CAD-CAM systems VS conventional design.

Quality evaluation.

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Study code : REST-ELM-2015-14

Sant Cugat del Valles, 6/05/2016.

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Abstract

OBJECTIVE : The aim of this study was to determine, by using a comparative scale, the quality of an indirect inlay done by two types of methods. Conventional hand-maid inlay (group control) and CAD-CAM inlay. **MATERIAL AND METHODS :** three groups were used to design both types of restoration : Graduate Students (GS) Master students (MS) and teachers (T). The Conventional hand-maid inlay (CHM) was done with with FILTEK composite, and the CAD-CAM inlay (CC) was done with Lava ultimate. Five criteria were analyzed in this study : surface lustre (SL), esthetic anatomical form (AF), marginal adaptation (MA), occlusal form contact point (OFCP), evaluator's general view (GV). All these quality criteria were compared between CHM and CC, but also between each deferents operators. **RESULTS :** The results of the study show statistically significant difference between the quality of CHM and CC (p-valor < 0,05). The null hypothesis was rejected. For all group mingled, the average score for the CC was 1,94 versus 2,22 for the CHM. More specifically, GS group showed statistically significant difference when designing the inlay regardless of the type of method used (CHM and CC) versus MS and T. However no statistically significant difference was observed between MS and T. Analyzing with more details for each group, the study reveled better results for CC than CHM for GS and T groups, but better results for CHM than CC for MS group. **CONCLUSION :** With the limit of the study, we can say that CC design showed better results than CHM design. But if we analyze with more details, MS group had better results with CHM than CC design. We can conclude that CC is a good alternative to CHM, but depending on the operator.

1. Introduction :

Computer-aided design (CAD) and computer-aided manufacturing (CAM) have become an increasingly popular part of dentistry over the past 25 years (1,2). The technology, which is used in both the dental laboratory and the dental office, can be applied to inlays, onlays, veneers, crowns, fixed partial dentures (2), implant abutments (3), and even full-mouth reconstruction (4).

CAD/CAM technology was developed to solve 3 challenges. The first challenge was to ensure adequate strength of the restoration, especially for posterior teeth. The second challenge was to create restorations with a natural appearance. The third challenge was to make tooth restoration easier, faster, and more accurate. In some cases, CAD/CAM technology provides patients with same-day restorations (5).

The major developments of dental CAD/CAM systems occurred in the 1980s. Dr. Duret was the first to develop dental CAD/CAM (6). From 1971, he began to fabricate crowns with an optical impression of abutment followed by designing and milling. The combination of materials that can be used and restoration types that can be produced vary with different systems. Some CAD/CAM systems can fabricate a final restoration with some materials with acceptable strength and esthetics while others require subsequent veneering to achieve acceptable esthetics (7).

Making prints is a chapter of restorative dentistry that is much abused materials, and more than an accurate impression wins distortions have treated improperly or for having waited too long to empty. A good impression for a cast restoration must meet the following conditions (8) : 1.Must be an exact duplicate of the prepared tooth and include all preparation and not enough tooth surface carved to allow the dentist and technician safely view the location and configuration of the

finishing line; 2. The teeth and adjacent tissues to the prepared tooth must be exactly reproduced to allow precise articulation model and an appropriate modeling of restoration; 3.Printing the preparation should be free from bubbles, especially in the area of the finishing line (8).

Among the materials used for the impression in fixed prostheses the more used are the addition silicones (8).

The conventional way of taking impressions sometimes is not as accurate as the intraoral scanning, because of the manipulation of materials and its distortion or fracture when transport to the laboratory (9).

The CAD-CAM systems have been used mostly for the manufacturing of prosthetic fixed restorations, such as inlay, onlays, venners and crowns (2). During the last decade technological developments in these systems have provided alternative restorations using different materials such as porcelain, composite resin and metallic blocks, which couldn't be prosecuted previously because of technical limitations (1,2,10,11).

As the literature have reported in some studies (12,13), the aim of this study is to evaluate some quality criteria, comparing an inlay made in a conventional way versus an inlay designed and milled with a CAD-CAM software. This study is focused mostly on the esthetic anatomical form, the marginal adaptation, and the anatomical correct form occlusal point (14,15).

2. Objectives :

2.1 Main Objective :

To evaluate the restoration quality between CAD-CAM systems and conventional prosthesis design on inlays.

2.2 Secondary Objectives :

1) To evaluate and compare the quality between CAD-CAM systems and conventional prosthesis design on inlays on undergraduate students.
2) To evaluate and compare the quality between CAD-CAM systems and conventional prosthesis design on inlays on post-graduate students.
3) To evaluate and compare the quality between CAD-CAM systems and conventional prosthesis design on inlays on teachers from the UIC.

3. Hypothesis:

Null Hypothesis (H0)

Depending on the operator, there is no influence in the quality of the restorations with the use of different CAD-CAM systems vs. conventional design.

Alternative hypothesis (H1)

There is influence in the quality of the restorations with the use of different CAD-CAM systems vs. conventional design, depending on the operator.

4. Material and methods :

The study was performed in the laboratory of the UIC during the period from september 2015 to april 2016. The study protocol was approved by the « CER » and the « Comisión de Trabajos Final de Máster de la Facultad de Odontología de la Universitat Internacional de Catalunya » (annex I and II).

One CAD-CAM system was used in this study and was compared with a conventional design of an inlay of composite. The materials names and brands used, were : FILTEK composite (Filtek Z250, 3M ESPE, St. Paul, USA) for the composite hand made inlay (CHM), and LAVA ULTIMATE block (Lava Ultimate A2-HT 14L, 3M ESPE, St. Paul, USA) for the CAD-CAM restoration (CC) (fig.1).

