FACULDADE DE MEDICINA

UNIVERSIDADE DE COIMBRA

MESTRADO INTEGRADO EM MEDICINA DENTÁRIA

STATE OF THE ART OF DENTAL IMPRESSIONS – DIGITALTECHNIQUES

SUPERVISOR: PROF. DOUTOR FERNANDO GUERRA

CO-SUPERVISOR: DR. RICARDO DIAS

AUTHOR: LUÍS GAIA BRAZ

COIMBRA 2012

State of the Art of Dental Impressions – Digital Techniques

Gaia Braz L.*, Dias R. Guerra F. ***;**

*** Estudante do 5.º ano do Mestrado Integrado em Medicina Dentária pela Faculdade de Medicina da Universidade de Coimbra**

**** Assistente convidado, Faculdade de Medicina da Universidade de Coimbra – Área de Medicina Dentária**

***** Professor auxiliar com Agregação, Faculdade de Medicina da Universidade de Coimbra – Área de Medicina Dentária**

Endereço: Área de Medicina Dentária da Faculdade de Medicina da Universidade de Coimbra, Avenida Bissaya Barreto, Bloco de Celas
3000-075 Coimbra

Telf: +351 239484183
Fax: +351 239402910

Endereço electrónico: lgaiabraz@gmail.com

Abbreviation Key

2D – 2 Dimension

3D – 3 Dimension

B – Bucco

CAD – Computer Assisted Design

CAM – Computer Assisted Machined

CDIS – Chairside Digital Impression System

COP - Clowd of Points

D – Distal

DP – Dental Plaster

GLM – General Linear Models

L – Lingual

M – Mesio

O – Occlusal

PVS – Poly(vinyl-siloxane)

Abstract

Introduction: Among keystones for the prognosis of fixed prosthesis rehabilitations are the impression quality and the respective work model. During conventional impressions, some errors induced by issues related to materials, techniques or human errors could occur and lead to information loss. 3D dental scanners have been in development since the 80's and they are a link to present and future of dental impressions and dental restorations.

Objective: The main objective of this pilot study is to evaluate the trueness of the iTero® CDIS by comparing the dimensions of a virtual model obtained by digital impression, the original model and the correspondent plaster model obtained by a traditional impression.

Materials and Methods: The pilot study was divided in two parts, both using the iTero®, and five Frasaco AG-3 acrylic teeth FDI 46, which were then impressed by a conventional technique and poured with type IV dental plaster. The first part consisted of the comparison of the measurements of the scanned acrylic teeth with the acrylic teeth and the dental plaster teeth, measured with a digital caliper. The second part compared the acrylic and dental plaster teeth while scanned by the iTero® and measured by it.

Results: On the first part of the pilot study, a pairwise comparison test showed a statistical match ($P>0.05$) between the acrylic teeth and the iTero®, and the dental plaster teeth and the iTero®. On the second part, iTero® readings comparison of both acrylic and dental plaster models showed no statistical differences.

Conclusion: Digital impressions seem a promising tool to be explored in the near future, even though more tests are required to evaluate its in-vivo performance. The iTero® dental scanner according to our pilot study, and considering its limitations, reflects trueness on the measurements performed.

Keywords: Conventional Impressions, Digital Impressions, Digital Impressions Error, CAD/CAM

Introduction

A conventional impression is a process by which a negative image of the desired area is produced and then poured with dental plaster into a stone cast model that replicates the positive model. During this process, some errors induced by issues related to materials, techniques or human errors could occur and may lead to information loss. To minimize the problem, materials should be selected according to properties and results expected (Table 1) (1).

In 1965, the polyether Impregnum^{TM} was released by ESPE^{TM}, and provided professionals with an impression material that had a relatively fast setting time, excellent flowability, outstanding detail reproduction, adequate tear strength, high hydrophilicity, and low shrinkage. However, polyether was found to be distasteful due to its bitter flavor.

In the 70's, PVS impression materials solved the issues of dimensional inaccuracy, odd smell and taste, and high modulus of elasticity. Moreover, PVS impression materials offered excellent tear strength, greater flowability and no distortion regardless of the delayed pouring of the models(1).

Techkouhie's recent review on impression materials used in fixed prosthodontics shed a light on their general and particular properties and what could be expected from each material. He also refers problems with the interaction and incompatibility of different materials which is something to be taken into consideration. For instance, the ferric sulfate or adrenalin used for hemostasis may inhibit the setting process of PVS and polyethers, while aluminium sulfate and epinephrine will not. More, the usage of latex gloves when manipulating PVS putty materials may alter the setting behavior of material, even in situations of previously worn latex gloves. Hand washing after removing the gloves detaches the contaminants and reduces the skin temperature thus preventing these thermal sensitive materials from deterioration or incorrect setting. Surfaces to be mold should be cleaned with 2% chlorhexidine to remove contaminants such as sulfur-based compounds and to avoid inaccuracies, and to decrease surface temperature(2).

Table I – Ideal properties of impression materials to fixed prosthesis(2, 3)

Impression Material	Dental plaster
Accuracy	Rigidity
Tridimensional stability	Not very friable
Low polymerization reaction shrinkage	Low setting expansion
Flowability/hydrophilicity	Good work lenght
Biocompatibility	Good reproduction of details
Appropriate setting time	Allows for the creation of a stone die
Strong tear strength/elastic recovery	Handling easiness by the dental technician
Acceptable smell, taste, and texture	(insensitive technique)

After taking the impression, stone models are obtained. Errors associated with type of gypsum, conditions and technique of manipulation of the dental plaster influence the final result of work model (Table II).

Table II – Errors associated to inaccuracies in cast models		
Materials	Techniques	Human
Mixing of the materials (proportions and temperature conditions) Incompatibilities Storage capability	Non rigid impression trays Anatomic limitations	Removing the tray before the materials have set. Removing the model before setting of dental plaster.

