is a closed system transferring the digital impression data as a proprietary format file that function only on Sirona’s supporting CAM devices, all the digital casts obtained with CEREC scanners were processed using CEREC SW 4.4.4 software to extract stereolithography (STL) files. An STL file format was compatible with and able to be exported into most 3D model processing software.

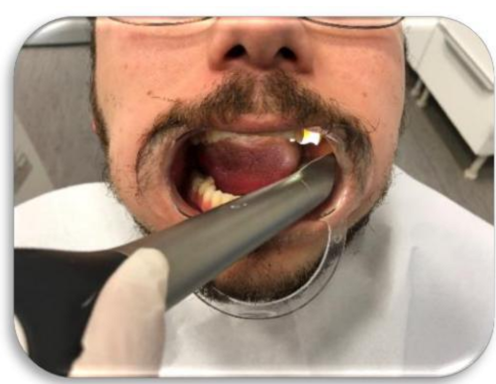

**Figure 5.4.** Scanning with CEREC

Additionally, CARES scanner works in camera image impression and demands a powder coating on the scanned surfaces. For this reason, the teeth and the scan body in the quadrant were coated with a thin layer of titanium dioxide powder (dentaco scan liquid, Essen - Germany) before scanning with CARES.
In every case, the opaquing layer was renewed before each scan.

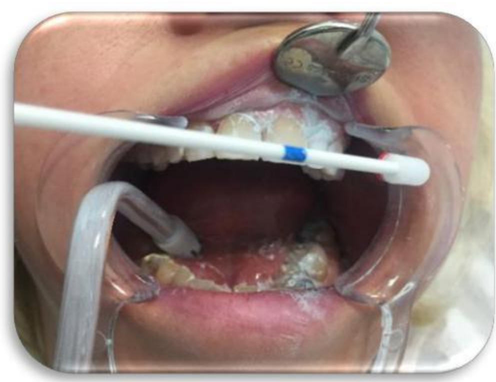

**Figure 5.5.** Coating the teeth with titanium dioxide powder

**Figure 5.6.** Model made by CAREC **Figure 5.7.** Model made by CEREC

### 5.2.2. Conventional impressions

Patients' conventional impression was acquired immediately after the finishing of intraoral digital scanning. IN order to obtain the conventional impressions, standard perforated metal stock trays (ASA Permalock; ASA Dental) were used. The optimal tray was chosen by testing a stock tray intraorally while ensuring sufficient space for the impression material. Tray adhesive was used if needed and an implant impression

coping handling of all impression materials was excuted according to the manufacturers' recommendations.

The conventional impressions were made using a poly-vinyl siloxane (PVS) material (Zetaplus, Zhermack, Italy) in one-step.

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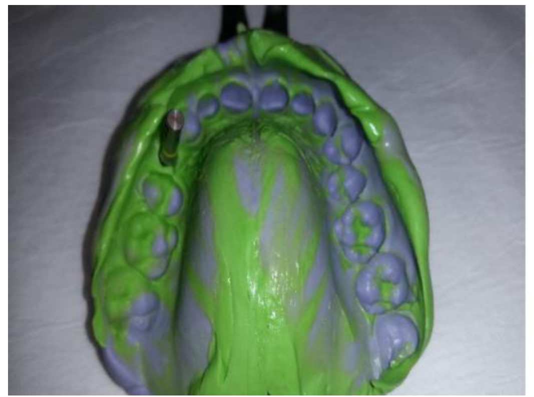


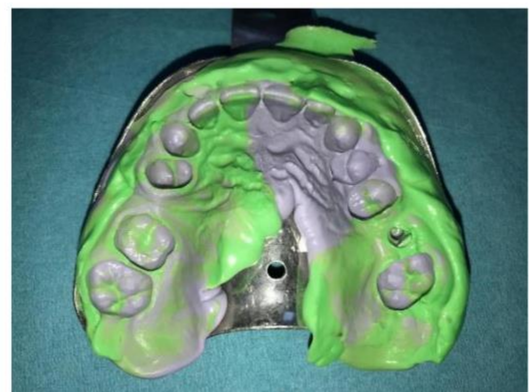


**Figure 5.8.** PVS impressions

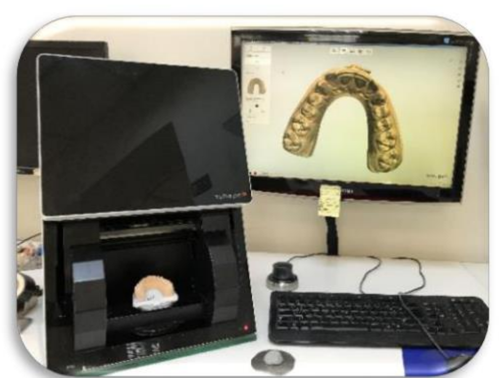
The following acceptance standards were applied to assess the outcome of both impression methods: (1) precise imprint of implant regions, (2) lack of voids in the occlusal, buccal, lingual and interproximal areas of neighboring teeth, (3) absence of voids in the occlusal surfaces of opposing teeth, and (4) appropriate capturing of vestibule up to the mucogingival junction.

The impressions which did not fit these standards resulted in retakes for conventional impression or rescan/ additional scans for the digital impressions.

Conventional impressions were disinfected for 10 minutes (Impresept; 3M ESPE, Seefeld, Germany) and suitable analog was seated over the impression post, afterwards the impression was poured with scannable Type IV dental stone (Vel-Mix™ Die Stone, California, USA). After 40 minutes, the impression trays were detached from the stone cast, and the stone casts were stored at room temperature and humidity.

Each cast was digitized once by a laboratory scanner (3Shape D700 scanner, Copenhagen, Denmark) after storaging them for at least 96 hours until the expansion of gypsum was finished to obtain the STL file format and set as gold standard models.