Fig.1 - Material used for composite hand made inlay (CHM) and CAD-CAM restoration (CC).

A fantom was needed to make an inlay in a first superior molar, an alginate impression was taken and it was duplicated 30 times (fig.2). Three different groups were formed to design the CHM and the CC inlay. One group was formed with 10 undergraduate students of the last year of dentistry (GS), an other one with 10 students of the "Master Restauradora y Estética" (MS), and the last one with 10 teachers of the dentistry department (T). Every single person use the "3 Shape from Lyra" CAD-CAM systems for the CC. Each person had to scan the lower arch of the fantom, the upper arch with the restoration and then the correct bite, placing both arch in maximum intercuspidation. "3 Shape from Lyra" CAD-CAM system works basically in four steps : all of them done by each operator. The first step was to localize and mark the limits of the preparation, then, the second seed was to check the correct insertion axis of the restoration. After that, the third step was to design the restoration focus on the correct anatomic form, and the correct occlusal contact point. Last step was placing the restoration in the virtual LAVA ULTIMATE block to guaranteed the correct milling.

Fig.2 - Upper and lower fantom, Inlay design in 1.6, and duplicated model.

From one part, to do the conventional design, this study asked every person to make an inlay restoration, and they had to do the basic steps of a conventional inlay prosthesis. This inlay was realized with composite FILTEK. On the other hand, this study asked to the operators to design and mill the inlay restoration with the CAD-CAM system "3 Shape from Lyra" with an LAVA ULTIMATE block.

Therefore, each evaluators had to design an inlay with conventional method, and design an inlay with 3Shape CAD-CAM system (fig.3). In total this study evaluated 30 CHM inlays, and 30 CC inlays. These 60 inlays (30 CHM + 30 CC), were evaluated en function of a scale of criteria quality (table 1).

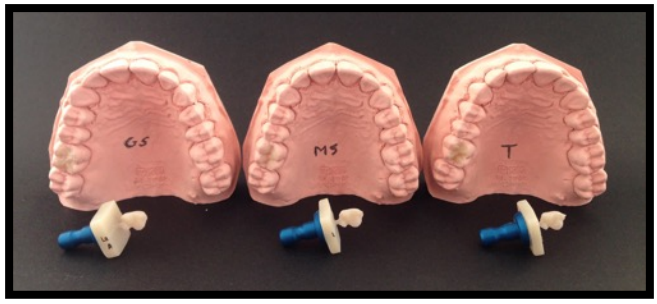


Fig.3 - Each person of each group designed 1 CHM and 1 CC.

	CHM	**CC**
10 GS	10 GS CHM	10 GS CC
10 MS	10 MS CHM	10 MS CC
10 T	10 T CHM	10 T CC
Total	30 CHM	30 CC
	60 Inlays	

Table 1 - 60 inlays evaluated. 2 design (CHM and CC) done by 3 groups (GS, MS, T) of 10 persons.

The scale of criteria quality for this investigation was designed with the help from the Heckel (16,17), Baston's (18), and Ng (12) criteria of quality. The scale gathered five parameters : 1. Surface lustre, 2. Esthetic anatomical form, 3. Marginal adaptation, 4. Approximal occlusal form contact point, 5. Evaluator's general view (table 2).

	1. Clinically excellent / very good	2. Clinically good	3. Clinically sufficient / satisfactory	4. Clinically unsatisfactory	5. Clinically poor
1. Surface lustre	1.1 Lustre comparable to enamel	1.2.1 Slightly dull, not noticeable from speaking distance 1.2.2 Some isolated pores	1.3.1 Dull surface but acceptable if covered with film of saliva 1.3.2 Multiple pores on more than one third of the surface	1.4.1 Rough surface, cannot be masked by saliva film, simple polishing is not sufficient Further intervention necessary 1.4.2 Voids	1.5 Very rough, unacceptable plaque retentive surface
2. Esthetic anatomical form	2.1 Form is ideal	2.2 Form is only slightly deviated from the normal	2.3 Form deviates from the normal but is esthetically acceptable	2.4. Form is affected and unacceptable esthetically. Intervention/correction is necessary	2.5 Form is unsatisfactory and/or lost. Repair not feasible / reasonable, Replacement needed
3. Marginal adaptation	3.1 Harmonious outline, no gaps, no white or discolored lines	3.2.1 Marginal gap (<150 µm), white lines 3.2.2 Small marginal fracture removable by polishing 3.2.3 Slight ditching, slight step/flashes, minor irregularities	3.3.1 Gap < 250 µm not removable 3.3.2. Several small marginal fractures 3.3.3 Major irregularities, ditching or flash, steps	3.4.1 Gap > 250 µm or dentine/base exposed 3.4.2. Severe ditching or marginal fractures 3.4.3 Larger irregularities or steps (repair necessary)	3.5.1 Restoration (complete or partial) is loose but in situ 3.5.2 Generalized major gaps or irregularities
4. Approximal occlusal form contact point	4.1 Localised on working cusp and occlusal contact with 80 µm paper	4.2. No localised on working cusp and occlusal contact with 80 µm paper	4.3. Localised on working cusp and occlusal contact with 200 µm	4.4 No localised on working cusp and occlusal contact with 200 µm	5.5 No localised on working cusp and no occlusal contact with 200 µm paper
5. Evaluator's general view					

Table 2 - Quality scale for the evaluation of each parameters. Five parameters : SL, EAF, MA, OFCP, GV. Five scores (1 : excellent - 5 : poor).