3D dental scanners have been developed since the 80's. Their ability to capture digital images can be advantageous in the treatment of patients who are gaggers and cannot tolerate impression materials, that have anatomical limitations, e.g., mandibular or maxilla tori which might difficult the removal of the impression tray, that have limited mouth opening or that have reduced interocclusal space(1). More, it is advantageous as allows dentists and laboratories to be synergistically in complement. Upon taking an impression, the clinician sends the data to the dental technician and, if needed, reviews the case while the patient is seated, thus adjusting any problem that might have been detected. This saves time to both the patient and the dentist, because it spares an additional visit for a new impression(4, 5).
Contemporary digital intraoral impression taking relies on optical measuring techniques with visible light. There are three main CDIS, which are summarized in table III.

Table III – Some CDIS systems and relatedproperties(6)			
	iTero®	CEREC® AC Bluecam	Lava C.O.S.®
Captation Method	parallel confocal imaging	active triangulation	active wave front sampling
Coating Powder	No	Yes (Optispray®)	Yes
Indications	All	All	Up to 4 unit bridges
Data Import/Export	Major CAD front end systems - Dental Wings, 3 Shape, CEREC® Conect, Standard STL File	CEREC® Connect	LAVA

Parameters such as trueness and precision are evaluated to ascertain the accuracy of the digital model. Trueness relates to the difference between the measured value and the true size of the object, whereas the precision reflects the fluctuation of several measurements of the same object (7).

The main objective of this pilot study is to evaluate the trueness of the iTero® CDIS by comparing the dimensions of a virtual model obtained by digital impression, the original model and the correspondent plaster model obtained by a traditional impression.

Materials and Methods

The laboratorial (experimental) part of our project comprised direct contact with the CDIS - CadentTM's iTero® (images 1 and 2), the system available at the Faculty of Medicine of the University of Coimbra.

Image 1 – Cadent™'s iTero® - Courtesy of Cadent™

Image 2 – iTero®'s Scanner - Courtesy of Cadent™

To understand the mechanics of the scanner, we read thoroughly the instruction manual and attended to a demonstration by the sales representative. The primary menu is in service of the patient's data inputation, laboratory choice, and set of the definitions of the preparation to be scanned (image 3).

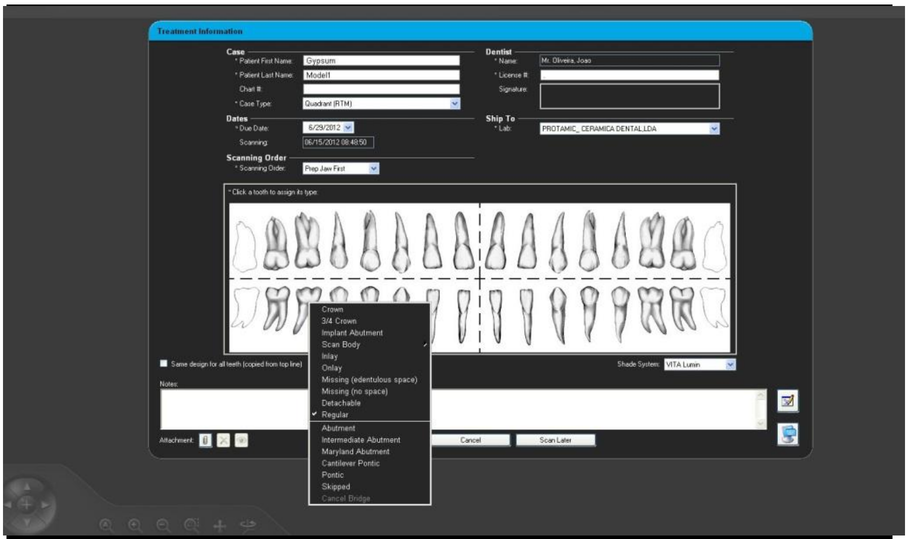

Image 3 – Patient's data and treatment selection

After choosing the preparation desired, the clinician must choose the restoration material, marginal design limit and color (image 4). Given the nature of the study, these factors were considered irrelevant, therefore, restoration material and colors were chosen at random.

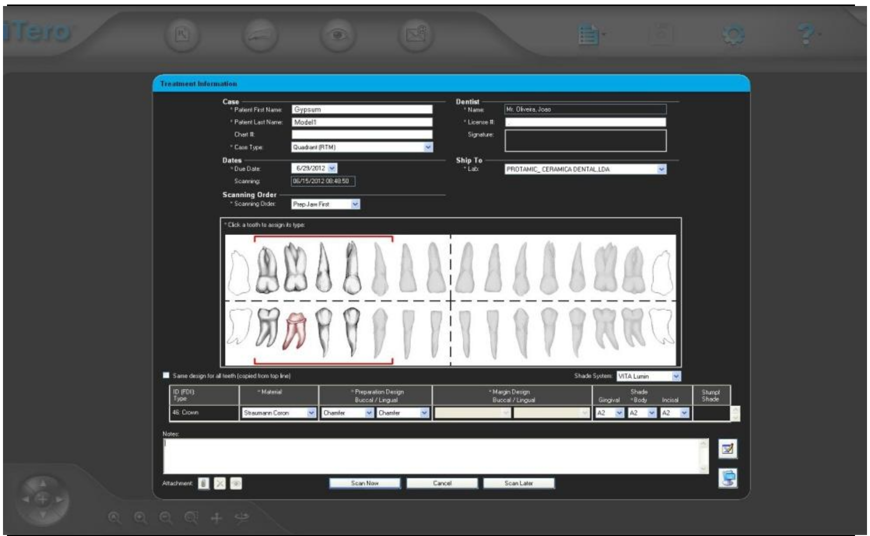

Image 4 – Patient's data and treatment selection

When the scanning procedure begins, the scanner is placed over the position indicated by the software and the commands to capture the images are given (images 5 - 8). Upon the superimposition of the images, the software builds the 3D virtual model that we will be used.