**Figure 5.9.** 3Shape scanning device used to scan models



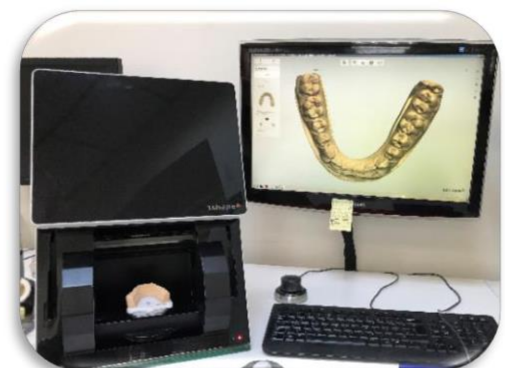


**Figure 5.10.** Digitizing the models and convert them to STL format

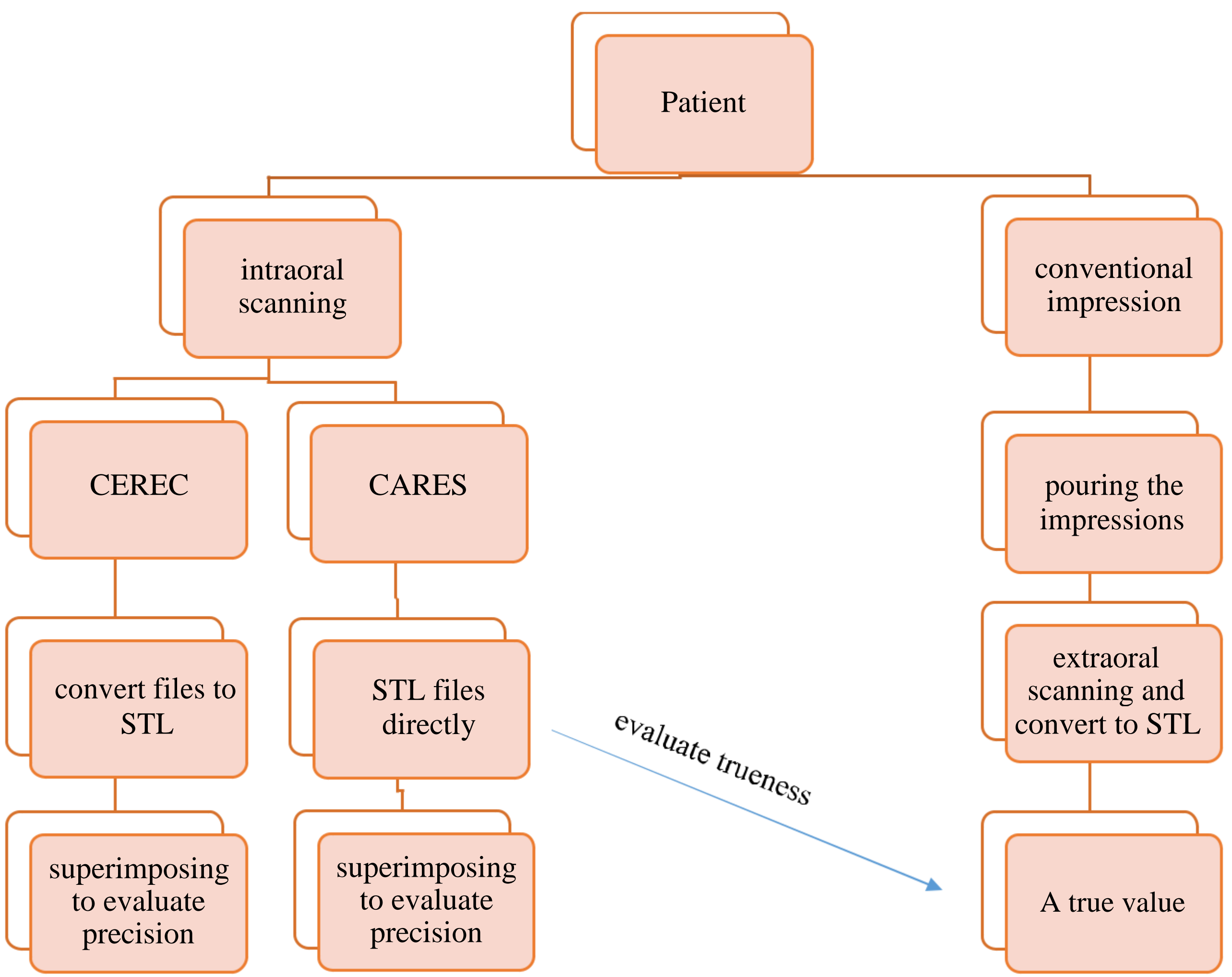



**Figure 5.11.** Diagram of study method for accuracy

All STL datasets obtained from intraoral scanner and gypsum casts were imported into the inspection software (Geomagic Control; Geomagic, Morrisville, USA). The STL data from each tested technique were pre-superimposed using CAD software (Geomagic Control; Geomagic, Morrisville, USA) according to a best-fit algorithm in order to align the orientations of the coordinate systems. To ensure an accurate superimposition, the datasets were trimmed to field of interest (the area of the implant, the adjacent teeth and about 1 mm of attached gingiva). Therefore, all irrelevant areas were discarded manually to ensure accurate superimposition and equal borders of all datasets (scan bodies were trimmed because of the deference in size between the systems). The trimmed models were again saved in STL file format and imported into Geomagic Control again for overall 3D compare.

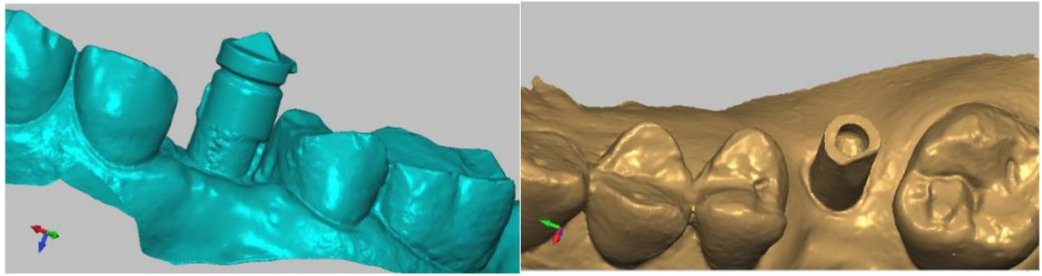
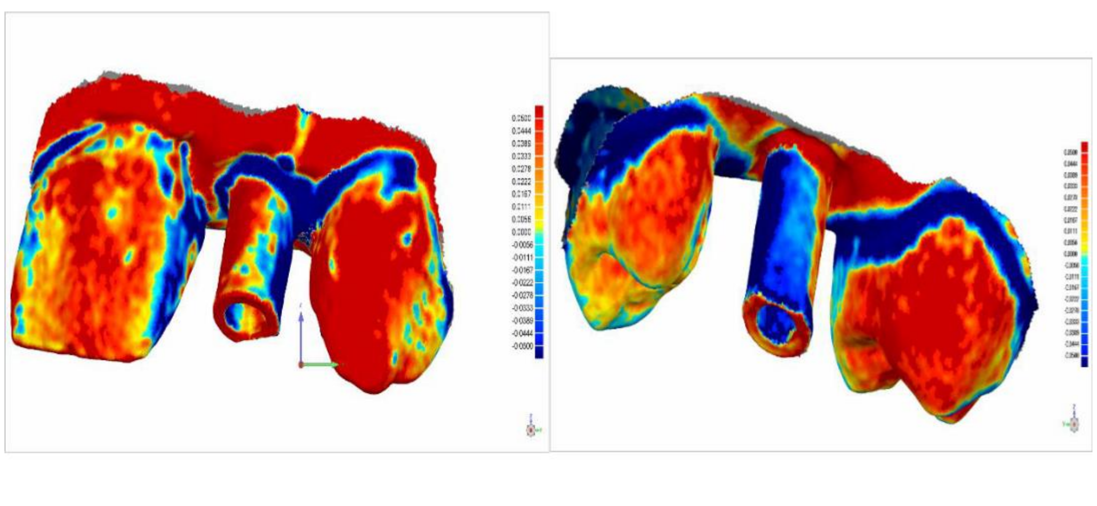


**Figure 5.12.** Trimmed models to ensure precise superimposition

For the 3D analysis, the digital of the control group and the tested group were superimposed using the best-fit tool, in which the test model would be aligned to the reference model automatically in three dimensions. Color maps to show the variances between the two aligned models and deviation information, such as average positive deviation, average negative deviation and standard deviation, were set to 20 color segments. The maximum and minimum critical values were set to ±50 µm. With these settings, 3D analysis outcomes were derived, and color maps were derived as qualitative results.