All of the 60 inlays were evaluated from 1 to 5. (1. Clinically excellent / very good, 2. Clinically good, 3. Clinically sufficient / satisfactory, 4. Clinically unsatisfactory, 5. Clinically poor).

For the evaluation of each quality criteria, the scale was filled surrounding the appropriate number of the parameter. There were one sheet of paper for each restoration : one for CHM, and one for CC for each person : 60 papers were completed and analyzed (fig.4). The evaluation was done by a qualified evaluator.

Fig.4 - Criteria scale : 60 papers completed and analyzed.

To evaluated the surface lustre (SL), was checked comparing all inlays with the enamel surface lustre of a natural tooth. Non of the inlays were polished, and for the CC the drilling burr was changed each 5 inlays.

The esthetic anatomical form (EAF), was checked comparing all inlays with the anatomy of the contralateral teeth on the fantom.

The marginal adaptation (MA), was checked with endodontic files (from 15 to 30) to evaluate the gap between the inlay and the preparation (fig.5).

Fig.5 - Marginal adaptation (MA) measurment, checked with endodontic files.

The approximal occlusal form contact point (OFCP), was checked using two types of articulating paper. One of 40 ym, and the other one of 200 ym (fig.6).

Fig.6 - Oclusal form contact point (OFCP) measurment, with two articulating papers.

All the data were collected and classified in an excel document, comparing all parameters. The data were organized in 3 tables : one for each group (table 3, 4, 5). After that, all data were analyzed comparing CHM and CC (table 6).

Restauration	Group	Person	SL	EAF	MA	OFCP	GV	Average
CHM	GS	1	4	4	2	4	4	3,6
CC	GS	1	3	1	2	1	2	1,8
CHM	GS	2	4	2	2	3	3	2,8
CC	GS	2	3	1	2	3	2	2,2
CHM	GS	3	3	3	2	4	3	3
CC	GS	3	2	1	1	1	1	3
CHM	GS	4	4	3	2	3	3	3
CC	GS	4	3	1	2	1	2	1,8
CHM	GS	5	4	3	3	4	4	3,6
CC	GS	5	2	1	2	3	2	2
CHM	GS	6	3	3	2	4	3	3
CC	GS	6	3	2	2	2	2	2,2
CHM	GS	7	2	2	2	3	2	2,2
CC	GS	7	3	2	2	2	2	2,2
CHM	GS	8	3	3	2	2	3	2,6
CC	GS	8	2	1	2	1	2	1,6
CHM	GS	9	2	2	2	3	2	2,2
CC	GS	9	2	2	1	3	2	2
CHM	GS	10	3	3	2	3	3	2,8
CC	GS	10	2	2	2	1	2	1,8
CHM			3,2	2,8	2,1	3,3	3,0	2,88
CC			2,5	1,4	1,8	1,8	1,9	2,06

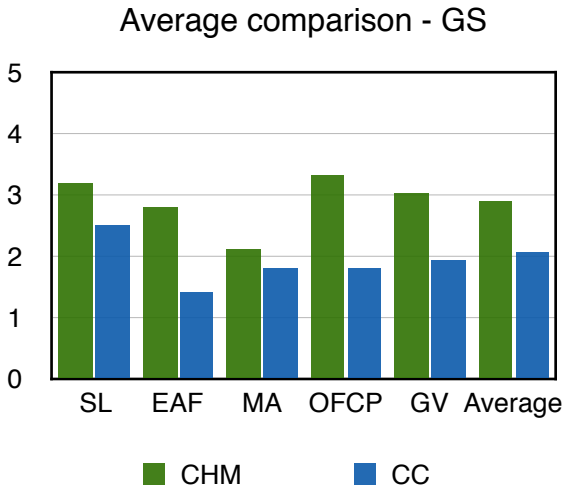


Table 3 - Data collected for GS group and comparison CHM/CC. Each 10 GS performed 1 CHM and 1 CC. Comparing all 5 parameters.

Restauration	Group	Person	SL	EAF	MA	OFCP	GV	Average
CHM	MS	1	2	1	2	2	2	1,8
CC	MS	1	3	1	1	2	2	1,8
CHM	MS	2	2	2	2	1	2	1,8
CC	MS	2	2	2	2	3	2	2,2
CHM	MS	3	2	2	2	1	2	1,8
CC	MS	3	2	2	1	1	2	1,6
CHM	MS	4	1	1	1	1	1	1
CC	MS	4	2	1	3	3	2	2,2
CHM	MS	5	2	2	2	1	2	1,8
CC	MS	5	3	1	2	1	2	1,8
CHM	MS	6	2	1	2	2	2	1,8
CC	MS	6	2	2	3	2	2	2,2
CHM	MS	7	3	2	2	2	2	2,2
CC	MS	7	3	2	2	2	2	2,2
CHM	MS	8	1	1	1	1	1	1
CC	MS	8	3	2	2	3	2	2,4
CHM	MS	9	2	1	1	2	1	1,4
CC	MS	9	2	1	1	1	1	1,2
CHM	MS	10	2	2	2	1	2	1,8
CC	MS	10	2	1	2	1	2	1,6
CHM			1,9	1,5	1,7	1,4	1,7	1,64
CC			2,4	1,5	1,9	1,9	1,9	1,92

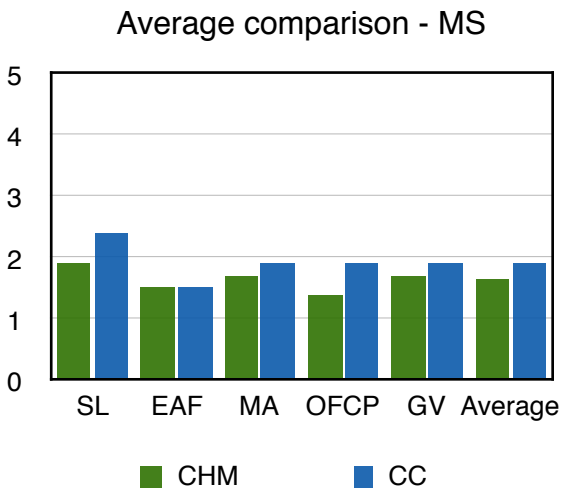


Table 4 - Data collected for MS group and comparison CHM/CC. Each 10 MS performed 1 CHM and 1 CC. Comparing all 5 parameters.

