GRADUATION PROJECT

Degree in Dentistry

THE USE OF THE INTRAORAL SCANNER AMONG DENTAL PROFESSORS AT THE UEM

Madrid, academic year 2022/2023

Identification number: 201

SUMMARY AND KEYWORDS

Introduction: This research aims to evaluate the use of IOS among the dental professors of the UEM. IOS are modern devices that provide digital impressions of the teeth and oral tissues. The study will review the current literature on IOS, the scanning technology, including their advantages and limitations comparing to the conventional impressions, as well as their impact on clinical practice of dentists, and patient outcomes. Furthermore, we will explain the CAD/CAM technology that permit to fabricate digitally the prosthesis, orthodontic appliances, or implant restorations. **Objectives:** Ultimately, this study seeks to provide valuable insights into the use of intraoral scanners in dentistry by the professors of UEM and justify how intraoral scanner contribute to the ongoing development of digital dentistry. **Materials and methods:** To conduct our research, we created a questionnaire with 9 questions related to the use of IOS, and we sent it to 92 professors in dentistry. We also search scientific articles to complete our investigation. **Results:** We observed that most of the professors of UEM use the IOS in their daily practice, they said that the use of the device is relevant and present many advantages for them and the patient. Also, that it can present limitations like scanning of the subgingival margin, distal areas, rehabilitation of full mouth. The non-users if IOS considered that the price is too elevated or the time to acquire it is relatively long. **Conclusion:** We concluded that this device used daily by professionals presented many benefits in the field of dentistry, especially for the prosthodontics, orthodontic and implantology branches. However, it may present different types of limitation within some treatments. Research and papers on this domain are limited, further studies need to be done.

Keywords: Dentistry, intraoral scanner, digital impressions, CADCAM, digital workflow.

RESUMEN Y PALABRAS CLAVES

Introducción: Esta investigación pretende evaluar el uso de los IOS entre los profesores de odontología de la UEM. Los IOS son dispositivos modernos que proporcionan impresiones digitales de los dientes y los tejidos orales. El estudio revisará la literatura actual sobre IOS, la tecnología de escaneo, incluyendo sus ventajas y limitaciones en comparación con las impresiones convencionales, así como su impacto en la práctica clínica de los dentistas, y los resultados del paciente. Explicaremos la tecnología CAD/CAM que permite fabricar digitalmente la prótesis, los aparatos de ortodoncia o implante restauraciones. **Objetivos:** Este estudio pretende proporcionar información valiosa sobre el uso de escáneres intraorales en odontología por parte de los profesores de la UEM, y justificar cómo el escáner intraoral contribuye al desarrollo continuo de la odontología digital. **Materiales y métodos**: Para llevar a cabo nuestra investigación, creamos un cuestionario con 9 preguntas relacionadas con el uso de IOS, y lo enviamos a 92 profesores de odontología. También buscamos artículos científicos para completar nuestra investigación. **Resultados:** Observamos que la mayoría de los profesores de la UEM utilizan el IOS en su práctica diaria, dijeron que el uso del dispositivo es relevante y presenta muchas ventajas para ellos y el paciente. También que puede presentar limitaciones como: exploración del margen subgingival, áreas distales, rehabilitación de boca completa. Los no usuarios de IOS consideraron que el precio es demasiado elevado o que el tiempo para adquirirlo es relativamente largo. **Conclusión:** Llegamos a la conclusión de que este dispositivo utilizado por los profesionales diariamente presenta muchos beneficios en el campo de la odontología, especialmente para las ramas de prostodoncia, ortodoncia e implantología. Sin embargo, puede presentar diferentes limitaciones en algunos tratamientos. La investigación y los artículos sobre este campo son limitados, por lo que es necesario realizar más estudios.
Palabras claves: Odontología, escáner intraoral, impresiones digitales, CADCAM, flujo de trabajo digital.

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1.INTRODUCTION

Intraoral scanners (IOS) are devices that have revolutionized the field of dentistry, especially in implantology, prosthesis, and orthodontic by offering a digital alternative for the dentists with a precise and non-invasive way to capture the geometry of a patient's teeth and soft tissue (1,2,3).

In the 1980s, the first digital intraoral scanner was developed by Dr. Werner Mörmann and Marco Brandestini and restorative dentistry was its intended use. (4)

The ANSI/IEC 60601-1 standard governs the design and construction of digital intraoral scanners; hence they are regarded to be Class I medical electrical devices. (5) Every scanner is composed of three primary elements: a wireless mobile workstation that allows for the entry of data; a computer monitor that allows for the entry of prescriptions, the approval of scans, and the review of digital files; and a handheld camera wand that is used to collect scan data while the patient is holding it in their mouth. (5)

1.1. Scanning technology

These devices emit a light source that can be either laser or structured light into the object that we need to scan. (4) Then, the scanning software generates the image of the dento gingival tissues taken by imaging sensors for producing points cloud. (4) To generate a three-dimensional surface model named Mesh of the object scanned, the same program triangulates these points cloud. The speed of the measurements, the quality of the images, and the accuracy of the scanner are all determined by the technology that is employed by the wand to acquire surface data. (6)

Nowadays, the following four types of imaging technologies are use: (5)

-TRIANGULATION

Triangulation is a technique that is utilized in CEREC (Sirona Dental Systems GmbH, Bensheim, Germany) for the purpose of measuring angles and distances using projected laser light from known spots. (5) The angle that the laser makes with respect to the sensor, in addition to the distance that separates it from the laser source, is already known. (7) According to the Pythagorean theorem, as light reflects off the object, the system determines the angle of reflection, and as a result, the distance from the laser

source to the surface of the item. For this technology to achieve consistent and predictable light dispersion across the target tissue, a thin coating of opaque powder must be placed to the surface of the tissue. (6,7,8)

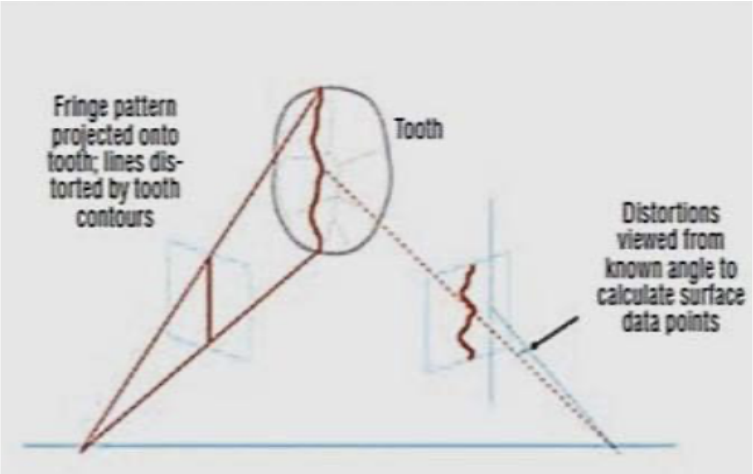


Figure 1: Process of triangulation (5)

-PARALLEL CONFOCAL

The laser beam that is being emitted is projected to the target through a filter that contains a very small pinhole. (5) Because only the light that is reflected from the thing that is in focus will be captured by the confocal imaging plane, it is known exactly where it is. (5) Data that is out of focus will not be recorded. Hence, the entire three-dimensional structure can be rebuilt by extracting two-dimensional images from a variety of confocal planes. (5,7) As a result, this method of image reconstruction is frequently referred to as « point-and-stitch reconstruction ». The iTero (Cadent, Carlstadt, United states) and TRIOS (3Shape, Copenhagen, Denmark) are two scanning devices that are capable of utilizing this method. (5,7,8)

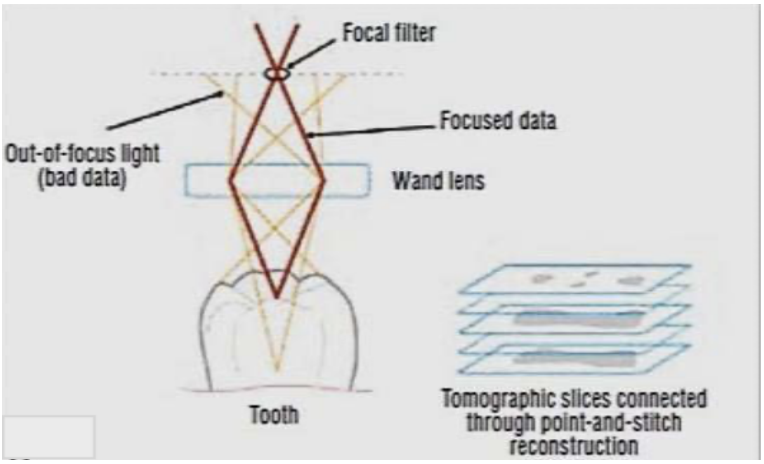


Figure 2: Process of parallel confocal (5)