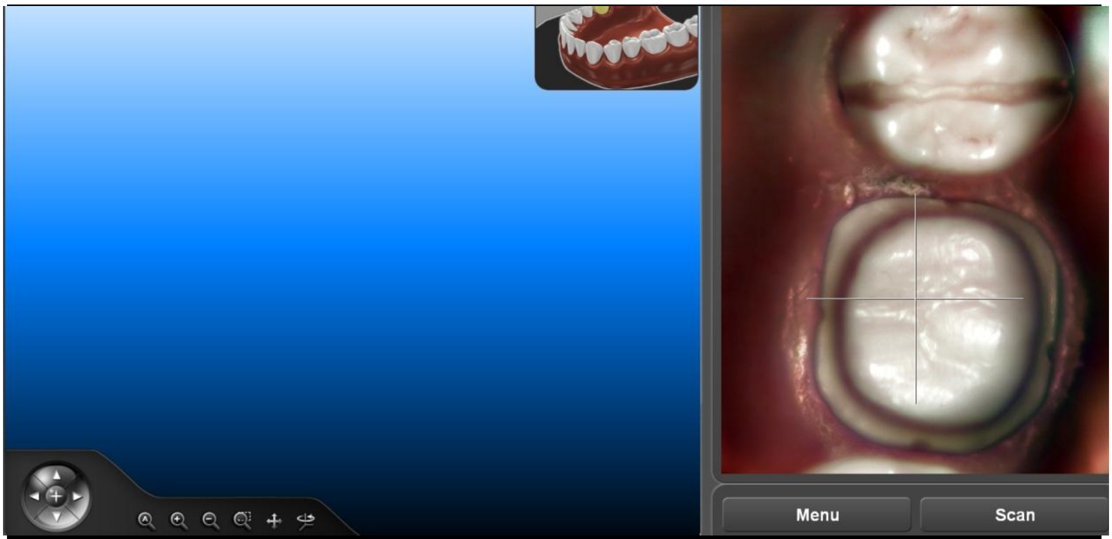

Image 5 – Scanning procedure's first shot – Occlusal FDI 46

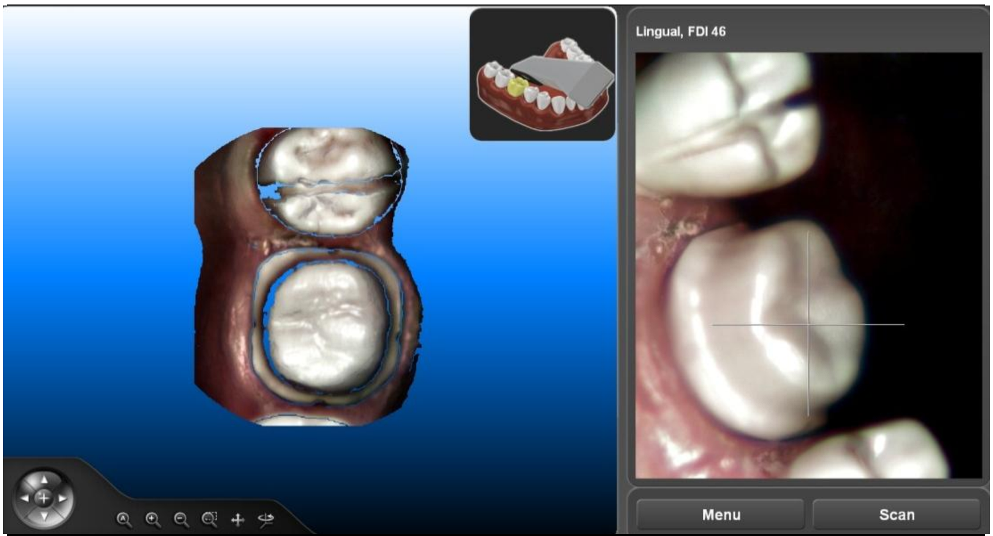

Image 6 – Scanning procedure's second shot – Lingual FDI 46

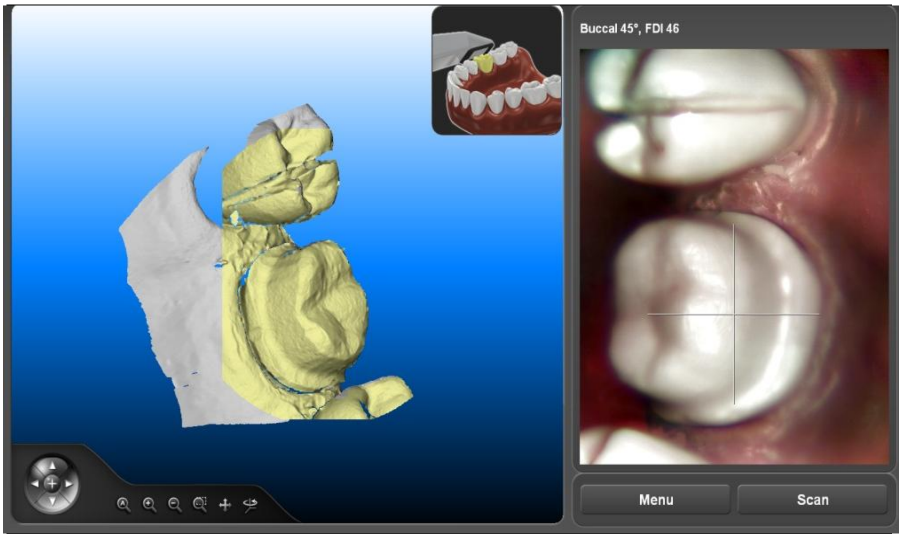

Image 7 – Scanning procedure's third shot – Buccal 45º FDI 46

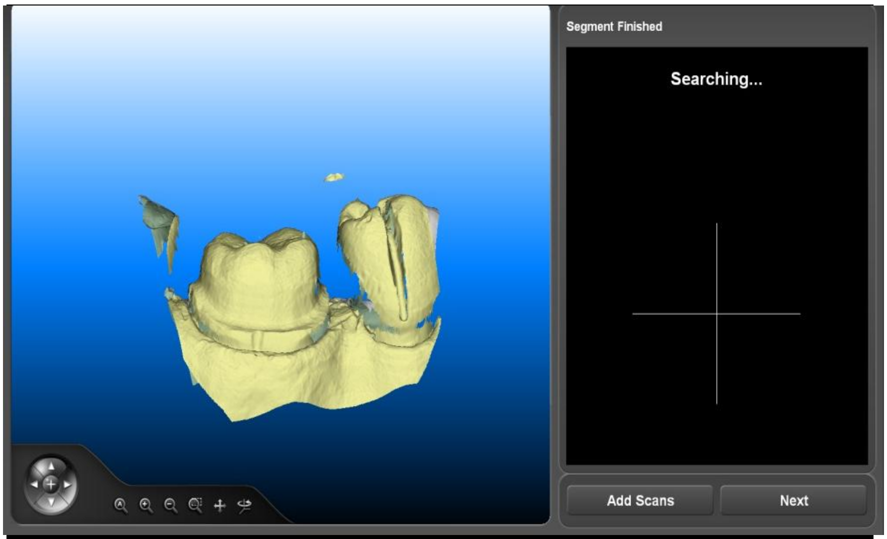

Image 8 – Scanning procedure's first segment finished

On both parts of our pilot study, we used Frasaco AG-3 models, and five acrylic teeth FDI #46 with metal-ceramic crown preparations. Teeth were carved about 1.5 mm in the occlusal aspect, 1.5 mm in the buccal aspect in two planes (the first near the occlusal plane with 30-35º relatively to hinge axis of the tooth, and the second in the cervical region, parallel to the main axis and converging to oclusal), and 1.2 mm in the lingual aspect. No buccal sulcus was carved, as it was not necessary for the purpose of our study. We carved 4 small grooves, one in each aspect of the marginal design limit to guide our readings.