Restauration	Group	Person	SL	EAF	MA	OFCP	GV	Average
CHM	T	1	2	2	2	2	2	2
CC	T	1	3	1	2	3	2	2,2
CHM	T	2	2	2	2	3	2	2,2
CC	T	2	2	2	2	1	2	1,8
CHM	T	3	2	3	2	3	2	2,4
CC	T	3	2	1	1	1	1	1,2
CHM	T	4	2	2	2	3	2	2,2
CC	T	4	2	2	1	2	2	1,8
CHM	T	5	1	1	1	2	1	1,2
CC	T	5	3	1	2	1	2	1,8
CHM	T	6	3	3	2	3	3	2,8
CC	T	6	3	2	2	2	2	2,2
CHM	T	7	2	3	2	2	2	2,2
CC	T	7	2	2	1	1	2	1,6
CHM	T	8	2	2	1	2	2	1,8
CC	T	8	2	2	1	1	2	1,6
CHM	T	9	2	2	2	2	2	2
CC	T	9	3	2	2	3	2	2,4
CHM	T	10	2	2	3	3	3	2,6
CC	T	10	2	2	2	1	2	1,8
CHM			2	2,2	1,9	2,5	2,1	2,14
CC			2,4	1,7	1,6	1,6	1,9	1,84

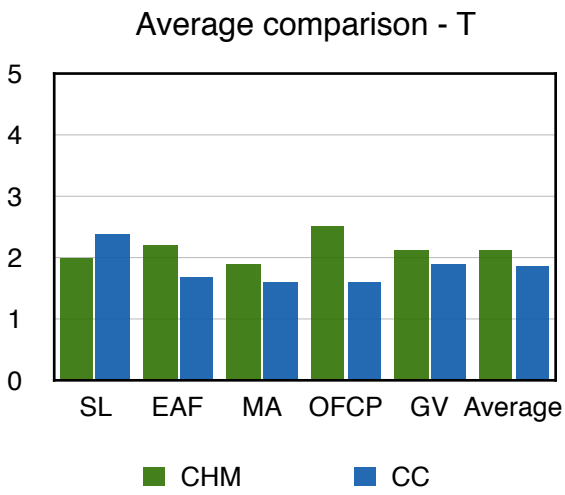


Table 5 - Data collected for T group and comparison CHM/CC. Each 10 T performed 1 CHM and 1 CC. Comparing all 5 parameters.

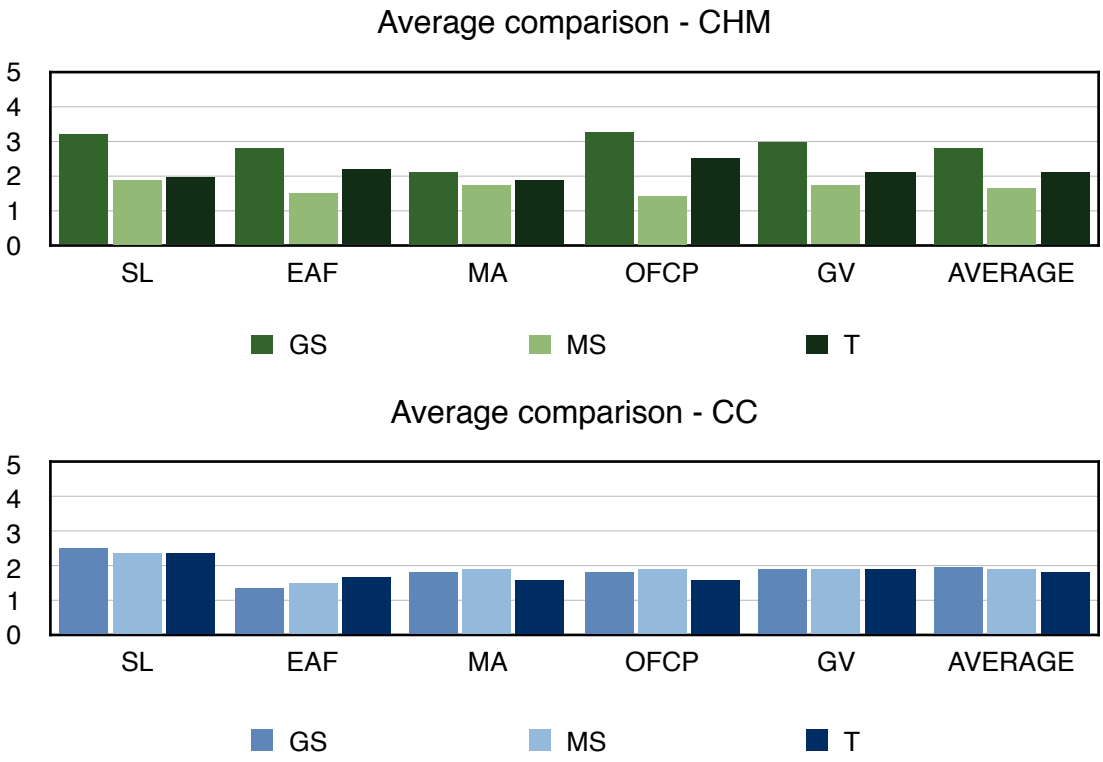


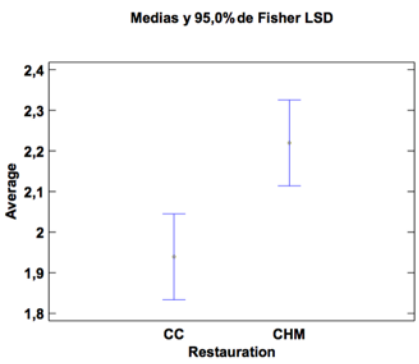
Table 6 - Comparison CHM/CC. The 5 parameters compared depending on the operator. One for CHM and one for CC.