-ACCORDION FRINGE INTERFEROMETRY

The Accordion Fringe Interferometry (AFI) technique makes use of two different light sources to project three different light patterns, which are referred to as "fringe patterns," onto the teeth and tissue. (5) When a fringe design comes into contact with an object's surface, the pattern gets distorted and transforms into a new pattern dependent on the specific contours of the object. (5) The term "fringe curvature" refers to the distortion that can be seen in the pattern of the fringe. A high-definition (HD) video camera that is placed at an angle of approximately 30 degrees away from the projector that is used to record the surface data points of the fringe curvature. (5,7) Because the distance measurement is determined by the difference between the three precision optical measurements, the differential measurement is unaffected by variations in the colors of the teeth or the materials they are made of. (5,7,8)

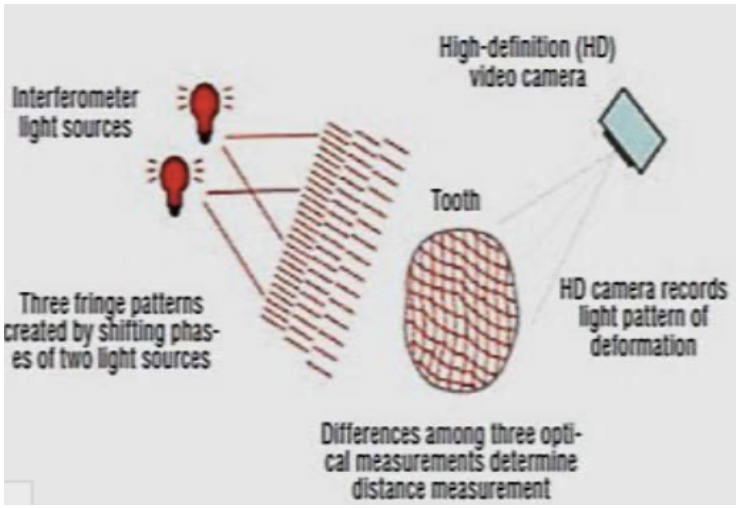


Figure 3: Process of Accordion fringe interferometry (5)

-THREE-DIMENSIONAL IN-MOTION VIDEO

The three-dimensional in-motion video is captured by a high-definition video camera equipped with trinocular imaging, which consists of three small video cameras placed at the lens of the HD video camera (5). Underneath each camera is a sensor known as a complementary metal-oxide semiconductor (CMOS), which is responsible for converting the light energy into electrical impulses. (5) To identify the 3D data, simultaneous calculations are performed from two different perspectives to establish the distances between two data points. (5,7) These distances are then collected in a video sequence and modelled in real time. Although powdering is necessary for the collection of surface data points, only a light dusting is necessary in comparison to the need of thick coating for triangulation (5,7,8)

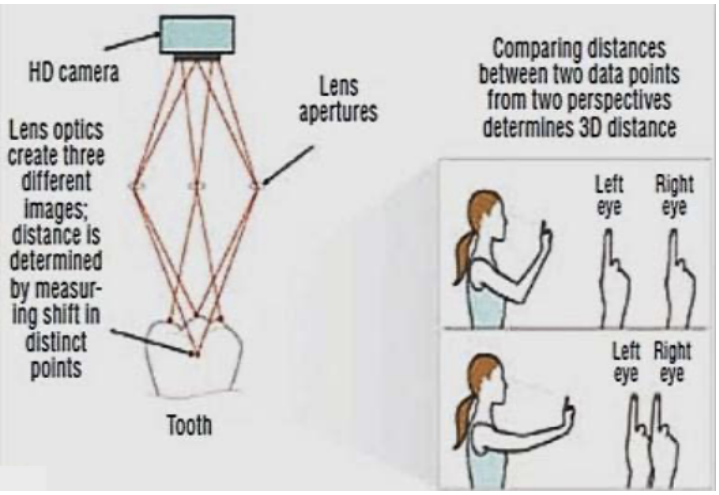


Figure 4: Process of three dimensional in-motion video (5)

Some digital scanners necessitate for the application of a thin layer of coating « powdering » in order to prevent the dispersion of light from the numerous translucent layers of the tooth and the restorative material at unanticipated angles. This increases the amount of surface data points and provides homogeneous light dispersion, both of which contribute to an increase in scanning accuracy. Powders consisting of an opaque mixture of titanium dioxide, zirconium oxide with amorphous silica, and aluminium hydroxide are utilized in this process. (5,7,8)

Figure 5: Process of powdering (5)

1.2. Type of intraoral scanners

Intraoral scanners are classified as either « closed system » or « open system » based on the digital file generated. (8)

« Closed system »: In this system the digital file created by the intraoral scanners are in a proprietary format that only works with the software and mills or printers of same format or company. These systems offer only a specific set of clinical applications. (8)

« Open system »: Files in these systems can be imported into any CAD software, mill, or printer. The produced files are saved in a regularly used format. The most common file format for 3D models is "stl," which stands for Standard Triangulation Language. These systems provide a theoretically infinite number of indicators. (8)

1.3. Dental impressions

Dental impression is an essential part of dentistry today, especially in the field of prosthetic, orthodontic, restorative dentistry and surgery. It is the representation of patient's teeth, gums, and surrounding oral structures. By the use of dental models, dentists can meticulously visualize and examine teeth from angles that would be difficult to see in a patient's mouth, allowing for better diagnosis and treatment planning. (9)

When a conventional impression is performed the professional capability, experience, skills, and the patient complacency influence the final outcome of the impression. In

addition, factors such as deformation of the impression material or expansion of the plaster models are unpreventable. (3)

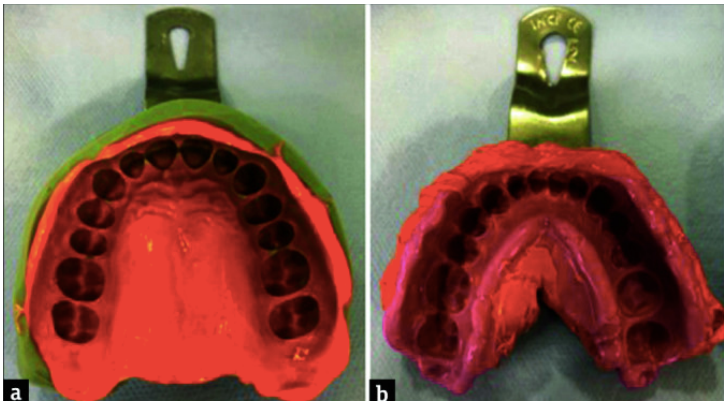


Figure 6:

A: Conventional impression of the maxilla using condensation type silicone (11)

B: Conventional impression of the mandible using additional type silicone (11)

Figure 7: Digital impression of the maxilla using intraoral scanner (11)

Compared to the strenuous process of fabricating restorations with the conventional workflow, the digital work flow is much easier as major technique sensitive steps can be avoided during the fabrication process. (10)

Today, modern dentistry has moved away from using impression trays and shifted to sophisticated sensors which are convenient. (4)

1.4. Advantages and disadvantages

Digital intraoral scanner has allowed to improve the precision, accuracy, trueness, and diversity of materials accessible to perform treatments in the different areas of dentistry. (2)

According to the description in ISO 5725-11, accuracy consists of precision and trueness at the same time. (12) The term «accuracy» generally includes a combination of all possible random components and a common systematic error or bias component during the measurement process. (12,13) Accuracy corresponds to being true, exact or the absence of error.

Trueness refers to the closeness of agreement between the arithmetic mean of many test results and the true or accepted reference value. This trueness value displays, in general, the systematic errors. The measure of trueness is usually expressed in terms of bias. (12,13)

In this sense, bias is defined as the difference between the expectation of the test results (arithmetic mean) and the true or accepted reference value. (12,13)

Precision refers to the closeness of agreement between independent test results obtained under stipulated conditions. It describes the statistical or random errors under repeated measurements. Precision in this sense is also the general term for variability between repeated measurements. (12,13).