Firstly, the study aimed at the comprehension of the trueness of the scanner. Teeth were individually molded by a conventional technique with Colthene's Affinis® Putty and light body (image 9), and poured with Kerr's ISO type IV gypsum Vel Mix-Stone (image 10) with the aid of a cast vibrator. Then both the mesio-distal and bucco-lingual diameter of the acrylic and gypsum teeth were measured with a digital caliper, sensitive to the micron (10^{-6}m) unit (Images 11 and 12). Teeth were also scanned to measure mesio-distal and bucco-lingual lengths visible from the occlusal aspect of the teeth.

Image 9 – Conventional impression of the individual preparations

Image 10 – The acrylic preparations and the dental plaster models

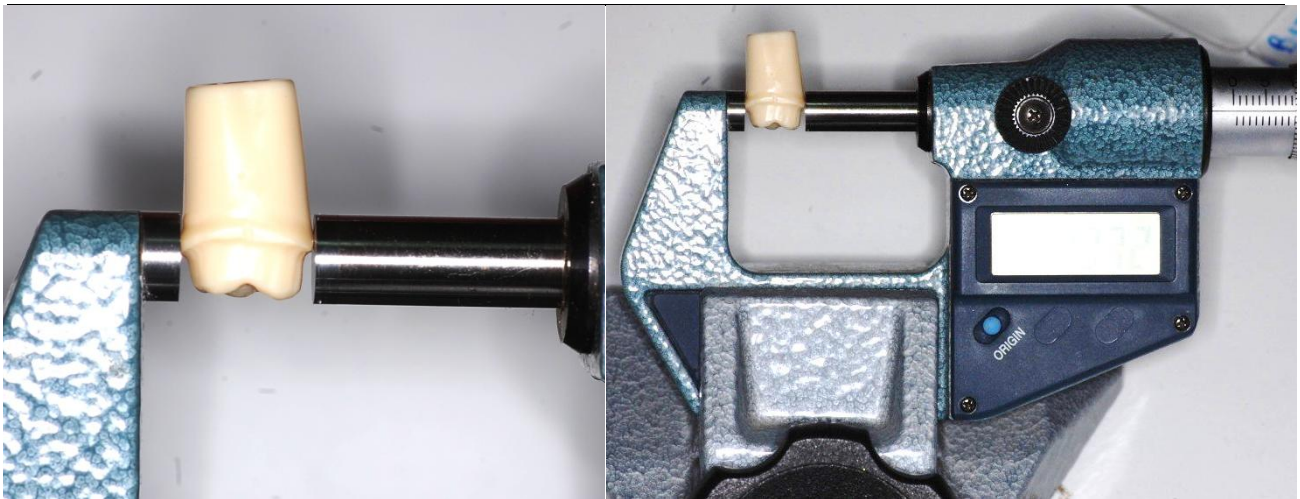

Image 11 and 12 – Measurement of an acrylic tooth with the digital caliper

On the second part of the pilot study, all the Frasaco models were impressed with Dentsply's Aquasil Soft Putty/Regular Set and Aquasil Ultra LV Fast Set, and were poured with Kerr's ISO type IV dental plaster Vel Mix-Stone with the aid of a cast vibrator (Image 13). After the dental plaster had set, we proceeded to the scans.