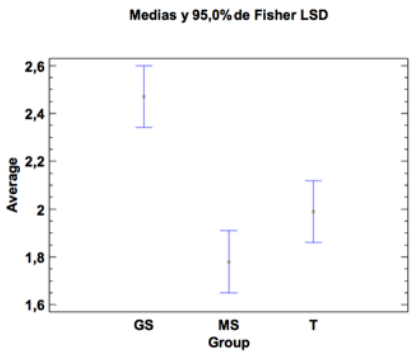
To test the normality of the data Shapiro-Wilk Test was performed. The results was tested by using a one way ANOVA statistical analysis. All the data analysis, were carried out using the STATGRAPHICS software (Statpoint technologies, Warrenton, Virginia, USA) with a significance level set at p = 0,05.

5. Results :

The principal objective of this study was to compare the quality of an inlay done by two technique : composite hand-maid (CHM) versus CAD-CAM (CC). Secondary objectives were to compare the quality of this same restoration, focusing on each of the three groups individually. The results will first be described considering all group together, then each criteria regarding to each group individually.

In terms of quality, the results of the study showed statistically significant difference between CHM and CC (p-valor < 0,05). The null hypothesis was rejected. For all group mingled, the average score for the CC was 1,94 versus 2,22 for the CHM (p-valor = 0,0102). More specifically, GS group showed worst results when designing the inlay regardless of the type of method used (CHM and CC) comparing to MS and T groups. However no statistically significant difference was observed between MS and T groups. Analyzing with more details for each group, the study reveled better results for CC than CHM for GS and T groups, but better results for CHM than CC for MS group (table 7).





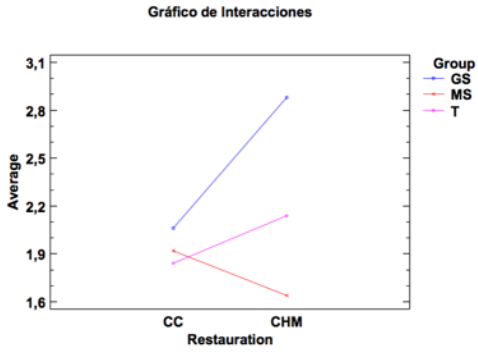


Table 7 - Analysis of Variance for Average.

For SL parameter, no statistically significant difference was observed for all group mingled (p-valor = 0,6547). However, GS group showed better results for CC than CHM, while MS and T groups showed better results for CHM than CC (table 8). EAF showed statistically significant difference (p-valor = 0,0000).

Fuente : SL	*Suma de Cuadrados*	*Gl*	*Cuadrado Medio*	*Razón-F*	*Valor-P*
EFECTOS PRINCIPALES					
A:Restauration	0,0666667	1	0,0666667	0,20	0,6547
B:Group	6,1	2	3,05	9,25	0,0004
INTERACCIONES					
AB	4,43333	2	2,21667	6,72	0,0025
RESIDUOS	17,8	54	0,32963		
TOTAL (CORREGIDO)	28,4	59			

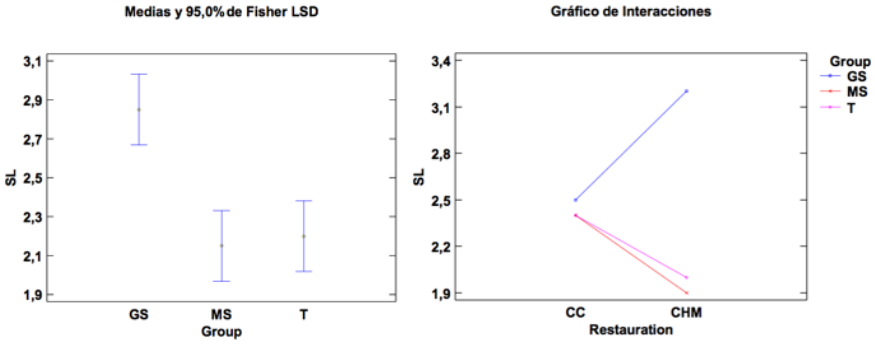


Table 8 - Analysis of Variance for SL.

EAF was significantly better with CC all groups together. More difference was observed in GS group in particular, difference was also observed for T group, but no difference was observed for MS group considering EAF. (table 9).

Fuente : EAF	*Suma de Cuadrados*	*Gl*	*Cuadrado Medio*	*Razón-F*	*Valor-P*
EFECTOS PRINCIPALES					
A:Restauration	6,01667	1	6,01667	19,46	0,0000
B:Group	3,9	2	1,95	6,31	0,0035
INTERACCIONES					
AB	5,03333	2	2,51667	8,14	0,0008
RESIDUOS	16,7	54	0,309259		
TOTAL (CORREGIDO)	31,65	59			

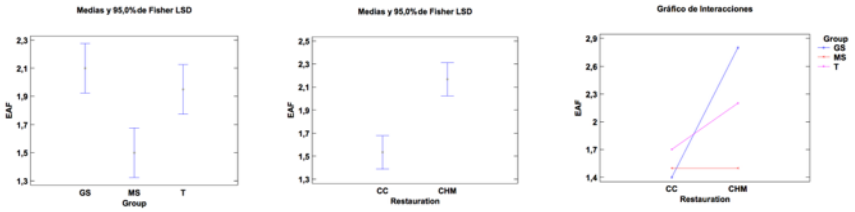


Table 9 - Analysis of Variance for EAF.