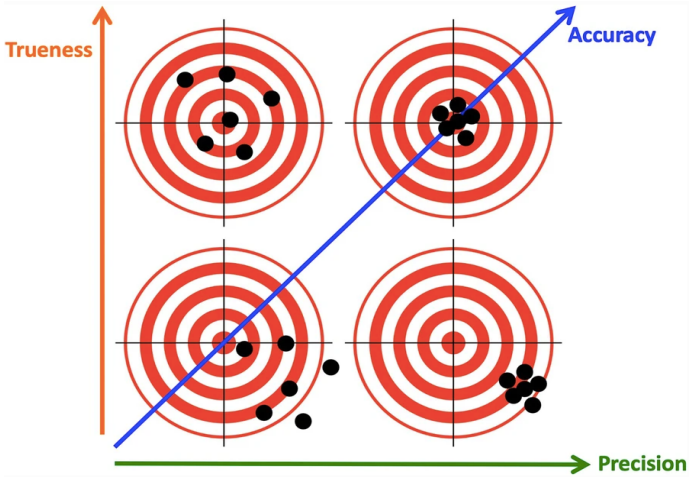


Figure 8: Image representation of trueness, accuracy and precision (14)

Another benefit of intraoral scanning is the ability to reduce chair time and instantly share digital impressions with other members of the treatment team, such as the dental lab or specialist. This results in improved collaboration and communication, leading to faster treatment times and improved patient experiences. (14,15,16)

Furthermore, because digital impressions can be easily adjusted and ameliorate on a computer screen, the use of intraoral scanners can help eliminate the need for taking multiple impression. This technology also eliminates the need for unpleasant impression materials, increasing patient feeling and satisfaction. (15,16)

Patients who suffer from anxiety and have a strong gag reflex find it difficult to tolerate traditional impressions; consequently, using IOS to replace conventional trays and impression materials provides an effective alternative. (13,17,18)

However, despite the benefits of digital impression procedure, the intraoral scanner is expensive and requires a trained operator with an appropriate gesture and adequate intra-oral scanning protocol to optimize the precision of the optical impression. (1,2,13)

In order to apply this technique, the learning curve, the inflammatory state of the periodontium, patient with a small mouth opening, difficulty of reaching more complicated anatomical features, such as the subgingival border or access to the distal parts of prepared teeth, must all be considered. (2,16,19)

ADVANTAGES	DISADVANTAGES
Time efficieny	Difficulty in detecting deep margin lines of prepared teeth
Simplified clinical procedures	Learning curve
No more plaster cast	Purchasing and management cost
Less problems of storage	Necessity of doing powdering on some of the scans
Better communication with the dental technician/ lab/patient	Learning of the device
Easier to explain diagnosis and treatment	Difficulty to acess the distal areas of the teeth
No allergy to impression/priting material	
High quality impression (no bubbles etc..)	
Avoid problems such as gag reflex	

1.5.CAD/CAM technology

Within all those advantages, it is very useful to understand what is the digital workflow and how we apply it in the field of dentistry, as each phase from diagnosis, planning and treatment is mediated by a digital phase. They are composed of 3 main components: a three-dimensional scanner that made a conversion of the oral cavity into digital data, a CAD software that will design the product needed (prosthesis, indirect restorations, orthodontics devices etc.) and a CAM software that permit manufacture the designed product. (20)

For more than 30 years, CAD/CAM (Computer Aided Design / Computer Aided Manufacturing) technology has benefited dental practices and laboratories by providing digital impressions, design, fabrication, and application of oral restorations and prosthetic appliances, implants, orthodontics, and other fields of dentistry. (16,21). Every function performed by a CAD/CAM system must be represented by three connected building blocks: (17)

-Digitalization: is the analog-to-numeric conversion. It entails gathering data from the area of the prepared teeth or implants, as well as nearby structures, and translating it into virtual impressions, optical imprints that are made at that time, either directly or indirectly, using scanners. It substitutes in favour of traditional impressions. (17,22)

Design: Computer-aided design with linear and surface modelling performed using software. (23)

-Manufacturing: Manufacturing using numerical control using milling machines, laser sintering machines, or 3D printers. The first two aspects are part of the CAD phase, while the third is part of the CAM phase, and each is a link in the digital system. The precision of these three components together will determine the system's success. (17,22)
CAD CAM restorations can be created in three methods (21)

1.Chair side production entails taking an impression chair side and afterwards creating the restoration simultaneously. It does not necessitate laboratory participation, and the patient/s can have their restoration during a single appointment. Certainly, it saves time, but it is costly and financial strain the patient. (21)

2.Laboratory manufacturing

It is comparable to the traditional approach in certain ways. The dentist takes the imprint and sends it to the lab, where the lab technician does the rest of the job. (21)

3.Production centralized

In centralized restoration production, an impression is taken, and a master cast is computerized in the lab before being sent to an external laboratory through the internet. The final restoration is created at that outsourced lab facility and delivered to the dentist. The concept is sound in that it simply takes a digitizer and software to accomplish the early steps and a high-quality restoration. (21)

Although IOS is becoming extremely popular in the field of clinical dentistry, a limited number of reviews are available in the literature and there are still large gaps of knowledges about it. (14) The opinion of the dental professors of the UEM will allow us to have a better overview of the various use of IOS among the different dental disciplines.

2.OBJECTIVES

-To establish the percentage of using intraoral scanner technology among dental UEM professors

-To investigate the several applications of intraoral scanner between the different dentistry disciplines

-To establish the different limitations of intraoral scanner in comparison to conventional technique according to UEM teachers

3.MATERIALS AND METHODS

The source of information we used for this observational research project were scientific platforms: PubMed, Medline, Cochrane, Science direct, Research Gate and CRAI library of the Universidad Europea, and the Journal of Prosthetic.

The keywords used to search for the paper were: Dentistry, intraoral scanner, digital impressions, CADCAM, digital workflow.

- Inclusion criteria :

Articles published in French, English, Spanish

Articles published after year 2014

Articles focused on dentistry area

- Exclusion criteria :

Articles in another language than English, Spanish, French

Articles published before 2014

Article non available entirely

The design our investigation to establish the practical application of the intraoral scanner with respect to the professors of the UEM, was based on a digital questionnaire (google form) which was provided to 92 professors of the dental degree by mail, including a link to access the questionnaire. The questionnaire was available from 24 February to 31 March 2023.

Google form is a free online software that allows to create surveys. It is part of Google 's web created in California by Larry Page with Alphabet as its parent company.

In order to start the research project, we must have the approval of the faculty/department where an application form was completed with all the information about how we will process to make our investigation. The tutor in charge of the project: Meriem Benabdallah sent to the university the application form and we got the approval on the 13 of January 2023 (see annex 1).

Then we sent all the documentation (Research project authorization form and the approval of the faculty/department) to the UEM research Ethics committee. We

obtained the approval on the 24 of February under the reference number: CIPI/23.062. (See annex 2)

The questionnaire was based on 9 questions which took less than 2 minutes of their time to answer. The participation in this study was free and voluntary and the information collected was confidential and anonymous.

- **Question 1:** Do you give your consent to participate in the survey as a volunteer so that the result of the survey can be used in the final degree project « The use of intraoral scanner among dental professors at the UEM »

- **Question 2:** Age

- **Question 3**: Do you currently use intraoral scanner (IOS) in your practice? If not, what is the main reason?

- **Question 4:** What type of intraoral scanner are you using and why?

- **Question 5:** Do you think the use of intraoral scanner is relevant in your daily practice?

- **Question 6:** What is the most frequent treatment or dental procedure you perform with intraoral scanner?

- **Question 7:** According to you, what is the main advantage of intraoral scanner in your work?

- **Question 8:** According to you, what is the limit of intraoral scanner in your work?

- **Question 9:** Are you satisfied with the results and evolution of treatments performed with intraoral scanner?

All the data collected were stored in an Excel sheet. Excel is a spreadsheet developed by Microsoft, it features calculation or computation capabilities, graphing tools etc. It was created in 1981 in United States by Charles Simonyi.