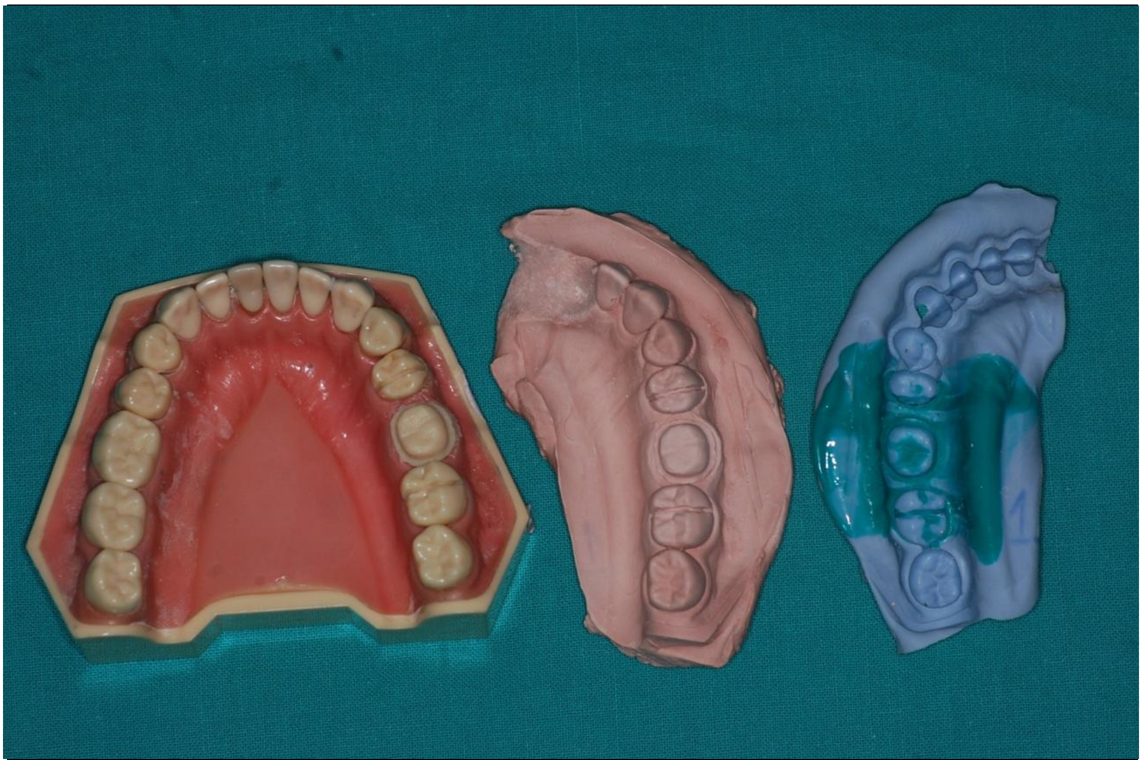

Image 13 – The Frasaco with a preparation, it dental plaster model, and the impression material

After scanning all the Frasaco and gypsum models, we proceeded to the measurements of the scans. A vertical line in the adjacent teeth was carved to guide the positioning of the scans and to aid on their interpretation. Measurements were made with the point-to-point ruler of the software, which calculates the distance between two points in space. To help positioning the images the 2D grid with 1mm was used with the help of the vertical guiding lines. As references to take the measurements we chose the highest points of the buccal cusps in the buccal aspect measured vertically down to the finishing line, the highest points of the lingual cusps in the lingual aspect measured vertically down to the finishing line, and the mesio-distal, and bucco-lingual lengths of the occlusal aspect. The ruler was set to present the results in millimeters with three decimals (microns) and the points were chosen and positioned manually.

Images of the different procedures were captured by photography or saved from the software. All the images from the software were copied with the "print screen" function (PRTSC), pasted on the MS Paint program, and saved as .jpeg files.

Results of pilot studies

Pilot study 1

The measurements are summarized in table IV.

Table IV – Measurements (µm)						
	Material/Face					
Amostra	Dental plaster MD	Frasaco MD	ITero® MD	Dental plaster VL	Frasaco VL	ITero® VL
1	9374	9398	9240	8832	8762	8792
2	9791	9904	9996	9198	9174	9366
3	9746	9935	9880	9204	9154	9304
4	9016	8957	8971	8587	8595	8575
5	9799	9802	9760	9386	9539	9575

Normality tests(Table V) were run to assess the possibility of application of the paired samples T-tests

Table V – Normality		
Material		Sig.
MD	Dental plaster	,320
	Acrylic	,286
	iTero®	,267
VL	Dental plaster	,286
	Acrylic	,215
	iTero®	,267

Given that the variables were dispersed normally, we were able to run a T-test individually comparing the samples among themselves (Table VI).

Table VI – Pairwise Comparisons		
Group		Sig.
Dental plaster	Acrylic	,849
	iTero®	1,000
Acrylic	Dental plaster	,849
	iTero®	1,000
iTero®	Dental plaster	1,000
	Acrilic	1,000

The analysis of this last test shows us that the readings made with the iTero® are a 100% match in significance with both the dental plaster, and the acrylic models and non-different from plaster!.

Pilot study 2

The measurements were organized in table VII(a and b) with its values in microns

Table VII a – Measurements (µm)							
		1		2		3	
		DP.	Fras.	DP.	Fras.	DP.	Fras.
O	MD	10,059	10,042	10,001	9,819	9,816	10,064
	VB	9,787	9,769	9,325	9,771	9,622	9,276
B	D	5,457	5,638	5,828	5,546	5,548	5,909
	C	5,338	5,397	7,294	6,410	6,403	7,120
	M	5,872	5,807	6,334	5,719	5,719	6,619
L	D	4,053	4,358	4,727	4,543	4,546	4,637
	M	4,519	4,310	4,502	4,286	4,282	4,957
Time		13'45''	12'02''	8'18''	4'28''	4'19''	15'17''
Scans		22	24	15	17	16	16

Table VII b – Measurements (µm)					
		4		5	
		DP.	Fras.	DP.	Fras.
O	MD	10,051	9,819	9,816	9,816
	VB	9,309	9,771	9,622	9,622
B	D	6,608	5,546	5,548	5,548
	C	7,067	6,410	6,403	6,403
	M	6,939	5,719	5,719	5,719
L	D	4,834	4,543	4,546	4,546
	M	4,787	4,286	4,282	4,282
Time		3'57''	4'28''	4'19''	4'19''
Scans		17	17	16	16

The test of normality (Table VIII) was made to assess the possibility of running T-tests

Table VIII – Normality test		
OMD	Frasaco	,386
	Dental plaster	,311
OVL	Frasaco	,272
	Dental plaster	,342
VC	Frasaco	,178
	Dental plaster	,259
VD	Frasaco	,278
	Dental plaster	,301
VM	Frasaco	,282
	Dental plaster	,200
LD	Frasaco	,143
	Dental plaster	,277
LM	Frasaco	,207
	Dental plaster	,235

The variables were mostly dispersed normally; we were able to run a T-test individually comparing the samples among themselves, but gave relevance only to the comparisons made between normalized variables.

Table IX – Pairwise Comparisons		
Pair 1	OMD - Dental plaster_OMD	,544
Pair 2	OVL - Dental plaster_OVL	,162
Pair 3	VD - Dental plaster_VD	,226
Pair 4	VC - Dental plaster_VC	,217
Pair 5	VM - Dental plaster_VM	,608
Pair 6	LD - Dental plaster_LD	,394
Pair 7	LM - Dental plaster_LM	,361

The analysis of this last test (Table IX) shows us that the readings made with the iTero® on the Frasaco models and the dental plaster ones are not different.