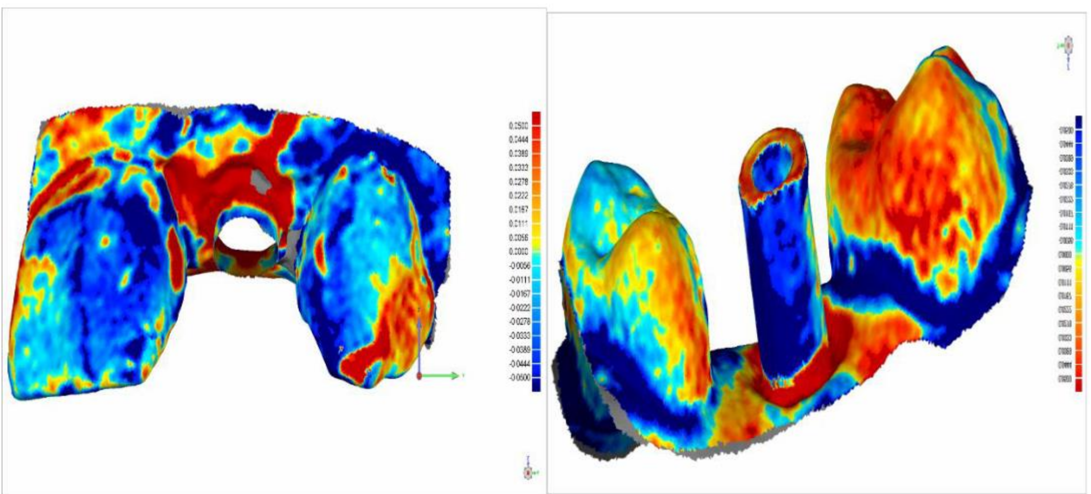


**Figure 5.13.** 3D analysis and color maps

### 5.2.3. Execution Time: Impression/Scan Time

**Digital approach**

We started by switching all the scanner devices, booting the operating system and setting up the scanning software, entering necessary information (patient’s name, hospital, region to be scanned, fictional type of restoration, fictional dental technician’s name), performing the scan and managing the scan data. Afterwards, we allowed a 2 minute intermission to cool down the scanner devices before beginning the next scanning procedure.

The effective work time was calculated as the sum of the actual impression taking, we did not include the time needed for preparation of the IOS software, time required for powdering the dentition, entering proper scan modes, insertion of the scan body, removal of the scan body and positioning of the patient. Scan time for digital impressions began with activation of the scan wand.

### Conventional approach

As for the conventional impression-taking procedure we didn’t include the time required for assembling the dispensing gun, applying adhesive to the tray if needed, Insertion and removal of the transfer post, disinfectant appliance and positioning the patient. Impression time for PVS impressions began with application of light body to the abutment tooth.

### Procedure

Time measurements were individually recorded by an observer in minutes/seconds (m/s) for the impression techniques using a stopwatch.

The number of required rescans and/ or impression retakes was acknowledged and added for calculation if needed.

No effect was acknowledged for the randomized order of treatment starting with digital or conventional workflow.

Working time was set as the time needed to attain an impression meeting the acceptance standards.

For statistical analyses, we determined one period: intraoral time including scans of the scan body.

### 5.2.4. Accuracy analysis

Trueness is known as the comparison between digital impression(from each system) set as test model and a conventional impression set as reference model (true value) of the same patient. Precision is defined as the comparison between repeated digital scanning models obtained from one patient from the same scanner. Following the 3D compare of every pairs, deviation information expressed as mean absolute deviation (average positive deviation + average negative deviation/ 2) accounting for trueness and standard deviation accounting for precision. The mean deviations for each patient were calculated.

### 5.2.5. Time efficiency analysis

For efficiency outcomes, the mean and standard deviation was calculated for each timed portion of the study. Measured time is recorded as min:sec and all data are presented as mean ± SD. Comparison of mean working time including retakes/rescans.

### 5.2.6. Statistical analysis:

In this study statistical analysis was performed with SPSS statistic software (version 21.0, SPSS Inc., Chicago, Illinois, United States). For each group classification, the mean value, the standard deviation (SD), the minimum and the maximum was calculated. For analyzing two dimensional deviations, Independent Samples Test was performed(for trueness and precision). And for analyzing three dimensional deviations, one-way ANOVA was executed (for time efficiency). LSD (least significant difference) test for post hoc comparison was conducted. The statistical significance was set at ($p < 0,05$).

# 6. Results

## 6.1. Dertermine Trueness

After the models were imported to Geomagic Control software the superimpositions were performed, the tables are shown below.

### 6.1.1. Distribution tables

**Table 6.1.** Superimposition results of CEREC AC Omnicam and conventional impression for trueness (μm)

| scanner | average positive deviation | average negative deviation | c-d mean |
|---|---|---|---|
| CEREC | 0,9108 | 0,9599 | 0,93535 |
| CEREC | 0,9851 | 0,9706 | 0,97785 |
| CEREC | 1,0049 | 0,9758 | 0,99035 |
| CEREC | 1,2678 | 1,2944 | 1,2811 |
| CEREC | 1,0489 | 0,6447 | 0,8468 |
| CEREC | 0,8188 | 0,8585 | 0,83865 |
| CEREC | 0,9311 | 0,7186 | 0,82485 |
| CEREC | 1,0765 | 1,0693 | 1,0729 |
| CEREC | 0,8846 | 0,9097 | 0,89715 |

**Table 6.2.** Superimposition results of CARES and conventional impression for trueness (μm)

| scanner | average positive deviation | average negative deviation | c-d mean |
|---|---|---|---|
| CARES | 0,8139 | 0,9228 | 0,86835 |
| CARES | 0,8492 | 0,9664 | 0,9078 |
| CARES | 0,9746 | 1,0078 | 0,9912 |
| CARES | 1,188 | 1,0828 | 1,1354 |
| CARES | 0,9183 | 0,6237 | 0,771 |
| CARES | 0,6359 | 0,5487 | 0,5923 |
| CARES | 1,0287 | 1,0085 | 1,0186 |
| CARES | 1,1199 | 1,1184 | 1,11915 |
| CARES | 0,8447 | 0,8499 | 0,8473 |