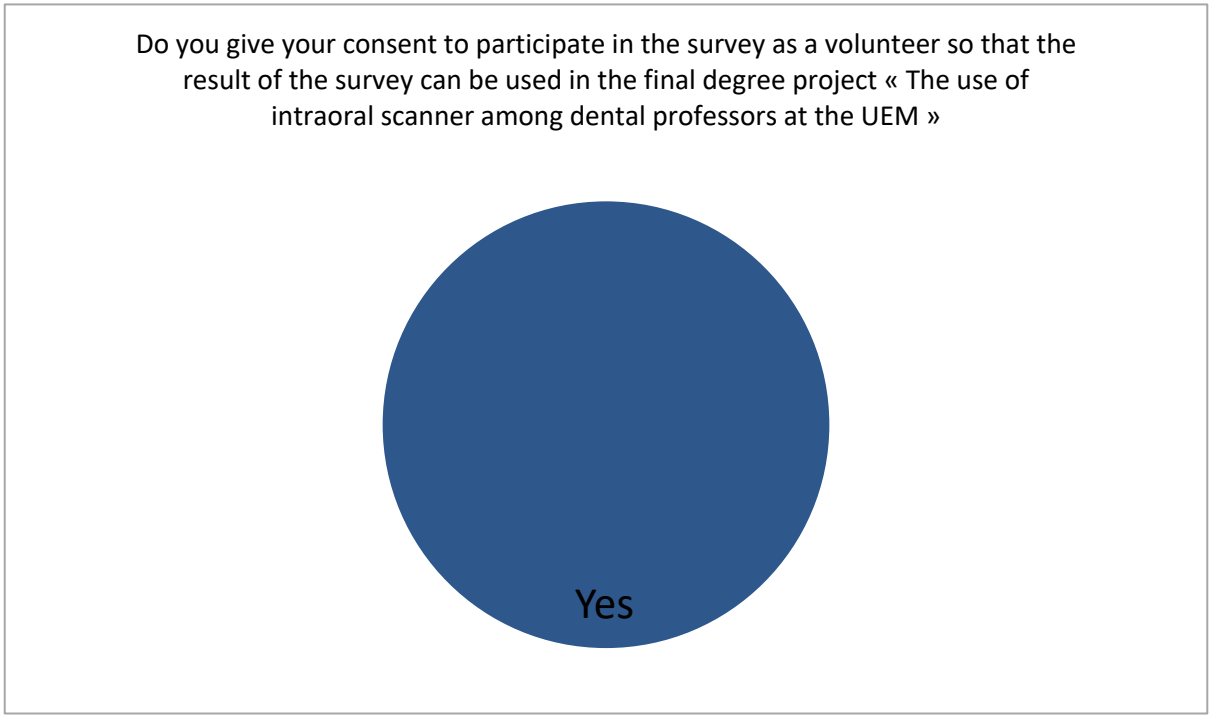
After we received all the answers, we did a descriptive analysis and make graphics to illustrate the most relevant results to facilitate the use and contextualization of the information from the survey.

4.RESULTS

92 questionnaires have been sent to different professors of the UEM; we received 30 answers. The following graphs are based on the answers obtained.

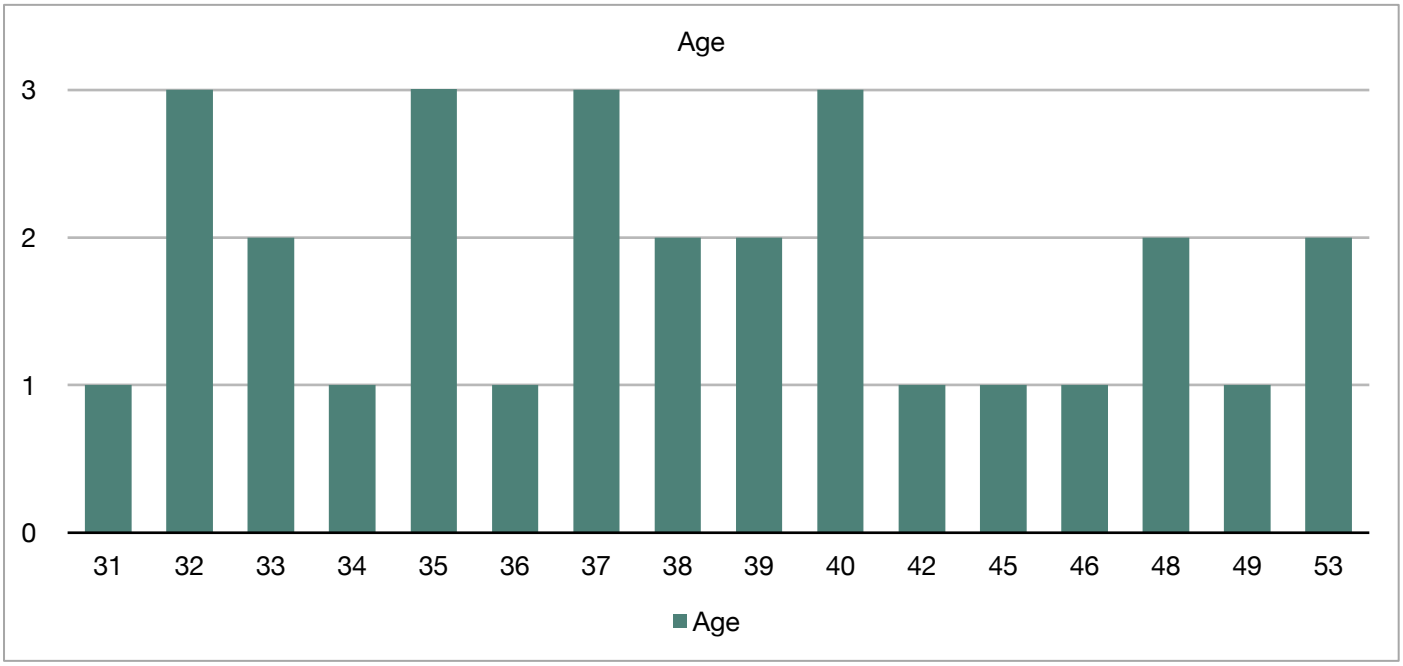
-To the question 1: Do you give your consent to participate in the survey as a volunteer so that the result of the survey can be used in the final degree project « The use of intraoral scanner among dental professors at the UEM »

- 30 professors answered
- 100% answered yes



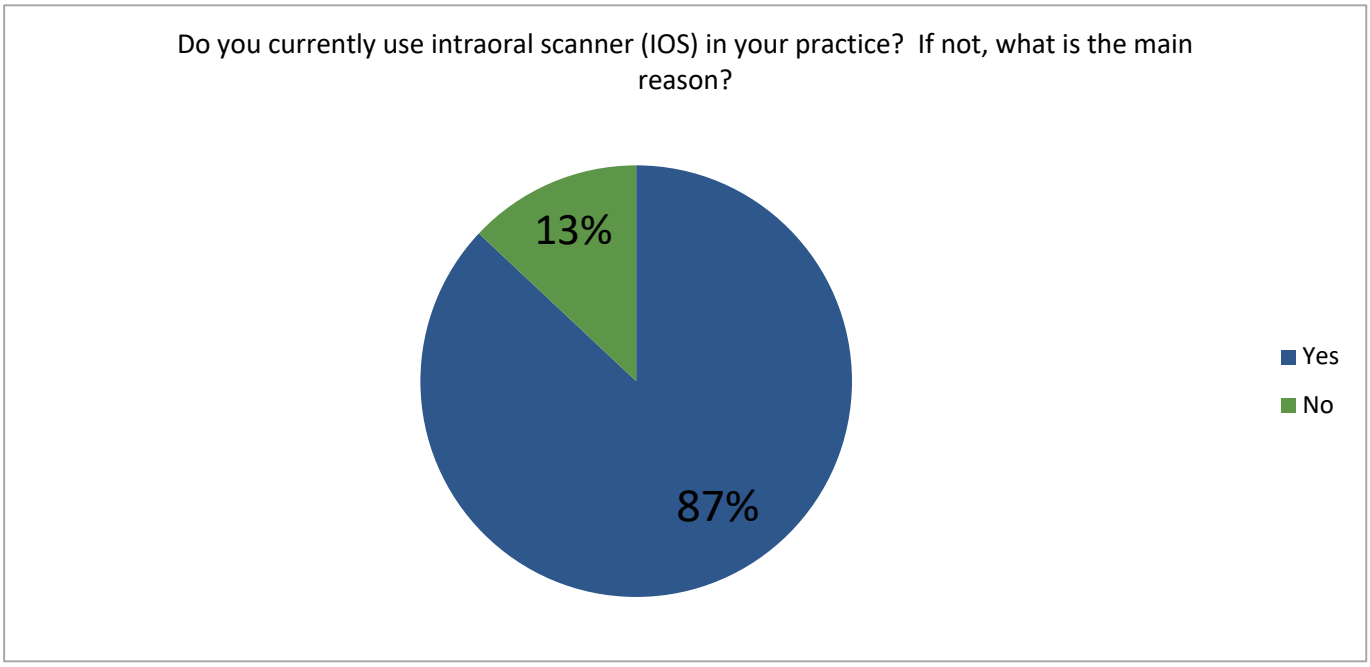
-To the question 2: Age

- 30 professors answered
- Scale of the age from 31 years old to 53 years old; mean age of 39 years old