No statistically significant difference was observed for MA (p-valor = 0,3283) (table 10).

Fuente : MA	*Suma de Cuadrados*	*Gl*	*Cuadrado Medio*	*Razón-F*	*Valor-P*
EFECTOS PRINCIPALES					
A:Restauration	0,266667	1	0,266667	0,97	0,3283
B:Group	0,433333	2	0,216667	0,79	0,4588
INTERACCIONES					
AB	0,833333	2	0,416667	1,52	0,2279
RESIDUOS	14,8	54	0,274074		
TOTAL (CORREGIDO)	16,3333	59			

Table 10 - Analysis of Variance for MA.

OFCP was statistically significantly better for CC rather than CHM (p-valor = 0,017). In particular, OFCP was more accurate with CC rather than CHM for GS and T group, but more accurate with CHM rather tan CC for MS group (table 11).

Fuente : OFCP	*Suma de Cuadrados*	*Gl*	*Cuadrado Medio*	*Razón-F*	*Valor-P*
EFECTOS PRINCIPALES					
A:Restauration	6,01667	1	6,01667	10,87	0,0017
B:Group	8,13333	2	4,06667	7,34	0,0015
INTERACCIONES					
AB	10,5333	2	5,26667	9,51	0,0003
RESIDUOS	29,9	54	0,553704		
TOTAL (CORREGIDO)	54,5833	59			

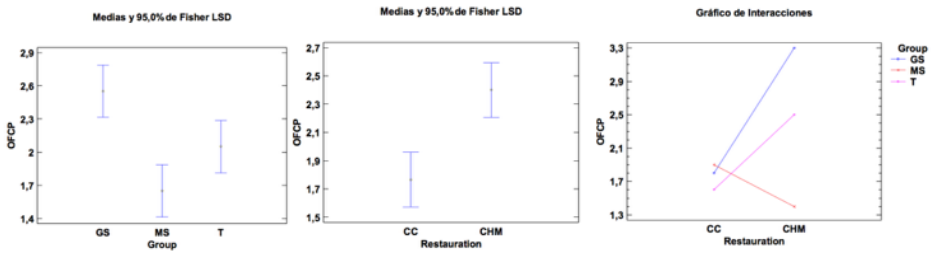


Table 11 - Analysis of Variance for OFCP.

Regarding to the GV, statistically significant difference was observed (p-valor = 0,0035) : CC was more accurate than CHM all group mingled. However, GS group showed better results for CHM rather than CC (table 12).

Fuente : GV	*Suma de Cuadrados*	*Gl*	*Cuadrado Medio*	*Razón-F*	*Valor-P*
EFECTOS PRINCIPALES					
A:Restauration	2,01667	1	2,01667	9,31	0,0035
B:Group	4,43333	2	2,21667	10,23	0,0002
INTERACCIONES					
AB	4,43333	2	2,21667	10,23	0,0002
RESIDUOS	11,7	54	0,216667		
TOTAL (CORREGIDO)	22,5833	59			

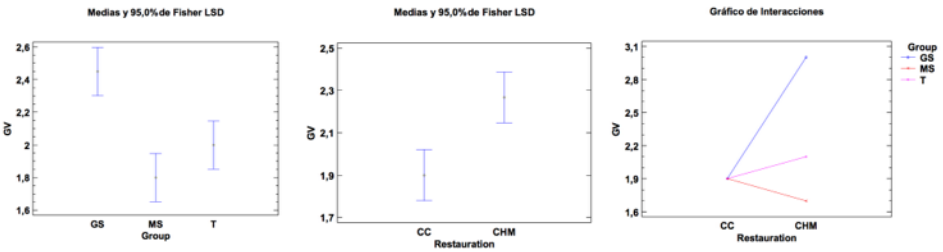


Table 12 - Analysis of Variance for GV.

Regarding the results of the study, null Hypothesis (H0) : there is no influence in the quality of the restorations with the use of different CAD-CAM systems vs. conventional design was rejected. There is influence depending of the method used to perform the inlay. According of the study, CC offers better quality than CHM all groups mingled. However MS group offers better results with CHM rather than CC.

6. Discusion :

As Pascal Magne (19) described in a study on 2006, indirect techniques with composite resins or ceramics are recommended for serial restorations when esthetics and dynamic occlusion issues are of primary concern. Indirect composite inlays are recommended for serial restorations without cusp coverage or with limited cuspal coverage leaving at least one functional cusp. The past decades, CAD-CAM techniques have been considerately growing, and today seems to bee an adequate alternative to indirect hand-maid restoration (20). The implementation of this digital method has decreased manufacturing costs by reducing technician time and material costs while increasing productivity (21), but this technique must guaranty some quality criteria : a correct esthetic anatomic form, an ideal contact and occlusal point, a correct margin fitting, resistance, durability… Some studies have demonstrated the advantage of using CAD-CAM system. In 2014 Ng et Al (12) compared the marginal fitting of crowns fabricated with digital and conventional methods, and the study concluded that the fully digital fabrication method provided better margin fit than the conventional method. A lot of study have been describing the marginal fit of a restoration after using a conventional impression and a digital impression. In a systematic review of 2016, Tsirogiannis et al (22), reveled that no significant difference was found regarding the marginal discrepancy of single unit ceramic restorations fabricated after digital and conventional impressions. Both the digital workflow and the conventional method ensure the clinically fully acceptable fabrication of single-unit ceramic restorations. In 2014, Anadioti et Al (23) analyzed the 3D and 2D marginal fit of pressed and CAD/CAM Lithium Disilicate crowns made from digital and conventional impressions. The results of the study were that the combination of PVS impression method and press fabrication technique produced the most accurate 3D and 2D marginal fits rather than digital impression.