### 6.1.2. Descriptive statistics

**Table 6.3.** Descriptive statistics of trueness groups

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound | | |
| average positive deviation | cerec | 10 | 0,992 | 0,132 | 0,044 | 0,891 | 1,093 | 0,819 | 1,268 |
| | cares | 10 | 0,930 | 0,169 | 0,056 | 0,801 | 1,060 | 0,636 | 1,188 |
| | Total | 20 | 0,961 | 0,150 | 0,035 | 0,886 | 1,036 | 0,636 | 1,268 |
| average negative deviation | cerec | 10 | 0,934 | 0,190 | 0,063 | 0,788 | 1,079 | 0,645 | 1,294 |
| | cares | 10 | 0,903 | 0,197 | 0,066 | 0,752 | 1,055 | 0,549 | 1,118 |
| | Total | 20 | 0,918 | 0,189 | 0,044 | 0,825 | 1,012 | 0,549 | 1,294 |
| c -d mean | cerec | 10 | 0,963 | 0,145 | 0,048 | 0,852 | 1,074 | 0,825 | 1,281 |
| | cares | 10 | 0,917 | 0,173 | 0,058 | 0,784 | 1,049 | 0,592 | 1,135 |
| | Total | 20 | 0,940 | 0,156 | 0,037 | 0,862 | 1,018 | 0,592 | 1,281 |

Table 3 gives the mean values and their standard deviation, as well as the minimum, median, maximum and 95 % confidence interval for each parameter after superimposition. The measurement results (mean ±standard deviation) for trueness were: 0,9627 ± 0,1446 µm for CEREC Omnicam, 0,916789±0,1726436 µm for CARES.

The Independent Samples Test was performed after the descriptive analysis to determine whether there are any statistically significant differences among study groups. Independent Samples Test result is shown in table 4.

**Table 6.4.** Independent Samples Test result to determine trueness

| Independent Samples Test | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
| | | F | Sig. | t | df | Sig (tailed) | Mean Difference | Std.Error Difference | 95%Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| average positive deviation | Equal variances assumed | 0,699 | 0,415 | 0,864 | 16 | 0,400 * | 0,062 | 0,071 | -0,090 | 0,213 |
| | Equal variances not assumed | | | 0,864 | 15,095 | 0,401 | 0,062 | 0,071 | -0,090 | 0,214 |
| average negative deviation | Equal variances assumed | 0,112 | 0,742 | 0,332 | 16 | 0,744 * | 0,030 | 0,091 | -0,163 | 0,224 |
| | Equal variances not assumed | | | 0,332 | 15,976 | 0,744 | 0,030 | 0,091 | -0,163 | 0,224 |
| c-d mean | Equal variances assumed | 0,38 | 0,546 | 0,613 | 16 | 0,549 * | 0,046 | 0,075 | -0,113 | 0,205 |
| | Equal variances not assumed | | | 0,613 | 15,524 | 0,549 | 0,046 | 0,075 | -0,114 | 0,206 |

According to Independent Samples Test, differences in trueness between CEREC Omnicam and CARES did not differ significantly ($P>0,05$).

## 6.2. Dertermine Precision

After the models wrer imported to Geomagic Control software the superimpositions were done, the tables are shown below.

### 6.2.1. Distribution tables

**Table 6.5.** Superimposition results of CEREC AC Omnicam impressions (μm)

| Scanner type | superimposition 1-2 | superimposition 1-3 | c-d mean |
|---|---|---|---|
| CEREC | 0,1747 | 0,0777 | 0,1262 |
| CEREC | 0,2017 | 0,2196 | 0,21065 |
| CEREC | 0,1105 | 0,1444 | 0,12745 |
| CEREC | 0,1263 | 0,0982 | 0,11225 |
| CEREC | 0,0844 | 0,0795 | 0,08195 |
| CEREC | 0,069 | 0,0614 | 0,0652 |
| CEREC | 0,0547 | 0,0888 | 0,07175 |
| CEREC | 0,0821 | 0,0984 | 0,09025 |
| CEREC | 0,0926 | 0,2357 | 0,16415 |
| CEREC | 0,1302 | 0,2152 | 0,1727 |

**Table 6.6.** Superimposition results of CARES impressions (μm)

| Scanner type | superimposition 1-2 | superimposition 1-3 | c-d mean |
|---|---|---|---|
| CARES | 0,0597 | 0,0893 | 0,0745 |
| CARES | 0,0837 | 0,1205 | 0,1021 |
| CARES | 0,0581 | 0,0685 | 0,0633 |
| CARES | 0,0803 | 0,0904 | 0,08535 |
| CARES | 0,1434 | 0,2159 | 0,17965 |
| CARES | 0,104 | 0,048 | 0,076 |
| CARES | 0,0785 | 0,1039 | 0,0912 |
| CARES | 0,1317 | 0,1061 | 0,1189 |
| CARES | 0,1278 | 0,1407 | 0,13425 |
| CARES | 0,0995 | 0,1314 | 0,11545 |

### 6.2.2. Descriptive statistics

**Table 6.7.** Descriptive statistics of precision groups

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound | | |
| superimposition 1-2 | cerec | 10 | 0,112620 | 0,0467570 | 0,0147859 | 0,079172 | 0,146068 | 0,0547 | 0,2017 |
| | cares | 10 | 0,096670 | 0,0299303 | 0,0094648 | 0,075259 | 0,118081 | 0,0581 | 0,1434 |
| | Total | 20 | 0,104645 | 0,0390750 | 0,0087374 | 0,086357 | 0,122933 | 0,0547 | 0,2017 |
| superimposition 1-3 | cerec | 10 | 0,131890 | 0,0669412 | 0,0211687 | 0,084003 | 0,179777 | 0,0614 | 0,2357 |
| | cares | 10 | 0,111470 | 0,0461100 | 0,0145813 | 0,078485 | 0,144455 | 0,0480 | 0,2159 |
| | Total | 20 | 0,121680 | 0,0569165 | 0,0127269 | 0,095042 | 0,148318 | 0,0480 | 0,2357 |
| c-d mean | cerec | 10 | 0,122255 | 0,0479711 | 0,0151698 | 0,087939 | 0,156571 | 0,0652 | 0,2107 |
| | cares | 10 | 0,104070 | 0,0346684 | 0,0109631 | 0,079270 | 0,128870 | 0,0633 | 0,1797 |
| | Total | 20 | 0,113163 | 0,0417899 | 0,0093445 | 0,093604 | 0,132721 | 0,0633 | 0,2107 |

Table 7 gives the mean values and their standard deviation, as well as the minimum, median, maximum and 95 % confidence interval for each parameter after superimposition. The measurement results (mean ±standard deviation) for precision were: 0,1222± 0,0479 µm for CEREC Omnicam, 0,1040±0,0417 µm for CARES.

The Independent Samples Test was performed after the descriptive analysis to determine whether there are any statistically significant differences among study groups. Independent Samples Test result is shown in table 8.