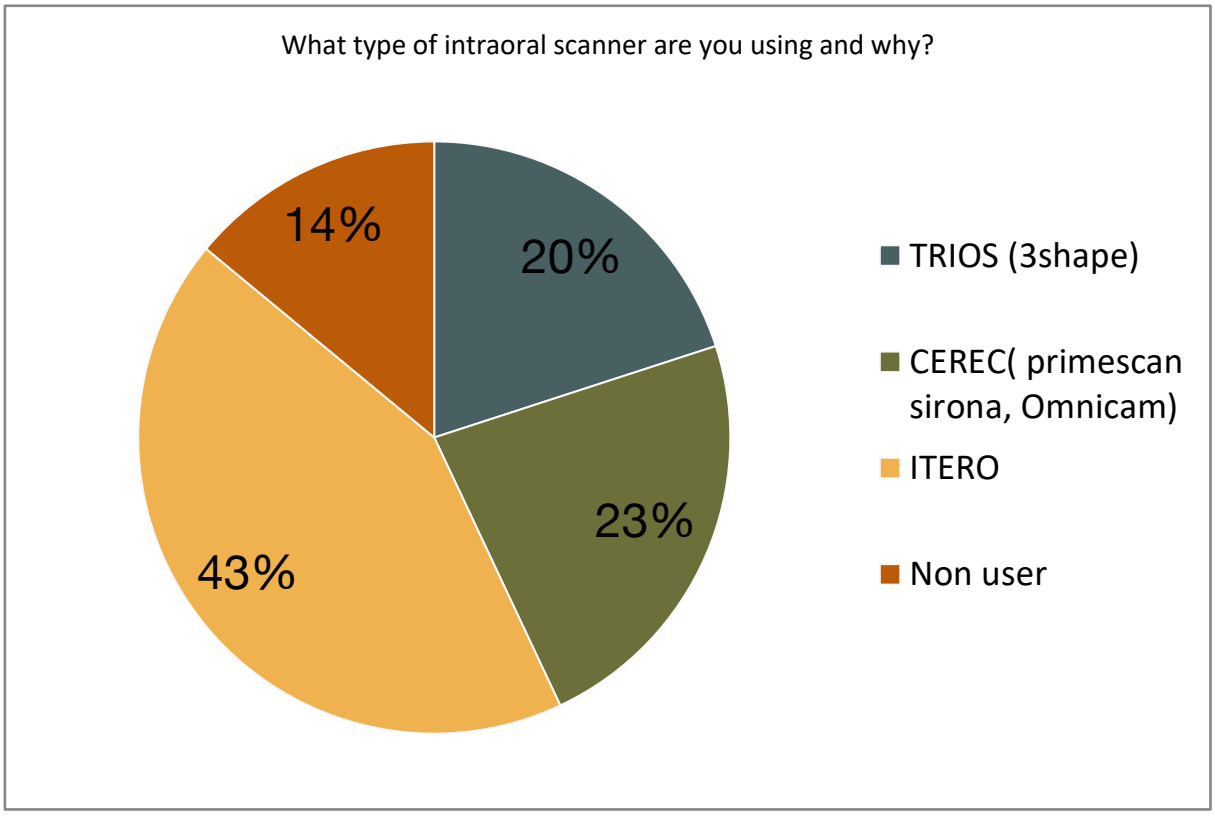
-To the question 3: Do you currently use intraoral scanner (IOS) in your practice? If not, what is the main reason?

- 30 professors answered
- 26 professors are using the intraoral scanner in their daily practice, corresponding to 87%
- 4 professors are not using the intraoral scanner due to the price of the device, lack of time needed to acquire it, corresponding to 13%



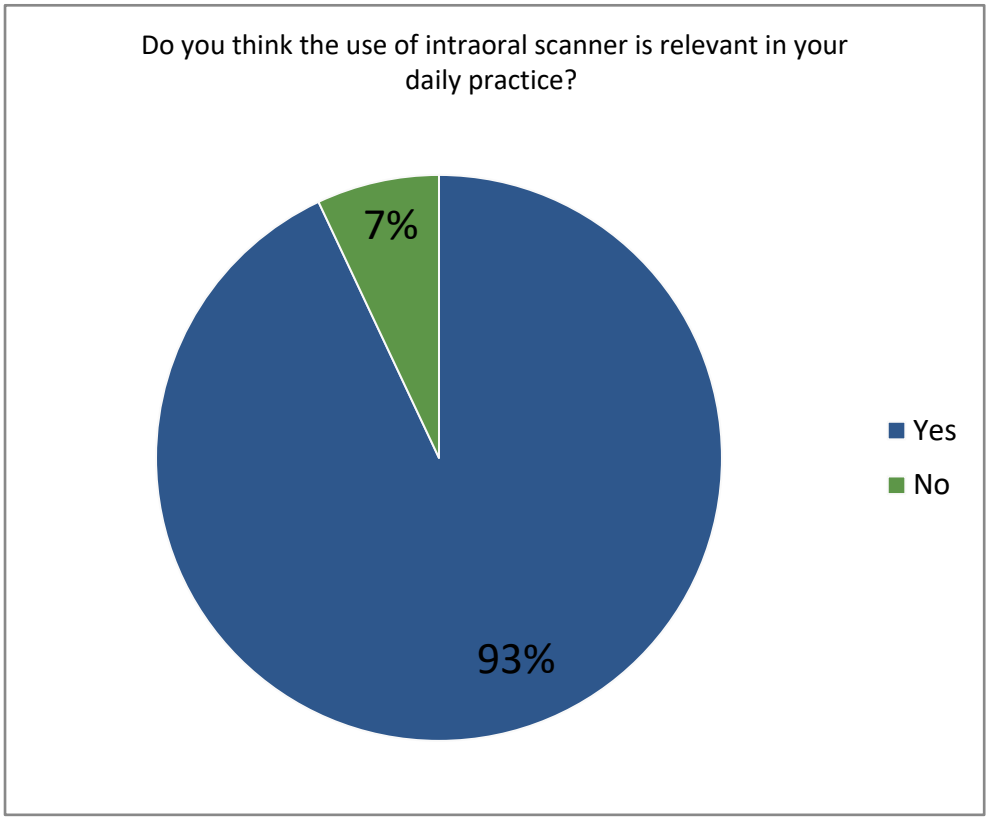
-To the question 4: What type of intraoral scanner are you using and why?

- 30 professors answered
- TRIOS (3shape): 6 professors are using it, corresponding to 20%, they did not precise the reason why they use this type.
- CEREC (Primescan sirona, Omnicam): 7 professors are using it, corresponding to 23%, it is the scanner available in their clinic
- iTero: 13 professors are using it, corresponding to 43%, it is the scanner available in their clinic and also, they use it for its reliability.
- No user: 4 professors are not using intraoral scanner in their practice, corresponding to 14%