Table X – Wilcoxon Signed Ranks Test		
	Test Statistics[b]	
	Dental plaster_OMD - OMD	Dental plaster_OVL - OVL
Asymp. Sig. (2-tailed)	,416	,138

We ran the Wilcoxon Test (Table X) on the variables that were not normally distributed, and concluded that they are also not different.

Discussion

On the analysis of the bibliography we must take into account that the world of digital research is permanently changing, with ground-breaking advances at each day. For example, Sirona™ launched in 2009 their most recent CSI, the CEREC® AC Bluecam, which means that our research results prior to 2009 will include its predecessor CEREC® 3D. Most of the available bibliography reflects the opinion of experts, either on the comfort of the different CDIS, or on its advantages regarding productivity. Lowe refers the main properties desired in an impression and model, and sets some criteria of acceptance. He then makes a general overview on the advantages of using CDIS, followed by a particular analysis of each system available at the time. During his paper, he also reveals some properties of the digital techniques that must be respected (6). Birnbaum et al. also refers to the CEREC® and the iTero® CDIS, in concord with Lowe's data(1). Other author, in 2012, stated the benefits of digital impressions for fixed prosthodontics and what it would allow us to do, and did a pilot study comparing the digital and conventional techniques in terms of efficiency, by having inexperienced second year dental students perform impressions of a conventional model by conventional and digital techniques. He measured the different steps of the processes in time, and assessed the students' perception of the level of difficulty and technique preferences with a visual analog scale questionnaire. He concluded that digital impressions are more efficient, and that the students found the digital technique easier to grasp than the conventional(8).

Glassman reviewed some impression problems related to the conventional technique, as the additional chair time that may be necessary in the seating appointment to adjust contacts and/or occlusion. He concludes on his case report, that with the Cadent™'s iTero®, minimal adjustments were required with highly aesthetic and functional results(9). Ender et al.'s 2011 *in-vitro* study makes another quick review on Cadent™'s, Sirona™'s, and 3M™'s CDIS's capitation methods. He described trueness and precision as components to the technique's accuracy, which is the target of his study. He concludes with the method he used, that achieving the conventional technique's accuracy is possible *in-vitro*, but states that these data must be confirmed by *in-vivo* studies(7).

Todorovic et al. published a review on possible errors that can occur during an optical impression procedure, concluding that most of the errors are originated by limitations in the preparation for the scanning, and on its handling. He recommends that software repairs are made only when they are minor and unimportant to the restoration; however, given the simplicity of the procedure, it is better to repeat the scan(10). Henkel et al. reviewed the technology available at the time, Sirona™'s CEREC®, and the launched Cadent™'s iTero®, establishing some comparisons between the two devices. In his overview of the digital impression technique it is stated that it can scan all of the materials found in the oral cavity.

He concludes that the digital impression techniques don't make up to an inadequate preparation of the teeth(11).

The development of our pilot study was limited because the iTero®'s software is a closed work platform (original files cannot be accessed in the software). Since we could not manage to transform the iTero® files into stereolithographic (.stl) files, we could not interpret our findings with an appropriate program. This resulted in the processing of our readings in the standard software, error bound due to a multitude of factors:

- The viewer tool allowed us to rotate the image along the X axis and the Z axis, but not in the Y axis, which was fixed on the position from which the scan was taken. Given that the scans were not taken in the same position, the alignment of the images was not possible, thus, making impracticable the perfect alignment of the images and its reference points. The task of aligning the images to take measurements from the same reference points was tough because we were not able to input the exact position of the tridimensional axis, but could only do it manually through comparison with a similar image based on the squared grid.
- The software ruler calculated the distance between points in space, which means that to get an exactly equal measurement we must have equal image positioning, previously stated as impossible to guarantee. This results in measuring apparently similar distances from points in different field depths, either increasing or decreasing the value of the mensuration due to a lack of stereopsis.

To partially overcome this limitation we established the two methodologies of our pilot study. In a first approach we compared readings made by the iTero® on the acrylic teeth and the measurements made on the gypsum and acrylic teeth with the help of a digital caliper. In our second approach we used the iTero® to scan the acrylic and the gypsum teeth, thus incurring on the same error with both readings, to analyze the difference between the acrylic and gypsum readings.

The comparison of the results of this study with those of other authors is difficult, given that different techniques and digitalization systems were used. In our research we did not find any study or article on iTero's accuracy. Studies referring to the accuracy of CDIS were presented based on volumetric studies (7), while ours limited to the single measure of the distance between two points in space. Similar studies, even though not directly testing the accuracy of any CDIS, go through the analysis of the marginal fitting of CAD/CAM crowns or veneers which were made from a digital scanner image obtained on a dental appointment, to analyze the results based on volumetric properties (9, 12). Despite the limitation of our method, we obtained very promising results that brighten the discussion around the subject.

Ender (2011) considered the variables studied to be independent in the processing of his data and therefore used ANOVA to reach his conclusions. Notwithstanding, we consider those variables, as in our study, to be matched, which is why we ran our data through GLM tests.

We ran the Shapiro-Wilk normality test on the data from both our pilot studies to see if they were modeled by a normal or Gaussian distribution.

The matched samples T-Tests is used for the comparison of two paired samples. We consider two samples to be different when the significance of their comparison is inferior to 0,05. On this pilot study we used the resulting significance to establish that two samples are not different. Two samples are proportionally similar, as the significance value approaches 1. When it does, the samples match. On the pairwise comparison of the first part of the pilot study, the comparison of the iTero® data with that of both the gypsum and the acrylic measurements has a significance of 1. This means that they match and are virtually the same. The significance of the comparison between the gypsum and acrylic measurements, however, is 0,849, which despite not being 1, is statistically almost equal. To understand the discrepant significance in this last reading we proceeded to the second part of our pilot test where we used the iTero® to scan both the acrylic teeth and the gypsum models and compared them. As before, we ran a normality test and the result was that the occlusal aspect readings were the only ones not distributed normally. We ran the data through a pairwise comparison test and considered only the results for the lingual and buccal aspects. The results were all over 0,05 in significance, although between 0,143 and 0,301, meaning that they were statistically not different. To interpret the occlusal aspect data we ran a Wilcoxon test and the significance of our results was also over 0,05. Even though far from 1, we can say that the acrylic readings and the gypsum ones are not different, and can predict that the inequality is due to procedure errors and material properties.