**Table 6.8.** Independent Samples Test result to determine precision

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| superimposition 1-2 | Equal variances assumed | 1,516 | 0,234 | 0,909 | 18 | 0,376 * | 0,0159500 | 0,0175557 | -0,0209332 | 0,0528332 |
| | Equal variances not assumed | | | 0,909 | 15,315 | 0,378 | 0,0159500 | 0,0175557 | -0,0214022 | 0,0533022 |
| superimposition 1-3 | Equal variances assumed | 3,530 | 0,077 | 0,794 | 18 | 0,437 * | 0,0204200 | 0,0257046 | -0,0335833 | 0,0744233 |
| | Equal variances not assumed | | | 0,794 | 15,971 | 0,439 | 0,0204200 | 0,0257046 | -0,0340793 | 0,0749193 |
| c-d mean | Equal variances assumed | 1,190 | 0,290 | 0,972 | 18 | 0,344 * | 0,0181850 | 0,0187166 | -0,0211372 | 0,0575072 |
| | Equal variances not assumed | | | 0,972 | 16,386 | 0,345 | 0,0181850 | 0,0187166 | -0,0214166 | 0,0577866 |

According to Independent Samples Test, differences in precision between CEREC Omnicam and CARES did not differ significantly (P>0,05).

On the basis of the results of this in vivo study, there was no deference regarding accuracy (trueness and precision) in comparison between CEREC omnicam and CARES for the impression of single tooth implant.

## 6.3. Determine Time Efficiency

The efficiency of impression methods was assessed by measuring working time in minutes/seconds (m/s) and numerical variables of interest were descriptively analyzed with sample means and standard deviations (SD).

### 6.3.1. Distribution tables

**Table 6.9.** time efficiency results of CEREC omnicam, CARES and conventional impressions

| patient | cerec | | | mean | standard deviation | cares | | | mean | standard deviation | conventional |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4,5 | 4,3 | 4,41 | 4,40 | 0,10 | 5,45 | 5,40 | 5,08 | 5,31 | 0,20 | 5,3 |
| 2 | 4,05 | 4 | 3,6 | 3,88 | 0,25 | 5,32 | 5,17 | 5,07 | 5,19 | 0,13 | 5,24 |
| 3 | 3,42 | 3,32 | 3,5 | 3,41 | 0,09 | 6,05 | 5,10 | 5,03 | 5,39 | 0,57 | 5,57 |
| 4 | 3,5 | 3,02 | 3,24 | 3,25 | 0,24 | 5,02 | 5,15 | 5,55 | 5,24 | 0,28 | 6,4 |
| 5 | 3,23 | 3,44 | 3,03 | 3,23 | 0,21 | 6,13 | 6,45 | 5,55 | 6,04 | 0,46 | 5,42 |
| 6 | 4,54 | 4,23 | 4,03 | 4,27 | 0,26 | 5,32 | 5,34 | 5,01 | 5,22 | 0,19 | 4,58 |
| 7 | 3,34 | 3,55 | 3,04 | 3,31 | 0,26 | 5,52 | 5,00 | 5,03 | 5,18 | 0,29 | 6,6 |
| 8 | 4,08 | 4,12 | 3,51 | 3,90 | 0,34 | 6,12 | 5,23 | 5,23 | 5,53 | 0,51 | 4,55 |
| 9 | 3,44 | 3,5 | 3,35 | 3,43 | 0,08 | 5,57 | 5,45 | 5,00 | 5,34 | 0,30 | 5,26 |
| 10 | 3,16 | 3,13 | 3,03 | 3,11 | 0,07 | 5,40 | 5,23 | 5,10 | 5,24 | 0,15 | 5,39 |

## 6.3.2. Descriptive statistics

**Table 6.10.** decreptive statistics of time efficiency groups

| | Number | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| cerec | 10 | 3,6190 | 0,45975 | 0,14538 | 3,2901 | 3,9479 | 3,11 | 4,40 |
| cares | 10 | 5,3680 | 0,25909 | 0,08193 | 5,1827 | 5,5533 | 5,18 | 6,04 |
| conventional | 10 | 5,4020 | 0,70684 | 0,22352 | 4,8964 | 5,9076 | 4,26 | 6,60 |
| Total | 30 | 4,7963 | 0,97910 | 0,17876 | 4,4307 | 5,1619 | 3,11 | 6,60 |

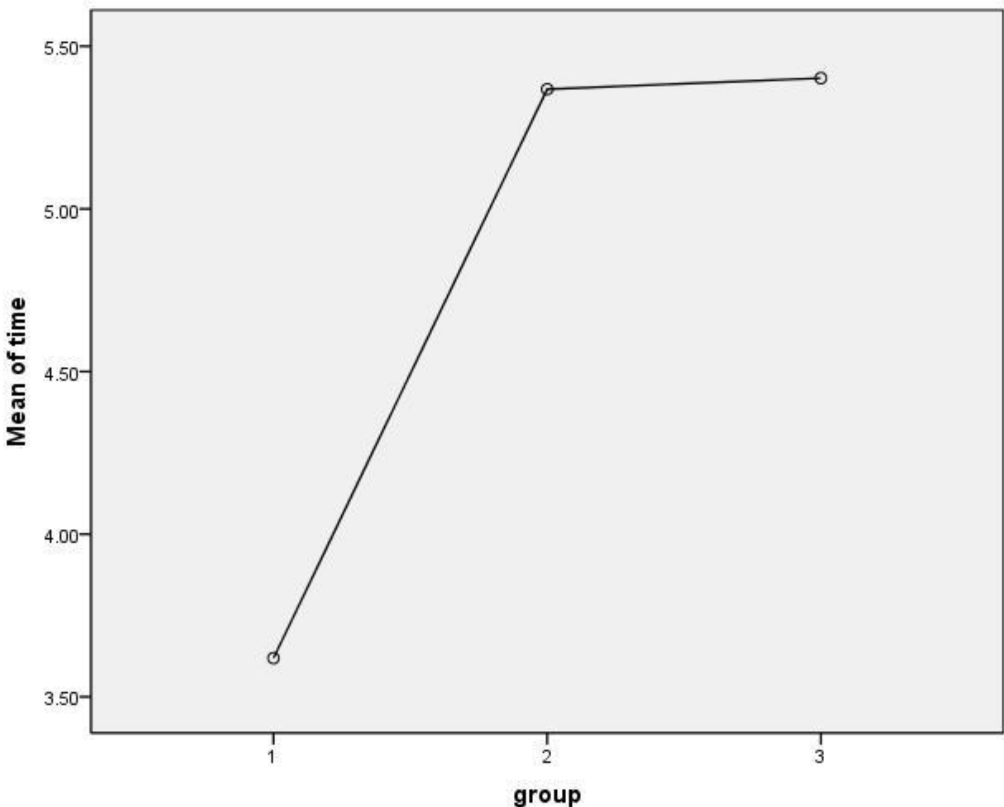



**Figure 6.14**. Graph line for the mean of time efficiency for the three groups

(1) Cerec time efficiency mean value

(2) Cares time efficiency mean value

(3) Conventional time efficiency mean value

Table 10 gives the mean values and their standard deviation, as well as the minimum, median, maximum and 95 % confidence interval for each parameter.

The measurement results (mean ±standard deviation) for time efficiency were: 3,619±0,4597 m/s for CEREC Omnicam, 5,368±0,2590 m/s for CARES, 5,402±0,7068 m/s for conventional.