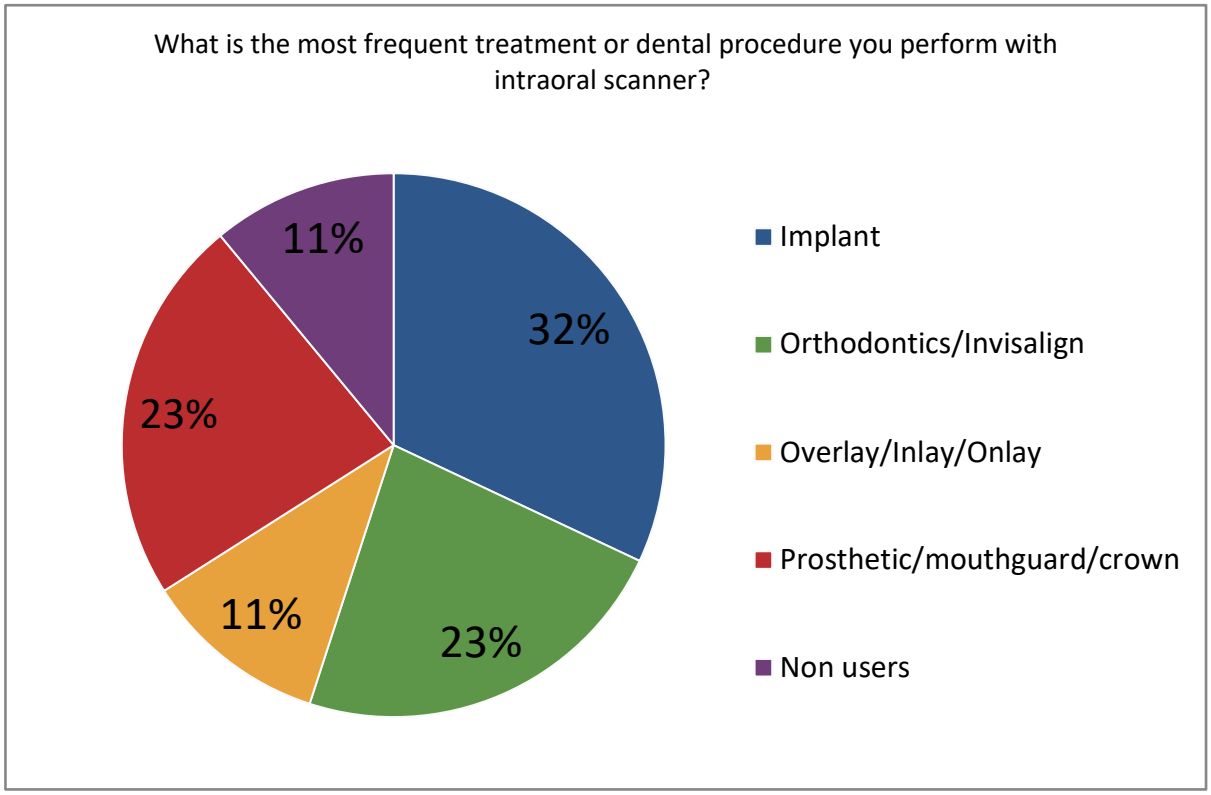
-To the question 5: Do you think the use of intraoral scanner is relevant in your daily practice?

- 30 professors answered
- 28 professors answered yes, the intraoral scanner is relevant in their practice, corresponding to 93%
- 2 professors answered no the intraoral scanner is not relevant in their practice, corresponding to 7%



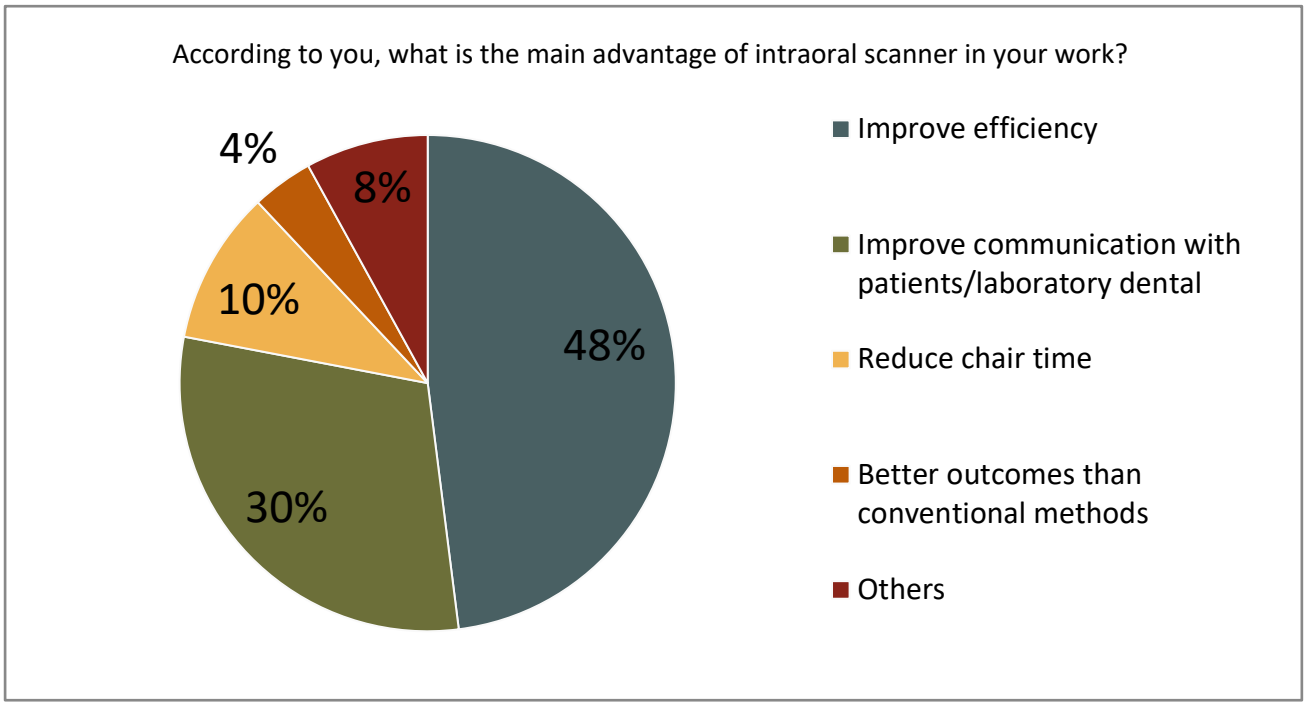
To the question 6: What is the most frequent treatment or dental procedure you perform with intraoral scanner?

- 30 professors answer (some professors put two/three answers), so we had a total of 35 answers.
- Implant: 11 professors use more frequently the intraoral scanner for implant treatment, corresponding to 32%
- Orthodontics/Invisalign: 8 professors use more frequently the intraoral scanner for orthodontics/Invisalign treatment corresponding to 23%
- Overlay/Inlay/Onlay: 4 professors use more frequently the intraoral scanner indirect restorations, corresponding to 11%
- Prosthetics/Mouthguard/Crown: 8 professors use more frequently the intraoral scanner for prosthetics treatment, corresponding to 23%
- Non-users: 4 professors do not use the intraoral scanner, corresponding to 11%



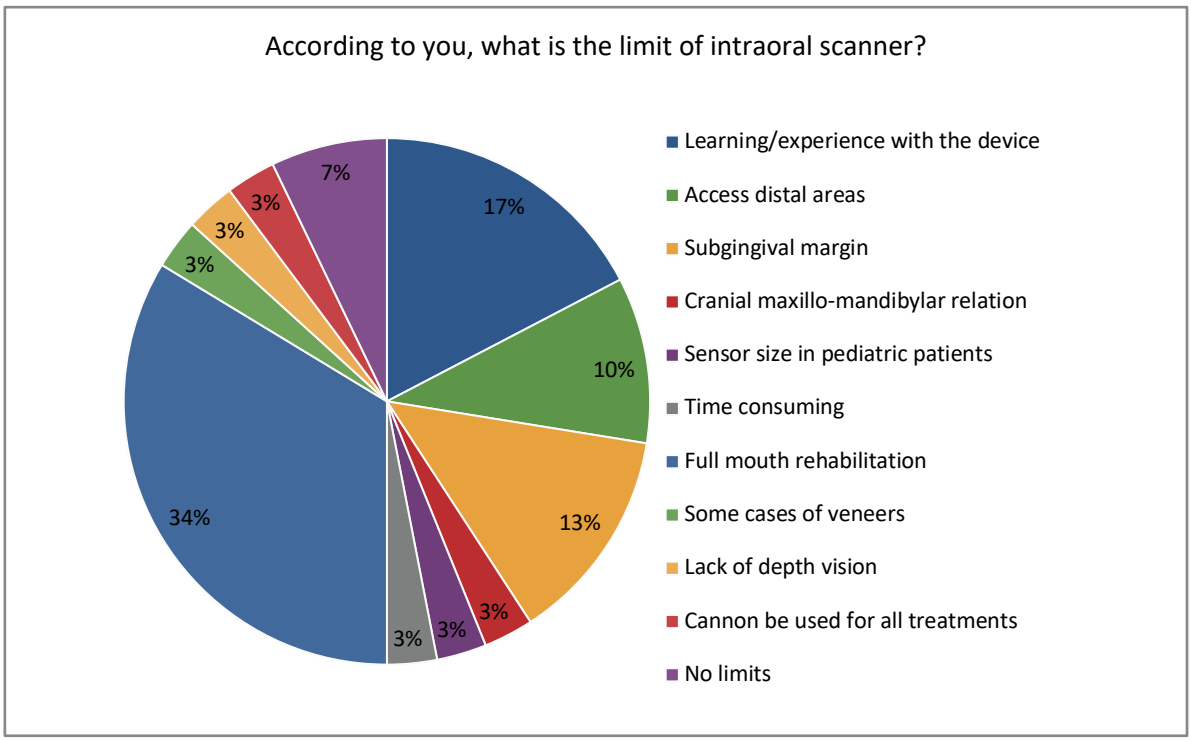
-To the question 7: According to you, what is the main advantage of intraoral scanner in your work?