Correct occlusal contact point has been described in several studies, comparing conventional and digital methods. In 2013, Litzenburger et Al (24) analyzed the fully automatic CAD design of the occlusal morphology of partial crowns compared to dental technicians' design. The results of the study show that in the design of naturally shaped occlusal inlay/onlay surfaces, a fully automatic CAD system can be at least as good as conventional wax-ups by dental technicians. In an other study talking about occlusion, in 2010 : Reich et Al described (25) the occlusal precision of laboratory versus CAD/CAM processed all-ceramic crowns. The results show the time necessary to adjust the occlusion with both design, and time did not differ significantly. Finally in 2015, a study of Kollmuss et Al (26) described the comparison of chairside and laboratory CAD/CAM to conventional produced all-ceramic crowns regarding morphology, occlusion, and aesthetics. The conclusions were that all methods had pros and cons regarding different parameters. Further improvements of CAD/CAM software shall lead to restorations comparable to conventional restorations in all aspects, especially in aesthetics. All tested methods of production for all- ceramic crowns produced clinically acceptable results. Thus, in an individual case, the method chosen can be determined by the dentist’s preference.

Analyzing this study, the results show statistically significant difference between the conventional and the digital methods, with better results for the digital methods. This result is true considering all parameters together (esthetic, lustre, occlusal point, marginal adaptation) and all three groups mingled (graduate student, master student and teachers). Looking with more details each parameters and comparing between each groups, some differences can be find. Results show better quality of the inlay for master student when using conventional method rather tan digital method.

7. Conclusion :

The principal objective of this study was to evaluate the restoration quality between CAD-CAM systems and conventional prosthesis design on inlays. With the limits of the study, we can say that CAD-CAM design showed better results than composite hand-maid design for an inlay, considering all groups and all parameters together. The secondary objective was to evaluate and compare the quality between CAD-CAM systems and conventional prosthesis design on inlays depending on the operator. Analyzing with more details, master student group had better results with composite hand-maid design rather than composite hand-maid design. We can conclude that CAD-CAM design is a good alternative to composite hand-maid design, but depending on the operator.

8. Future expectations :

In a future, we can expect an evolution of the digital technique. In the last decades the CAD-CAM design get closer to the conventional technique, but one question is still without answer : one day, will the best digital technique better than the best conventional technique ?

8. References :

1. Birnbaum NS, Aaronson HB. Dental impressions using 3D digital scanners: virtual becomes reality. Compend Contin Educ Dent. 2008 Oct;29(8):494, 496, 498-505
2. Liu PR, Essig ME. Panorama of dental CAD/CAM restorative systems. Compend Contin Educ Dent. 2008 Oct;29(8):482, 484, 486-8
3. Lee SJ, Gallucci GO. Digital vs. conventional implant impressions: efficiency outcomes. Clin Oral Implants Res. 2013 Jan;24(1):111-5.
4. Bahillo J, Jané L, Bortolotto T, Krejci I, Roig M. Full-mouth composite rehabilitation of a mixed erosion and attrition patient: a case report with v-shaped veneers and ultra-thin CAD/CAM composite overlays. Quintessence Int. 2014 Oct;45(9):749-56.
5. Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. Dent Clin North Am. 2011 Jul;55(3):559-70
6. Duret F, Preston JD. CAD/CAM imaging in dentistry. Curr Opin Dent. 1991 Apr; 1(2):150-4
7. Sneha S. Mantri. CAD-CAM in dental restorations: An overview. July 2010. Vol II. Disponible en http://www.researchgate.net/publication/228931572_CADCAM_in_Dental_Restorations_An_Overview
8. Nandini VV, Venkatesh KV, Nair KC. Alginate impressions: A practical perspective. J Conserv Dent. 2008 Jan;11(1):37-41
9. Lee SJ, Gallucci GO. Digital vs. conventional implant impressions: efficiency outcomes. Clin Oral Implants Res. 2013 Jan;24(1):111-5
10. Fuster-Torres MA, Albalat-Estela S, Alcañiz-Raya M, Peñarrocha-Diago M. CAD/CAM dental systems in implant dentistry: update. Med Oral Patol Oral Cir Bucal. 2009 Mar 1;14(3):E141-5