The one-way analysis of variance (ANOVA) test was performed after the descriptive analysis to determine whether there are any statistically significant differences among study groups. ANOVA test result is shown in table 11.

**Table 6.11** ANOVA test results to determine time efficiency

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 20,797 | 2 | 10,399 | 40,092 | .000 |
| Within Groups | 7,003 | 27 | ,259 | | |
| Total | 27,800 | 29 | | | |

According to ANOVA, variations in time efficiency between CEREC Omnicam, CARES and conventional techniques differ significantly ($P<0,05$).

To determine differences among the study groups LSD (least significant difference) test for post hoc comparison was performed.

### 6.3.3. Post hoc tests LSD

To detect the different group least significant difference LSD test was done, LSD results are detailed in table 12.

### 6.3.4. Multiple comparisons

**Table 6.12.** LSD test results on study groups

| Multiple Comparisons | | | | | | |
|---|---|---|---|---|---|---|
| (I) group | (J) group | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
| | | | | | Lower Bound | Upper Bound |
| cerec | cares | -1,74900* | ,22776 | .000 | -2,3137 | -1,1843 |
| | conventional | -1,78300* | ,22776 | .000 | -2,3477 | -1,2183 |
| cares | cerec | 1,74900* | ,22776 | .000 | 1,1843 | 2,3137 |
| | conventional | -,03400 | ,22776 | ,988 | -,5987 | ,5307 |
| conventional | cerec | 1,78300* | ,22776 | ,000 | 1,2183 | 2,3477 |
| | cares | ,03400 | ,22776 | ,988 | -,5307 | ,5987 |

*. The mean difference is significant at the 0.05 level.

The LSD test results showed significant difference among the study groups according to statistical significance ($p < 0,05$), and accordingly it indicates that CEREC Omnicam group (3,619±0,4597 m/s) was significantly more time efficient than CARES group (5,368±0,2590 m/s) and conventional group (5,402±0,7068 m/s). There were no significant differences between CARES and conventional impressions in the same manner.

On the basis of the results of this in vivo study, CEREC omnicam was found to be superior regarding time efficiency in comparison with CARES and conventional approaches and might accelerate the work flow of making impressions.

## 7. Discussion

The null hypothesis was (1) due to the requirement of layer of powder, the inhomogeneous powder thickness may affect the accuracy comparing with powder free system. (2) There will be no difference in the time required to perform clinically acceptable impressions using material-based (polyvinyl siloxane [PVS]) monophasic method and chairside digital scanning techniques.

According to our results, the null hypothesis was partially rejected, (1) No significant differences were found between the two scanning systems regarding both trueness and precision. (2) A significant deference ($p < 0,05$) were found in the time efficiency, CEREC OM showed the lowest mean deviation and consequently more time efficient than CARES and conventional impressions. No significant differences were found between CARES and the conventional method regarding the time efficiency.

Modern technologies offer not only innovative potentials of functional rehabilitation but also a new patients' prospective towards digitization trend in general. Patients are accustomed to using digital instruments (such as smartphones and laptops) in their daily life, and they are well informed, from health-care-related online platforms, about deferent and new technical advances. Therefore, patients' mindset on dental implant therapy has shown an ongoing change over the last decade (Pommer and Zechner, 2011).

Patients anticipate esthetic and functional treatment results from implant-supported restorations. In fact, their expectations are higher for implant-supported rehabilitation than for conventional prosthodontic reconstructions. Additionally, the patients hope for less intensive treatment protocols, including shorter appointments combined with condensed overall therapy, as well as convenience sessions without affecting their social life. With the use of CAD CAM technology, patients do not experience gagging, the suffocation hazards and taste irritation encountered during conventional impression-taking procedures (Patel, 2011). However, studies on implants are generally limited to the survival of dental implant and clinical/radiographic surrogate parameters.

Recently, new published randomized controlled trials compared patients perceptions towards digital implant impressions with those for conventional implant

impressions (Wismeijer and Mans, 2014). These trials showed constant outcomes with an overall patients' preference considerably in favor of the intraoral optical scanner, rather than the conventional method regarding the obtaining of the three-dimensional implant impression. Furthermore, one pilot study assessed the operators' perceptions when comparing conventional and digital impressions in a standardized application for single-implant crowns (Lee et al., 2013). Trial contributors were inexperienced undergraduate dental students executing both methods on a phantom model. In this trial, the digital procedure also had greater operators' acceptance than the conventional technique. Overall, according to patients' perception and satisfaction with implant-impression procedures, the intraoral optical scanner is preferable to the conventional technique' (Yuzbasioglu and Kurt, 2014).

There is few clinical studies that are currently available. The findings of these studies showed that fully anatomic implant-supported crowns, created using a complete digital method, appear to be a practical treatment concept. Partially quadrant-like intraoral optical scans and computer assisted design/computer-assisted manufacturing technology, in combination with prefabricated implant abutments, revealed a reduced treatment approach in posterior sites (Bragger and Joda, 2014). Additionally, the need for chairside modifications, such as secondary grinding and polishing, can be decreased, or may not even be required, within a complete digitized procedure using monolithic restorations. This increase the time efficiency and may also minimize the threat of cracks and chipping as an outcome of the absence of veneered ceramics (Joda and Bragger, 2015). In this study, the measurement results (mean ±standard deviation) for trueness were: 0,9627 ± 0,1446 μm for CEREC Omnicam, 0,916789±0,1726436 μm for CARES, while the measurement results (mean ±standard deviation) for precision were: 0,1222± 0,0479 μm for CEREC Omnicam, 0,1040±0,0417 μm for CARES.

Deficiencies with elastomeric impression materials and techniques have been documented to support the need for new and better impression techniques .Commonly reported weaknesses of elastomeric impression materials include technique sensitivity, patient discomfort, dimensional changes after polymerization, tray distortion , dental stone distortion, and distortion from disinfection agents. Despite these minor shortcomings, the combination of elastomeric impression materials and dental stone casts has been successful over a long period (Ragain and Grosko, 2000).

One advantage acquired from digital impression workflow is the ability to utilize digital magnification and quality control tools to highlight defective areas and provide

guidance on how to capture missing areas of the digital impression. This allows immediate identification of defects, and the dentist can rescan those areas without the need to remake the entire impression. However, digital impressions also have disadvantages, and, when compared with elastomeric impressions, the potential exists for greater distortion of the digital impression, possibly due to poor technique or the limitations of the specific scanning technology. (Ahlholm and Sipila, 2016.).

In vivo use of IOS could be compromised by many aspects: movements of the object, saliva, fogging of the optics, and other patient-, operator- and device-related limiting factors. Scanning location can be important, as distant regions could be difficult to reach in a real clinical situation. Length of the edentulous ridge, lack of attached gingiva, tongue and cheek mobility could also negatively affect the ability to stitch the images. Scanning strategy and mode were also proved important aspects (Gimenez, 2015).