The average time consumed in scanning procedures was 8 minutes and 49 seconds, including additional rescans. The scans that took the longest were the scans of the model 1 of both frasaco and gypsum, which were also the first ones being taken. If we look back to Galluci's study from 2012, the average working time that inexperienced second year dental students took was 8'54''±3'12'', and 1'40''±1'05'' for additional rescans. If we consider the mean time of a conventional technique, with the mixing of the impression materials, material setting time, pouring the gypsum, it's setting time, and the time for it to reach the laboratory, there is no doubt that this is a faster process. If we include the time to repeat impressions or the pouring of the gypsum because some error occurred, or any delays in delivery, we can state that overall, a digital impression technique is much faster while reliable (8).

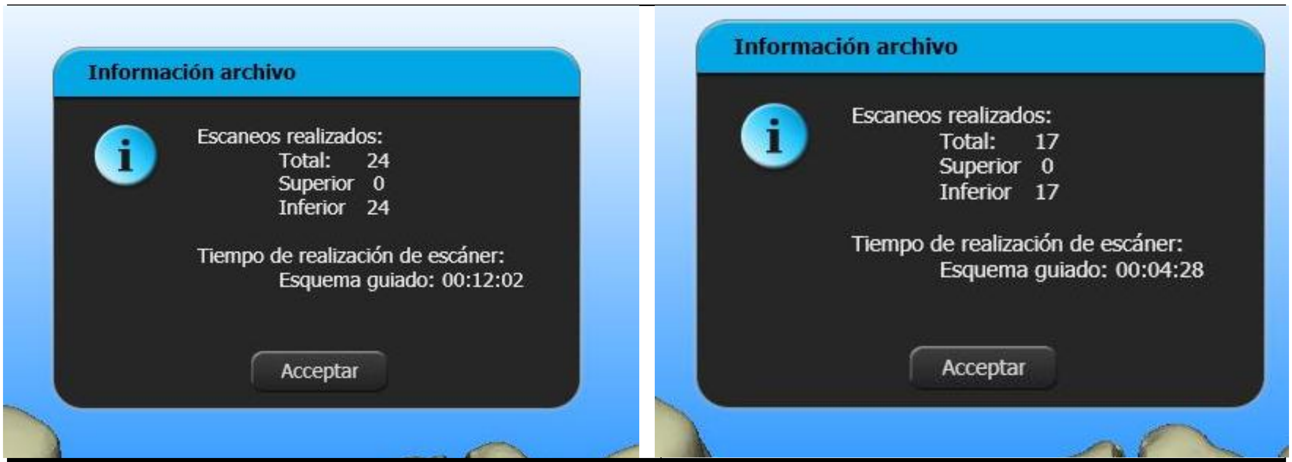

Image 11 and 12 – Time and number of scans of the first scan vs. time and number of scans of the last scan

As stated by Galluci in 2012, digital impression taking is more efficient than conventional impression and easy to correct voids with additional rescans, without having to repeat the whole procedure. His study implies that with knowledge of the procedure and experience over time, the scanning technique will improve(8).

Nonetheless, more studies, both in-vitro and in-vivo, are needed to access the precision and trueness of iTero's scans. Bearing that in mind and considering analyzing the limitations of our study and difficulties found, we propose two protocols to further studies. Ideally, a study would benefit from the comparison of the existing CDIS systems. To do so, a control group must be created, which could be composed of a standard digitalization of a study model (in 2011, Ender used the Alicona Infinite Focus(7), which has 100.000 measurement points in its scan, with a vertical resolution of less than 10 nm). The test groups would be composed of

1- Scan of the model by Sirona's CEREC® AC Bluecam with optispray
2- Scan of the model by Sirona's CEREC® AC Bluecam without optispray
3- Scan of the model by 3M Espe's Lava C.O.S.® with powder coating
4- Scan of the model by 3M Espe's Lava C.O.S.® without powder coating
5- Scan of the model by Cadent's iTero®
6- Scan of the model by 3Shape's Trios®

With the superimposition of each of these scans and the digital control model with a 3D image rendering program we would be able to ascertain the trueness and precision of the optical scans, and thus, their accuracy. Yet, another test group could be created by taking conventional impressions of the study model, die casting and scanning the plaster models with the standard scanner. Consequently it is possible to measure the accuracy of the conventional impression against that of digital impressions. Through this method we can compare the accuracy of the conventional impressions versus the different digital impression devices.

To achieve greater objectivity, the second protocol starts from a standard model.

1. Obtain a conventional impression and scan it with a standard scanner
2. Scan the model with the CDIS as described in the first protocol
3. Analyze the impression/scan data
4. Pour the conventional impression with type IV gypsum
5. Obtain stereolitographic models of the dental scans
6. Scan the gypsum and stereolitographic models with the standard scanner and analyze the data.

With .stl type files we could create COP images, and superimpose them in a 3D renderer software (e.g. SAL3D), giving us accurate volumetric data, and point-to-point measurements (7). This technique would uncover with exactitude the accuracy (precision and trueness) of this CIS technique.

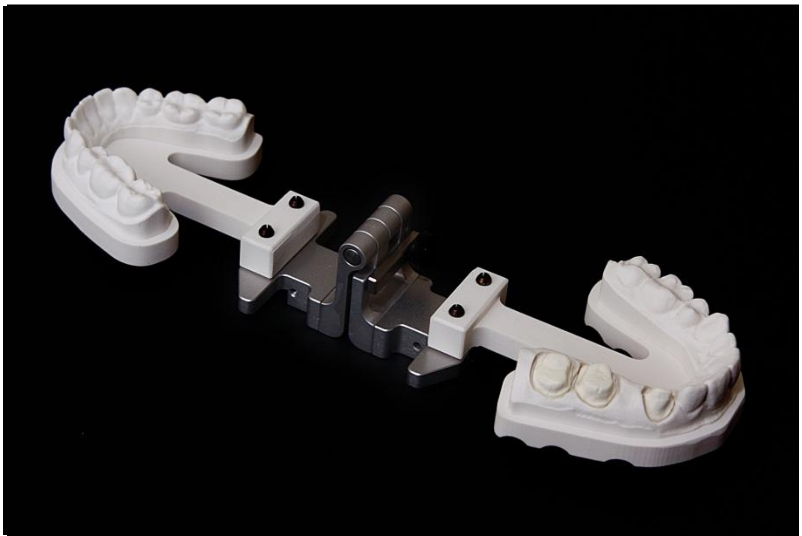

Image 13 – Stereolitographic model - Courtesy of Cadent™

With this method we get to compare data in similar steps of the process and reduce the number of variables involved.