- 30 professors answered
- Improve efficiency: 14 professors answered this choice, corresponding to 48%
- Improve communication with patients/laboratory dental: 9 professors answered this choice, corresponding to 30%
- Reduce chair time: 3 professors answered this choice, corresponding to 10%
- Better outcomes than conventional methods: 1 professor answered this choice, corresponding to 4%
- Others: 2 professors answered this choice, corresponding to 8%

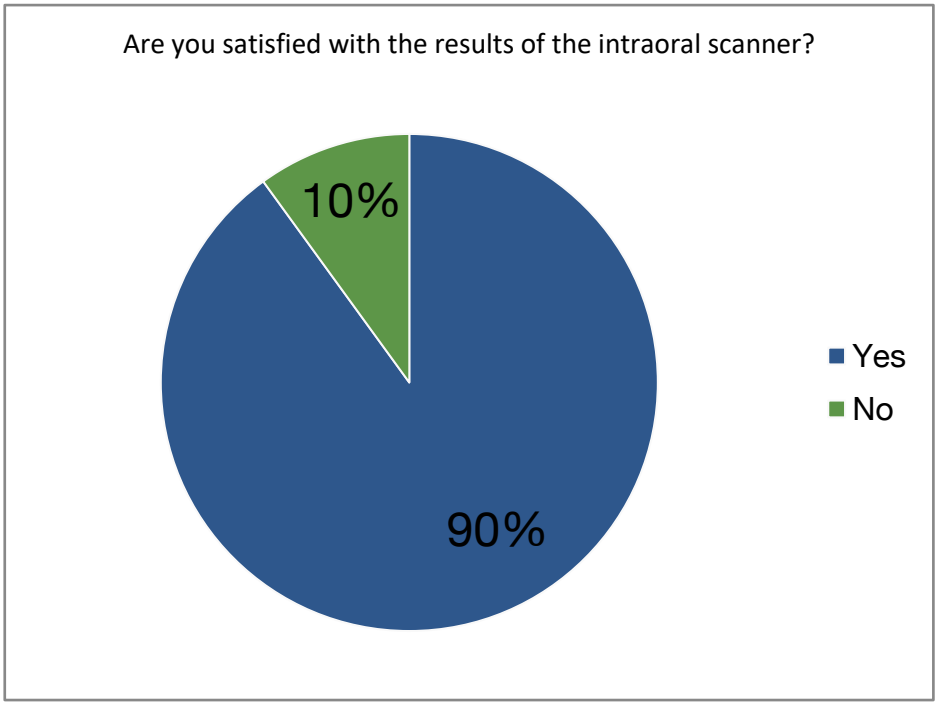


-To the question 8: According to you, what is the limit of intraoral scanner in your work?

- 30 professors answered
- Learning/experience with the device: 5 professors answered this limit, corresponding to 17%
- Access distal areas: 3 professors answered this limit, corresponding to 10%
- Subgingival margin: 4 professors answered this limit, corresponding to 13%
- Relation cranial maxillo-mandibular: 1 professor answered this limit, corresponding to 3%
- Sensor size in pediatric patients: 1 professor answered this limit, corresponding to 3%
- Time consuming: 1 professor answered this limit, corresponding to 3%
- Full mouth implants rehabilitation: 10 professors answered this limit, corresponding to 34%
- Some cases of veneers: 1 professor answered this limit, corresponding to 3%
- Lack of depth vision: 1 professor answered this limit, corresponding to 3%
- Cannot be used for all treatments: 1 professor answered this limit, corresponding to 3%
- No limits: 2 professors answered this limit, corresponding to 7%



- **-To question 9:** Are you satisfied with the results and evolution of treatments performed with intraoral scanner?
- 30 professors answered
- 27 professors answered yes they are satisfied with the results of the intraoral scanner, corresponding to 90%
- 3 professors answered no they are not satisfied with the results of the intraoral scanner, corresponding to 10%



5.DISCUSSION

Regarding the results we obtained about the age of the professors of the UEM, no correlation between age and utilization or not of intraoral scanner has been found. In fact, the non-users are respectively 37,49,53 years old. But Dalal et al said that the use of intraoral scanner can be challenging for older clinicians, as they might be unfamiliar to use internet and software. (18)

From the results of my survey, most of the professors of UEM are using intraoral scanner in their daily practice, and few one does not use it due to the price of the device, lack of time needed to acquire it. Regarding the study, made in 2020 by Merchant et al, 94,3% of general practitioner and 100% of prosthodontists used the intraoral scanner in their practice. (2) Also, in a study conducted in 2021 by the American dental association, 53% of practitioner use intraoral scanner and 47% did not use it. (9) However, in a randomized crossover trial of 2016 made by Joda T and Bragger U, they concluded that a few numbers of dental clinics (5 to 15%), have initiates the optical impression within the intraoral scanner.(4) Some dentists might be unwilling to integrate this type of devices in their practice, since they trust that elastomeric conventional impression materials and technique are used since long time and presented a good effectivity.(4) But, with the popularization of the digital devices, IOS continue to immerse the market, and most of the practitioners must decide if they invest or not in those type of equipment. (4) In fact, it is necessary to learn about new devices, software, and machines and to understand how to integrate them efficiently into the workflow, to choose the most appropriate IOS types for their patients. (1,15) In terms of results, we see a real concordance, as most of the professors are users of IOS.

Concerning the question about the type of scanner that used the professors of the UEM, 3 commercial brands available in the market were answered: TRIOS, iTero and CEREC. The widely used was iTero, in fact, most of the professors are using this brand in their daily practice. Some of them precise that they are using it because it is the scanner available in their clinic, they have commercial agreement with this brand, or for its high reliability. It is important to point out the importance of the distributor company, because if there is any problems or dysfunction of the devices, the dental team must be

able to contact the distributor for urgent assistance or to realize maintenance of the scanner. (13) iTero scanner is considered as type « open system » as it uses the « standard triangulation system (STL) files that are compatible with many systems like Invisalign. (7) It presents a scanner sleeve that can be useful in order to retract tongue, cheek or soft tissues. (7)

One of the most advantages of the TRIOS intraoral scanner, is that the system does not require the powdering process (7) explained before. Regarding a study made by Mutwali et al, to measure the distance between arches, they found that TRIOS obtained the lowest score in term of trueness and precision. However, in a study realized by BioMed where they are comparing the accuracy of different intraoral scanner available on the market (8), they found that the TRIOS series obtained a higher accuracy compared to others commercial brands of intraoral scanner. (8) Their study agreed, with a study done by Renne et al where they established that the 3shape trios have the better balance in term of speed and accuracy, in the full arch scanning. (8)

In one study, it showed that iTero element, using chair and room light conditions resulted in better accuracy, whereas, for CEREC Omnicam, zero light resulted in better accuracy and for Trios 3, room light gave the best accuracy. (2)

Concerning the CEREC Omnicam, powder agent is not required also. (7) The handpiece permits to have a simpler camera rotation as it contained a rounded camera tube. (7) Moreover, case may be sent from the dental clinic to a lab employing Sirona in Lab software through Sirona connect, which is a free serve with unlimited usage and no yearly additional costs. (7)

The characteristics of each IOS dictate their principal application areas, and understanding the variations within IOS may allow clinicians to select the best tool according to their specialties. (13)

However, trueness and accuracy are not the only features that might be distinguish the commercially available devices today. A lot of criteria should be evaluated to differentiate the IOS in terms of their clinical usage (need of powdering, scanning speed, tip size of the handpiece, and impressions in color or not). (13)

Regarding the main advantage of intraoral scanner, improve efficiency was the most cited one by the professors of the UEM. Speaking about the time efficiency, an intraoral scanner is enabled to capture a complete arch within 3min, it did not show up that a main difference in time efficiency taking from a conventional impression, but rather it come from the amount of time saved avoiding subsequent steps of conventional impressions .(6) Indeed, with digital impressions, stone cast for example are not needed (6), also there is no need to deliver plaster models via couriers to the dental laboratory as the three-dimensional virtual model of the patient can be sent directly to the dental laboratory.(6) All these advantages permit to save a lot of time and money during a working year.(6)

It also enables to improve efficiency in the implant treatment plan for example, as it allows, thanks to the scanning, a precise and correct planning of an implant treatment. (4)

In terms of management and archiving, with digital impressions, the dentist can store all of those files that can be easily find in whatever place and any time. As, they do not require physicals saved compared to the conventional ones. (4)

The IOS also improve communication with patients and dental laboratories. The dental technician and the clinician could both evaluate the impression in direct thanks to the IOS. (6) In fact, as explained before, the dentist can send immediately by email the scan of the patients to the lab, so the technician can correctly verify it and approved it or may require the clinician to produce another optical impression without asking the patient to come for a second visit, it simplifies clinical procedures. (6)

IOS also provides the opportunity to show our patient the 3D model of their future restoration or the different phase of their aligners in orthodontics, showing them their final smile at the end of the treatment. It is an advantage because they provide more interest in their treatment and an effective communication with the dentist is enhanced. (4,6)

In our results, there is a big difference regarding the main advantages, as said before most of the professors of UEM said that clinical efficiency is the main advantage.