Accuracy of digital impressions can also be affected by other factors. Characteristics of the scan bodies could be another source of errors. Shorter and less visible scan bodies can negatively influence the accuracy. It was recommended that longer scan bodies should be used with deep-placed implants. One of the studies included in the systematic review used longer scan bodies, which could also contribute to better measured accuracy. Sharp angles of the scan bodies could negatively influence scan accuracy (Papaspyridakos and Gallucci, 2016).

Spraying of the scan bodies with powder is still needed for some of the IOS to reduce the reflections and aid the stitching of the images. Clinically, a slight powder layer can be also utilized as an indicator for moisture, especially in regions where liquids (saliva/blood) are difficult to spot during scanning and powdering could potentially influence the accuracy of scanning through homogeneity and thickness of spray. It was reported that experienced clinicians achieved greater homogeneity and thinner coatings. Therefore it is recommended to use only light dusting on the surfaces to be scanned. In our study, the powdering did not affect the accuracy outcomes.

As powder could be inhaled by the patient and clinician or swallowed by patient, Burhardt's study researched the influence of the titanium dioxide powder and found that over 60-70% of subjects reported noticing the powder. More information is needed about the effect of it on human health (Patzelt and Vonau, 2013).

Clinically significant success standards for the impressions were introduced defining an precise imprint by the absence of data lacks ("scan holes") with IOS and no

voids with the conventional impression in the implant region including adjacent teeth and soft tissues. Rescans or incorporation of additional scans were mostly due to the difficulty in scanning the interproximal contacts of adjacent teeth next to the implant region and the areas of refection from the laser source. Areas of deficiency were identified and the clinician asked to re-scan the area or, if necessary, re-powder and re-scan. These times were added accordingly. Number of re-scans for digital were not recorded because entire scan were not needed to be remade due to the ability to spot-add missing data.

Digitization of workflow in restorative dentistry has improved the efficiency of patient treatment. Dentists can now accomplish restorative results with the same level of accuracy more efficiently and with less discomfort. Efficiency reductions can be attributed to decreased number of patient visits, reduced time per visit and, and a decrease in steps needed to accomplish a satisfactory restorative result (Joda and Bragger, 2014).

Researchers compared conventional techniques with digital ones in one previous study. Lee and Gallucci assessed the efficiency of digital and conventional impressions of single-implant reconstructions models by undergraduate dental students. The mean fully treatment time was 24 minutes 42 seconds for the conventional method and 12 minutes 29 seconds for the digital method, with a statistically significant difference of more than 12 minutes ($P < .001$). The researchers incorporated the preparation time and procedure durations for retakes or rescans in their calculation. According to this in vivo study, one sextant were scanned from each patient to examine the difference in time efficiency (impression taking time only) between the digital and conventional techniques. The measurement results (mean ±standard deviation) for time efficiency were: 3.619±0.4597 m/s for CEREC Omnicam, 5.368±0.2590 m/s for CARES, 5.402±0.7068 m/s for conventional, thus the CEREC Omnicam were more time efficient than the CARES and conventional approaches.

Another study was conducted to 50 patients with single implants, and 12.13 min were documented for conventional (open tray, Impregum), while IOS (Omnicam, Sirona, Bensheim, Germany) required only 6.39 min although complete arch scanning was executed (Schepke et al., 2015).

The combination of intraoral scanning (IOS) with CAD/CAM processing in a complete virtual environment ensures clinical, technical, and economic advantages for fixed implant restorations (Joda and Bragger, 2016).

Although it is necessary to apply an adhesive before making a conventional impression; to disinfect an impression before shipment; or, when using an intraoral scanner, to start up the hardware, put in the patient information and postprocess the data, these steps do not affect the actual clinical time needed to make an impression. When one focuses on the relevant steps for the dentist—in the conventional approach, processing, setting, and confirming the interarch registration; in the digital approach, performing the coating if needed, scanning the abutment, scanning the antagonist and scanning the interarch registration without considering steps that can be done before, simultaneously with or after the actual impression making, the difference between the conventional and digital approaches is less.

In comparing the chairside time required to complete each type of impression, the CARES digital impression required significantly more time than the other two impression groups. The CEREC omnicam impressions had the shortest median time. It should be noted that these measurements include only the time spent making the impression, and do not take into consideration the time required to disinfect and process any of the impressions.

We suppose that in comparison with the results we had, highly experienced clincians may be faster with digital systems, whereas inexperienced ones may be slower with them or even faster with conventional materials. The individual clinician's effort and speed have a major influence on the efficiency of his or her work.

Although a direct comparison with published results is difficult because of variations in study design, the results of this study are in agreement with values reported in the literature for time efficiency, trueness and precision of intraoral impression systems.

Nowadays, it is not a question of 'if' but of 'when' to jump on the digitalization trend in implant dental field. This trend will change the entire dental field. It should be confirmed that further scientific validation on digital technique is essential to understand the influence of this promising technology for adjusting well-established conventional prcedures. The benefits will be reduced production costs and improved time-efficiency, and patients' perceptions of a modern treatment concept will also be met. Supplementary clinical studies on different digital systems and different digital workflows will be vital for better utilization of these processes and for understanding the potential of the digital technology.

## 8. Conclusion

Within the limitation of this in vivo study, both of the intraoral scanning systems were capable to give sextant impression of single tooth implant with clinically satisfying accuracy (trueness and precision), there were differences between the digital and conventional methods regarding impression taking time and CEREC OM was more time efficient than CARES and the conventional way.

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# 10. Enclosures

## 10.1. Ethical Committee Approval

T.C.
MARMARA ÜNİVERSİTESİ
Diş Hekimliği Fakültesi
Klinik Araştırmalar Etik Kurulu
ARAŞTIRMA BAŞVURUSU ONAY BELGESİ

| BAŞVURU BİLGİLERİ | | | |
|---|---|---|---|
| PROTOKOL KODU | 2017-99 | | |
| PROTOKOL ADI | Comparison of the accuracy and time efficency between conventional and two digital systems impressions of single tooth implant | | |
| SORUMLU ARAŞTIRMACI | Yrd.Doç.Dr.UMUT ASLAN | | |
| DİĞER ARAŞTIRICILAR | Dt. MOHAMAD ALIBRAHIMNESFALDONIA | | |
| ARAŞTIRMA MERKEZİ | M.Ü.DİŞ HEK.FAKÜLTESİ | | |
| DESTEKLEYİCİ | | | |
| ARAŞTIRMANIN FAZI VE TÜRÜ | FAZ 1 | ☐ | |
| | FAZ 2 | ☐ | |
| | FAZ 3 | ☐ | |
| | FAZ 4 | ☐ | |
| | Gözlemsel ilaç çalışması | ☐ | |
| | Tıbbi cihaz klinik araştırması | ☒ | |
| | İn vitro tıbbi tanı cihazları ile yapılan performans değerlendirme çalışmaları | ☐ | |
| | İlaç dışı klinik araştırma | ☐ | |
| | Diğer ise belirtiniz | | |
| ARAŞTIRMAYA KATILAN MERKEZLER | TEK MERKEZ ☒ | ÇOK MERKEZLİ ☐ | ULUSAL ☐ / ULUSLARARASI ☐ |

| DEĞERLENDİRİLEN BELGELER: Belge Adı | Tarihi | Versiyon Numarası | Dili |
|---|---|---|---|
| ARAŞTIRMA PROTOKOLÜ | | | Türkçe ☒ İngilizce ☐ Diğer ☐ |
| BİLGİLENDİRİLMİŞ GÖNÜLLÜ OLUR FORMU | | | Türkçe ☒ İngilizce ☐ Diğer ☐ |
| OLGU RAPOR FORMU | | | Türkçe ☐ İngilizce ☐ Diğer ☐ |
| ARAŞTIRMA BROŞÜRÜ | | | Türkçe ☐ İngilizce ☐ Diğer ☐ |

| DEĞERLENDİRİLEN DİĞER BELGELER: Belge Adı | | Açıklama |
|---|---|---|
| SİGORTA | ☐ | |
| ARAŞTIRMA BÜTÇESİ | ☐ | |
| BİYOLOJİK MATERYEL TRANSFER FORMU | ☐ | |
| İLAN | ☐ | |
| YILLIK BİLDİRİM | ☐ | |
| SONUÇ RAPORU | ☐ | |
| GÜVENLİLİK BİLDİRİMLERİ | ☐ | |
| DİĞER: | ☐ | |

**KARAR BİLGİLERİ**

**Karar No:2017-95** **Tarih: 25.04.2017**

Yukarıda bilgileri verilen başvuru dosyası ile ilgili belgeler araştırmanın/çalışmanın gerekçe, amaç, yaklaşım ve yöntemleri dikkate alınarak incelenmiş ve uygun bulunmuş olup araştırmanın/çalışmanın başvuru dosyasında belirtilen merkezlerde gerçekleştirilmesinde etik ve bilimsel sakınca bulunmadığına toplantıya katılan etik kurul üye tam sayısının salt çoğunluğu ile karar verilmiştir.
İlaç ve Biyolojik Ürünlerin Klinik Araştırmaları Hakkında Yönetmelik kapsamında yer alan araştırmalar/çalışmalar için Türkiye İlaç ve Tıbbi Cihaz Kurumu'ndan izin alınması gerekmektedir.

Etik Kurul Başkanının
Unvanı/Adı/Soyadı:Prof.Dr.Nimet Gençoğlu
İmza:

*Not: Etik kurul başkanı, imzasının yer almadığı her sayfaya imza atmalıdır.*

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# T.C.
# MARMARA ÜNİVERSİTESİ
## Diş Hekimliği Fakültesi
## Klinik Araştırmalar Etik Kurulu
## ARAŞTIRMA BAŞVURUSU ONAY BELGESİ

| KLİNİK ARAŞTIRMALAR ETİK KURULU | |
|---|---|
| PROTOKOL ADI VE KODU | Comparison of the accuracy and time efficency between conventional and two digital systems impressions of single tooth implant Prot:2017-99 |
| ETİK KURULUN ÇALIŞMA ESASI | İlaç ve Biyolojik Ürünlerin Klinik Araştırmaları Hakkında Yönetmelik, İyi Klinik Uygulamaları Kılavuzu |
| BAŞKANIN UNVANI / ADI / SOYADI: | **Prof.Dr.Nimet Gençoğlu** |

| UNVANI/ADI/SOYADI | UZMANLIK ALANI | KURUMU | İMZA |
|---|---|---|---|
| Prof. Dr. Nimet Gençoğlu | Endodonti | Marmara Üniversitesi Diş Hekimliği Fak. | |
| Prof.Dr.Ali Recai Menteş | Çocuk Diş Hekimliği | Marmara Üniversitesi Diş Hekimliği Fak. | |
| Prof.Dr.İlknur Tanboğa | Çocuk Diş Hekimliği | Marmara Üniversitesi Diş Hekimliği Fak. | |
| Prof.Dr.Filiz Onat | Tıbbi Farmakoloji | Marmara Üniversitesi Tıp Fakültesi | |
| Prof.Dr.Yaşar Özkan | Ağız Diş ve Çene Cerrahisi | Marmara Üniversitesi Diş Hekimliği Fak. | |
| Prof.Dr. Ahu Acar | Ortodonti | Marmara Üniversitesi Diş Hekimliği Fak. | |
| Prof.Dr.Zühre Hale Cimilli | Endodonti | Marmara Üniversitesi Diş Hekimliği Fak. | |
| Prof.Dr. Şebnem Erçalık Yalçınkaya | Ağız Diş ve Çene Radyoloji | Marmara Üniversitesi Diş Hekimliği Fak. | |
| Doç.Dr. Afife Binnaz Hazar Yoruç | Metalürji ve Malzeme Mühendisliği | İstanbul Yıldız Teknik Üniversitesi | |
| Doç.Dr. Buket Evren | Protetik Diş Tedavisi | Marmara Üniversitesi Diş Hekimliği Fak. | |
| Doç.Dr. Tolga Güven | Deontoloji | Marmara Üniversitesi Tıp Fakültesi | |
| Dr. Zerrin Kurşun | Halk Sağlığı | Çekmeköy Toplum Sağlığı Merkezi | |
| Avukat Burçak Çopuroğlu | Hukuk | Serbest | |
| Gürol Pekel | Sivil | Serbest | |

Etik Kurul Başkanının
Unvanı/Adı/Soyadı:Prof.Dr.Nimet Gençoğlu
İmza:

*Not: Etik kurul başkanı, imzasının yer almadığı her sayfaya imza atmalıdır.*

2

# 11. CURRICULUM VITAE

| Name | Muhammed | Surname | ALIBRAHIM |
|---|---|---|---|
| Place of Birth | Aleppo | Date of Birth | 01.01.1990 |
| Nationality | Syrian - Turkish | Tel | 00905061040239 |
| E-mail | Dr.nusfaldonia89@gmail.com | | |

**Educational Level**

| | Name of the Institution where he/she was graduated | Graduation year |
|---|---|---|
| Masters | Marmara University Faculty of Dentistry<br>Department of Prosthodontics | |
| Undergraduate | Aleppo University Faculty of Dentistry | |
| High school | Al-Buhtry School | |

**Job Experience**

| | Duty | Institution | Duration (Year - Year) |
|---|---|---|---|
| | | | |

| Foreign Languages | Reading comprehension | Speaking* | Writing* |
|---|---|---|---|
| English | Very good | Very good | Very good |
| Turkish | good | good | good |
| Arabic | Mother language | Mother language | Mother language |

| Foreign Language Examination Grade | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| YDS | ÜDS | IELTS | TOEFL IBT | TOEFL PBT | TOEFL CBT | FCE | CAE | CPE |
| | | | 75 | | | | | |

| | Math | Equally weighted | Non-math |
|---|---|---|---|
| ALES Grade | | | |
| (Other) Grade | | | |

**Computer Knowledge**

| Program | Use proficiency |
|---|---|
| Microsoft office | Good |

*Evaluate as very good, good, moderate, poor.