Regarding other CDIS, Todorovic claimed that the accuracy of some readings is affected by irregular light dispersion by the surfaces. The CEREC® and Lava C.O.S.® use an opaque powder coating, which equalizes the dispersion. He listed some errors bound to happen to anyone who handles CEREC® CDIS.(10).

Improper handling of the scanner relates to scanner instability, or improper positioning, and the author considered this error to be the least harmful, given that one can repeat the scanning sequence without consequence. According to his research, the human hand can be static for about 0.5’’, which means that the clinician should have a stable support for the front portion of the scanner. The actual model, the CEREC® AC Bluecam, which captures a continuous image feed, corrects the error created by possible hand motion. Larger deviations will distort the virtual model, resulting in irregular areas and incorrect dimensions of dental restorations. Errors in the vertical position will blur or grease the image. A factor that commonly induces scanning error or difficulty is the size of the camera, mainly on cases where we need to scan third molars, or when the distal agonist is missing(10).

The tooth/teeth preparation must not have retentive areas, because they will probably not be "seen" by the scanner, and this will result in the dental restoration to have a thicker cement layer, which will reduce the adhesion. One of the main disadvantages of the CEREC® systems is that it uses titanium dioxide contrast powder (Optispray®) on all the surfaces scanned to enhance the reflection of light. The downside of this technique is that the system scans the powder and not the teeth, which means that the reading will vary with the thickness of the contrast powder layer. The CEREC® system cannot read uncovered dental surfaces, so the powder application, even though adjustable, is mandatory(10).

Finally, the marginal sulcus must be carefully prepared. If the finishing line is supragingival, rinsing with water and drying is sufficient. If the preparation is made to have an infragingival or gingival finishing line, the sulcus must be made visible(10).

The ergonomy of the technique is of major importance, given that the handling of the iTero® intra-orally requires us, clinicians, to hold our arms and support the weight of the camera on our superior member and back, eventually, increasing the risk on olecranon or sub-acromial bursitis, or carpal tunnel syndrome, and none of the reviewed articles make any reference to it. Given that these are symptoms acquired over-time, we will have to wait until any long term studies are published on the subject.

Conclusion

In spite of the limitations imposed to our pilot study, we can state that the iTero® CIS has clinically acceptable readings on its targets. However, more studies are required to absolutely prove it.

Digital impressions seem a promising tool to be explored in the near future, even though more tests are required to evaluate its in-vivo performance. The iTero® dental scanner according to our pilot study, and considering its limitations, reflects trueness on the measurements performed.

Furthermore, we can enhance the scan with single repetitions, not having to repeat the whole process. The possibility to immediately communicate with the laboratory presents the opportunity to discuss the case while the patient is still in the dental chair. With this method we can expect a greater compliance from the patient.

Finally, we consider that the iTero's extra-oral handling with work models is easy, with a fast learning curve. However due to the size and weight of the model's sleeve, questions arise regarding its ergonomic properties.

Disclaimer

This study did not receive external funding. Cadent™ kindly replied to our information request, and allowed the publication of their intellectual property.

Acknowledgements

This pilot study would not be possible without the support of the faculty, who provided us with bibliographic and laboratorial materials. The results were achieved thanks to Dr. Ana Messias, who processed and helped interpret them. Lastly, I would refer the importance of the tutors in guiding this project. The project supervisors, Professor Guerra and Dr Ricardo Dias, were essential to the development of the project and to its conclusion.

Bibliography

1. Birnbaum NS. Dental Impressions Using 3D Digital Scanners: Virtual Becomes Reality. Compendium of continuing education in dentistry. 2008;29(8):494-505.
2. Techkouhie AH. Impression Materials in Fixed Prosthodontics: Influence of choice on clinical procedure. American College of Prosthodontics. 2010;20:153-60.
3. Dalstra M, Melsen B. From alginate impressions to digital virtual models: accuracy and reproducibility. Journal of orthodontics. 2009;36(1):36-41; discussion 14. Epub 2009/03/17.
4. Touchstone A, Nieting T, Ulmer N. Digital transition: the collaboration between dentists and laboratory technicians on CAD/CAM restorations. Journal of the American Dental Association. 2010;141 Suppl 2:15S-9S. Epub 2010/06/11.
5. Garg AK. Cadent iTero's digital system for dental impressions: the end of trays and putty? Dental implantology update. 2008;19(1):1-4. Epub 2008/04/11.
6. Lowe R. CAD/CAM Dentistry and Chairside Digital Impression Making. 2008.
7. Ender A, Mehl A. Full arch scans: conventional versus digital impressions--an in-vitro study. International journal of computerized dentistry. 2011;14(1):11-21. Epub 2011/06/11.
8. Lee SJ, Gallucci GO. Digital vs. conventional implant impressions: efficiency outcomes. Clinical oral implants research. 2012. Epub 2012/02/23.
9. Glassman S. Digital impressions for the fabrication of aesthetic ceramic restorations: a case report. Practical procedures & aesthetic dentistry : PPAD. 2009;21(1):60-4. Epub 2009/05/22.
10. Todoroviæ A. Possible errors during the optical impression procedure. Stomatološki glasnik Srbije. 2010;57(1):30-7.

11. Henkel GL. A comparison of fixed prostheses generated from conventional vs digitally scanned dental impressions. Compendium of continuing education in dentistry. 2007;28(8):422-4, 6-8, 30-1. Epub 2008/06/27.

12. Christensen GJ. Impressions are changing: deciding on conventional, digital or digital plus in-office milling. Journal of the American Dental Association. 2009;140(10):1301-4. Epub 2009/10/03.