Whereas, in a panel survey of the American dental association, better outcomes than conventional methods were the most voted by the participants. (15) In case of single-tooth restoration and fixe partial prothesis of up to four or five components, the scientific literature currently said that the accuracy of optical impression is clinically adequate and comparable to conventional impressions. (6) But optical impression are not as accurate as traditional impressions for treatment like full arch protheses, implant of partial fixed prostheses with more than 5 elements. (6)

Among other advantages, we should include the reducing risk of infection, as clinician do not have to handle the impression materials (4), the reducing patient's pain and discomfort, as no impression materials placed directly in the mouth of the patients are necessary. (4) In fact, they can cause discomfort due to inconvenience from the impression materials in the trays. (6) Also, it is more comfortable for some patient with strong gag reflex or children. (6)

The benefits of digital scanning for orthodontists include enhanced diagnosis and treatment planning, increased case acceptance, quicker record submission to laboratories, fewer retakes' impressions, shorter chair times, standardization of office procedures, less need for storage, improved appliance accuracy, enhanced workflow, lower inventory costs, and shorter treatment times. The patient will benefit from a better case presentation, a more comfortable and anxiety-free orthodontic experience, shorter chair visits, simpler refabrication of lost or damaged appliances, and maybe shorter treatment times. (7)

Speaking about the most frequent treatment performed with IOS among the dental professors, 32% answered for implants. However, in the panel survey of the American dental association (15), 90% of the respondents answered single tooth-supported crowns as the most realized treatment with the scanner. (15) IOS are digital tool of great helpfulness and can be used in various specialties of dentistry like prostheses, surgery, and orthodontics. (11) Regarding the result of our survey, those fields were also the most answered. Nowadays, the CAD/CAM technology are permitted to produce digitally implants abutments and surgical guide, that have ideally enabled for more accurate and precise flapless insertion of implant. (20,21)

In the orthodontics field, the IOS serve as a very helpful equipment for diagnosis and treatment. (11) In fact, orthodontist can fabricate customized orthodontics devices for example: aligners, bracket or expanders with more accuracy and efficiency (7,11) and permit to evaluate the anticipated results in advance. (20) Also, we must underline that, also related to the branch of orthodontics, the IOS are useful and adopted better within children or patient with cleft lip or palate, as they present less discomfort than conventional procedures. (22,23). However, in a clinical trial made by Grünheid et al, about patients' acceptability and perceptions, they observed that patients preferred conventional impressions because they noticed that the size of the scanner tip provide discomfort. (24) But this problem tends to be solved, in fact, the new design of intraoral scanners presents a narrower tip. (24)

Regarding prostheses, dentist used digital impressions for preparations over natural teeth, fabricate various prosthesis restorations: indirect restoration like inlays/onlays/overlays, single crown with Zirconia for example, as it is the more used for the fabrication, and fixed /removable partial dentures or implant-supported restorations. (11,15) IOS is also useful in this field, as we obtained a reduction of visits compared to the appointments required using a conventional workflow. (20)

In a prospective clinical study made by Otto T and De Nisco, they concluded that the indirect restorations fabricated by CAD/CAM have a higher survival rate than the ones produced with conventional procedures. (15) Talking about the removable complete dentures, we count only 2 manufacturers that affirm they can produce removable complete dentures with the CAD/CAM technology. (15) But, a lot of studies have been suggested about the creation of a removable full denture, but, until today, no clinical findings or trials have been published. (15)

93% of the professors think that the use of IOS is relevant in their daily practice. IOS became one of the beneficial and helpful dental treatment devices for patients, dentist, and dental laboratories. (4)

Despite these numerous advantages, IOS presented some limitations, and obviously cost is one of a major issue for some dentists. (15) Among the professors, the full mouth

rehabilitation represented the most important limitation. The inaccuracy produced by intraoral scanner of fully edentulous patients does not seem compatible in the production of long-span restorations on multiple implants, for which traditional impressions are still advised. (11,14) We also see in the studies that it is difficult to obtained a correct capture of the occlusion information in the case of complex prosthodontics treatments. (14)

The learning curve was also a limitation regarding the professors. For some people, the learning curve might be challenging. (14) In fact, the IOS technology is complicated, and in order to provide an accurate scanning, skills, dexterity, training and experience are required. (18,36) Especially for aged people, that sometimes are not familiar with software, internet. (18)

Using the IOS is a huge challenge for the professionals, because they also have to take into account when scanning, the soft tissue retraction, moisture control, gingival fluid or blood, as they can cause error due to refraction of the light. (4)

Subgingival margins represent a difficulty for the dentist with IOS, in case of hemorrhage as they can obscured the subgingival margins and consequently make the scan imprecise. (18) Also, we can find some scanning errors when have the presence of saliva film on the scanned tooth, that might cause a misreading of the geometry of the surface. (2)

Talking about the satisfaction with the IOS, 90% of the professors answered yes, they are satisfied. It is almost an equality compared to the panel survey (15), where 91% of the respondents were satisfied with the device. (15) In fact, numerous filed of dentistry, either orthodontics, prosthodontics takes the huge advantages provide by CAD/CAM by giving treatment of quality with accuracy and effectivity, making also satisfied patients. (21,22) In a study of Gjelvold et al, they observed that compared to traditional impression procedures, using a digital impression approach was more comfortable for dentists and patients. (5)

Regardless of the technology utilized, an objective review of the research available in the literature suggest that IOS is clinically appropriate for everyday practice. Each

technology must be considered in the context of the specific activity, needs, and practitioner expectations. Every practitioner who wants to reach a successful clinical approach while scanning prepared teeth must have complete knowledges of IOS technology. Nevertheless, due to the absence of defined protocols or comparative in vivo investigations, there is presently no scanning technique, scanner, or technology that can be agreed upon as being more accurate. (7) Most of the results we obtained from our survey among the professors are cohesive with the literature. (7)

6.CONCLUSION

Most of the professors of the UEM are currently using the intraoral scanner in their practice, we obtained a percentage of 87% of users. Price and time to acquire it are the main reasons of the non-users.

We investigate among the several applications and found that, IOS can be used in many fields of dentistry as: prosthodontics, orthodontic, implantology, indirect restoration, pediatric dentistry. This device is very helpful and useful for the dentist as they can enhanced diagnosis, and treatment plan and are also much more accepted by the patients than the conventional impressions.

Despite the numerous advantages, this technology presents some limitations for the realization of some treatments. In fact, the scanning forms for full mouth rehabilitation, subgingival margin, learning, need of experience with the device and access to distal areas are one of the most limits cited by the UEM professors and the practitioners.

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8.ANNEXES

Yo, Mª Jesús Pardo Monedero, directora del Departamento de Odontología Preclínica **APRUEBO** la realización del Trabajo Fin de Grado titulado: **The use of the intraoral scanner among dental professors at the UEM.** que va a ser desarrollado por el alumno D. Ignace Jayati y tutorizado por la profesora Dra. Dña. Meriem Benabdallah.

Código de aprobación: OD. 022/2223

Madrid 16 de enero de 2023.

Fdo: Dra. Mª Jesús Pardo Monedero.
DD. Odontología preclínica.
Grado en Odontología. UEM.

Annexe 1: Approval of the faculty/department

Universidad Europea

Comité de Ética de la Investigación de la Universidad Europea

Meriem Benabdallah

Universidad Europea de Madrid

Villaviciosa de Odón, 24 de febrero de 2023

Estimada investigadora:

En relación al Proyecto de Investigación titulado:

"The use of intraoral scanner among dental professors at the UEM",

este Comité de Ética de la Investigación ha procedido a la revisión del mismo y ha acordado que está en situación de:

APROBADO,

Al proyecto se le ha asignado el código interno **CIPI/23.062**

Atentamente,

Fdo.: Lola Pujol

Secretaria del Comité de Ética de la Investigación

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Annexe 2: Approval of the ethics committee