11. Hamza TA, Ezzat HA, El-Hossary MM, Katamish HA, Shokry TE, Rosenstiel SF. Accuracy of ceramic restorations made with two CAD/CAM systems. J Prosthet Dent. 2013 Feb;109(2):83-7
12. Ng J, Ruse D, Wyatt C. A comparison of the marginal fit of crowns fabricated with digital and conventional methods. J Prosthet Dent. 2014 Sep;112(3):555-60.
13. Lemaire ED, Upton D, Paialunga J, Martel G, Boucher J. Clinical analysis of a CAD/CAM system for custom seating: a comparison with hand-sculpting methods. J Rehabil Res Dev. 1996 Jul;33(3):311-20.
14. Renne W, McGill ST, Forshee KV, DeFee MR, Mennito AS. Predicting marginal fit of CAD/CAM crowns based on the presence or absence of common preparation errors. J Prosthet Dent. 2012 Nov;108(5):310-5.
15. Mously HA, Finkelman M, Zandparsa R, Hirayama H. Marginal and internal adaptation of ceramic crown restorations fabricated with CAD/CAM technology and the heat-press technique. J Prosthet Dent. 2014 Aug;112(2):249-56.
16. Hickel R, Peschke A, Tyas M, Mjör I, Bayne S, Peters M, Hiller KA, Randall R, Vanherle G, Heintze SD. FDI World Dental Federation: clinical criteria for the evaluation of direct and indirect restorations-update and clinical examples. Clin Oral Investig. 2010 Aug;14(4):349-66
17. Hickel R, Roulet JF, Bayne S, Heintze SD, Mjör IA, Peters M, Rousson V, Randall R, Schmalz G, Tyas M, Vanherle G. Recommendations for conducting controlled clinical studies of dental restorative materials. Science Committee Project 2/98--FDI World Dental Federation study design (Part I) and criteria for evaluation (Part II) of direct and indirect restorations including onlays and partial crowns. J Adhes Dent. 2007;9 Suppl 1:121-47
18. Batson ER, Cooper LF, Duqum I, Mendonça G. Clinical outcomes of three different crown systems with CAD/CAM technology. J Prosthet Dent. 2014 Oct; 112(4):770-7
19. Magne P. Composite resins and bonded porcelain: the postamalgam era? J Calif Dent Assoc. 2006 Feb;34(2):135-47

20. Van Noort R. The future of dental devices is digital. Dent Mater 2012;28:3-12.
21. Beuer F, Schweiger J, Edelhoff D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. Br Dent J 2008;204:505-11.
22. Tsirogiannis P, Reissmann DR, Heydecke G. Evaluation of the marginal fit of single-unit, complete-coverage ceramic restorations fabricated after digital and conventional impressions: A systematic review and meta-analysis. J Prosthet Dent. 2016 Apr 6. pii: S0022-3913(16)00139-6.
23. Anadioti E, Aquilino SA, Gratton DG, Holloway JA, Denry I, Thomas GW, Qian F. 3D and 2D marginal fit of pressed and CAD/CAM lithium disilicate crowns made from digital and conventional impressions. J Prosthodont. 2014 Dec;23(8): 610-7
24. Litzenburger AP, Hickel R, Richter MJ, Mehl AC, Probst FA. Fully automatic CAD design of the occlusal morphology of partial crowns compared to dental technicians' design. Clin Oral Investig. 2013 Mar;17(2):491-6.
25. Reich S, Brungsberg B, Teschner H, Frankenberger R. The occlusal precision of laboratory versus CAD/CAM processed all-ceramic crowns. Am J Dent. 2010 Feb;23(1):53-6.
26. Kollmuss M, Kist S, Goeke JE, Hickel R, Huth KC. Comparison of chairside and laboratory CAD/CAM to conventional produced all-ceramic crowns regarding morphology, occlusion, and aesthetics. Clin Oral Investig. 2016 May;20(4): 791-7

9. Annexes

CER Comitè d'Ètica de Recerca | Universitat Internacional de Catalunya

CARTA APROVACIÓ DIRECTA PROJECTE PEL CER

Codi de l'estudi: REST-ELM-2015-14
Versió del protocol: 1.0
Data de la versió: 05/12/2014
Títol: CAD/CAM systems vs conventional design. Quality evolution

Sant Cugat del Vallès, 19 d'octubre de 2015

Investigador: Thomas Blanc

Títol de l'estudi: CAD/CAM systems vs conventional design. Quality evolution

Benvolgut,

Valorat el projecte presentat, el CER de la Universitat Internacional de Catalunya, considera que, el contingut de la investigació, no implica cap inconvenient relacionat amb la dignitat humana, dignitat d'animals, ni atempta contra el medi ambient, ni té implicacions econòmiques ni conflicte d'interessos.

Per aquests motius, el Comitè d'Ètica de Recerca, RESOLT FAVORABLEMENT, emetre aquest CERTIFICAT D'APROVACIÓ, per que pugui ser presentat a les instàncies que així ho requereixin.

Em permeto recordar-li que si en el procés d'execució es produís algun canvi significatiu en els seus plantejaments, hauria de ser sotmès novament a la revisió i aprovació del CER.

Atentament,

Dr. Josep Argemí
President CER-UIC

FACULTAD DE ODONTOLOGÍA
Comisión Científica – TFM

Proyecto de Trabajo Fin de Máster: REST-ELM-2015-14

14 de julio de 2015

Dr. Miguel Roig
Investigador Principal
Área de Restauradora y endodoncia
Facultad de Odontología
Universitat Internacional de Catalunya

Estimado Dr. Roig:

La Comisión de Trabajos Final de Máster de la Facultad de Odontología de la Universitat Internacional de Catalunya, en su sesión del día 10 de julio revisó y aprobó el proyecto de investigación:

Título:	***CAD-CAM System VS Conventional design. Quality evaluation.***
Investigador Principal:	Dr. Roig (UIC)
Tutor:	Dr. Juan Ricardo Mayoral (UIC)
Alumno:	Thomas Blanc (Máster Universitario en Odontología Restauradora Estética)
Duración:	2 años

El número de identificación del proyecto TFM es: **REST-ELM-2015-14.**

Antes de comenzar su trabajo experimental, deberá asegurarse de que cuenta con la aprobación ética del Comité Ético de Investigación correspondiente.

Atentamente

Dra. Montserrat Mercadé i Bellido
Coordinadora de la Comisión Científica

IP or tutor signature	Supporting researcher: