Survival of CAD/CAM Feldspathic Crowns in Brazilian Navy Dentistry: 24 Months of Preliminary Study

Keywords

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ABSTRACT

Purpose: CAD/CAM feldspathic ceramic (FC) materials remain used for their low cost and ease of chairside production. The purpose of this study was to describe preliminary clinical results, reporting the success and survival of FC dental crowns in a high-demand service using a simplified CAD/CAM technique. Materials and Methods: A calibrated dentist fabricated indirect restorations using the CEREC method and intraoral scanning (Cerec Omnicam, Cerec MCXL) for high-demand dental care. Forty crowns were seated adhesively and evaluated after 24 months using the newly validated UERJ criteria. Statistical analysis was performed with the McNemar test (p<.05). Results: The survival clinical rate of FC CAD/CAM crowns after 24 months was 100%. However, 65% of indirect restorations presented reparable complications. No failure with loss of restoration was detected. Within the complications, most parts were in the proximal contact point, with statistically different significance in follow-up. Conclusion: This study demonstrates that FC CAD/CAM crowns made using a simplified technique have a high clinical survival rate after 24 months, which is crucial for high-demand service. A more extended clinical evaluation period using the same criteria is necessary to draw further conclusions.

INTRODUCTION

In a clinic with a high demand for rehabilitation, the functional and aesthetic restorative treatment associated with a practical and quick solution treatment is crucial. This is a reality in the Brazilian Navy after the introduction of the CAD/CAM system in 2014.

The chairside experience in the manufacture of crowns allows resolution in a single consultation.[1-4] In this working simplified mode, the dentist can master the preparation, making, and installation of the crown without the need for additional work from the prosthesis laboratory. This reduces cost and waste of time.[5]

One of the first blocks to appear on the market that could be milled and installed at the same clinical appointment was feldspathic ceramic (FC).[6] Despite having a reduced flexural resistance compared to the others (around 112 to 120 MPa when polished or glazed, respectively), these ceramics associated with adhesive cementation present a retention degree of around 12 MPa higher than that recommended by the International Organization for Standardization (ISO) for CAD/CAM materials.[7] CEREC Blocks are feldspathic ceramic blocks composed of fine crystals (4 μm),[8] which manual polishing with rubbers produces a piece with good optical qualities and acceptable aesthetics. In addition to the raw material being

cheaper on the dental market, the adhesive cementation of a ceramic piece to the preparation of a tooth, without the need for additional firing, already justifies this ceramic as the material of choice for mass treatment.

Various criteria have been used to evaluate restorations,[9-12] still; they have yet to address addressed indirect restorations, like ceramic crowns, with parameters that could be compared in review studies.[13-14] The UERJ criteria is a recent method for evaluating indirect restorations, which can be applied to ceramic restorations.[15]

Currently, the literature contains only one clinical study focusing on chairside-fabricated CAD/CAM crowns using feldspathic ceramic (FC) blocks.[16] Therefore, this preliminary study aimed to evaluate the 24-month clinical performance of indirect FC CAD/CAM restorations fabricated through a simplified, cost-effective technique and to assess patient satisfaction levels.

METHODS

ETHICAL APPROVAL AND CONSENT

The present study was carried out at the Department of Prosthodontics, Faculty of Dentistry, Rio de Janeiro State University (UERJ) and Brazilian Navy dental clinic. All procedures were reviewed and approved by two Research Ethics Committees: Pedro Ernesto University Hospital (Rio de Janeiro, Brazil) and Marcilio Dias Navy Hospital (Rio de Janeiro, Brazil). The individuals signed all pertinent informed consent forms.

PARTICIPANTS

The patients were recruited from a daily patient collective of the Brazilian Navy Dental Clinic, a high-demand clinic in Rio de Janeiro. There were 34 volunteers, and they required at least one indirect restoration. The distribution of gender was 17 male patients and 17 female patients. The patient's average age was 45 years, and good general health status was mandatory. Forty crowns were fabricated. Twenty-one maxillary teeth and 19 mandibular teeth were treated. Inclusion and exclusion criteria are shown in Table 1. Baseline evaluation was performed at the same day restoration seating (baseline). The recall was performed after 24 months (follow-up) and the evaluation criteria used were criteria developed by Universidade do Estado do Rio de Janeiro - UERJ.[15]

CLINICAL AND LABORATORY PROTOCOL

Cavities were prepared which included a 1.5–2 mm occlusal reduction with a rounded internal shoulder angle and a 1.5 mm thick axial wall, according to proposed by Özsoy.[17] The vertical preparation angle was at least 3°. All transitions from the axial to the occlusal areas were rounded. Quadrants scans of the maxillary and mandibular arch were made with the CEREC Omnicam (Sirona, Germany, DE). The restoration was designed by the same dentist who accompanied the case, using the same software CEREC 4.5.2 (Sirona, Germany, DE), and parameters shown in Table 2. Then, CEREC Blocs (Sirona, Germany, DE) were milled with the CEREC MCXL milling unit (Cylinder pointed bur 12 and step bur 12s). The milling mode was set to "standard." No post-processing of the FC restorations was performed, except for manual polishing with siliconized rubbers for ceramics (EDENTA AG, Au, Switzerland). All the crowns were performed on a single visit, without any provisional, according to the working mode chosen for this study.

Special attention should be given to the occlusal thickness of restoration. In general, the operator controlled the occlusal thickness of the designed restorations through the parameters entered on the platform, with an ideal limit of 1000mm. The occlusal thickness is shown in the graph *(Figure 1)*.

Before preparing the adhesive surface of the restoration, each restoration was visually inspected upon receipt for cementation to rule out any crowns that had cracks or fractures in their structure. The restorations were also checked for their adaptation to the preparation, and proximal contacts were tested with dental floss. Crowns with weak proximal contact points were remade. The internal surface of the crowns was etched for 60 seconds with 10% hydrofluoric acid (Biodinâmica, Rio de Janeiro, Brazil) and then rinsed off with water spray for 60 seconds. The crowns were air-dried with oil- and water-free air. Before luting, a silane agent (FGM, Joinvile, Brasil) was applied to the luting surface of the restorations for at least 60 seconds and air-dried. The prepared teeth were cleaned with pumice stone and water paste, rinsed, and air dried. For cementation, isolation with cotton rolls and a retraction cord were used together with a powerful suction device to avoid moisture contamination. Luting auto-adhesive composite resin (SDI, Illinois, EUA) was applied to the piece before seating it on the tooth preparation. Luting composite resin was polymerized with a light cure unit (Ultradent, Utah, EUA), using 16J/cm^2 over all accessible faces for 20 seconds each. The

Table 1. Inclusion and exclusion criteria; in 34 patients participated (17 male, 17 female patients, average age 45+ - Years).

Inclusion Criteria	Exclusion Criteria
Have at least 1 tooth with the need for indirect restoration	Partial coverage restorations
Premolars or molars could be included	Patients with a high risk of caries.
Healthy patients capable of moving to the research site	Patients with limited motor activities, Pregnant or breastfeeding

Table 2. Pre-defined restorations parameters for the design.

Parameters	µm
Radial spacer	70
Occlusal spacer	70
Resistance of proximal contacts	25
Resistance of occlusal contacts	-25
Minimum radial thickness	800
Minimum occlusal thickness	1000
Margin thickness	50
Margin ramp thickness	50
Margin ramp angle	60

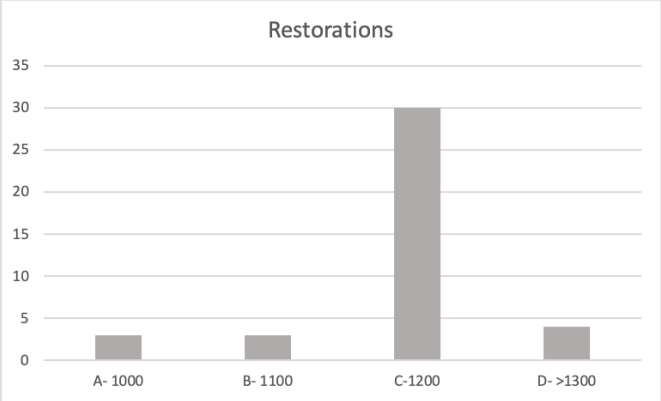

Figure 1: The frequency of restorations by the occlusal thickness. A- 1000 µm; B- 1100 µm; C- 1200 µm; D- > 1300 µm..

restoration margins were finished, and the occlusal contacts were adjusted as necessary using fine diamond rotatory instruments coupled with constant water-cooling, followed by polishing with siliconized rubber points (EDENTA AG, Au, Switzerland). After cementation, a detailed clinical inspection of the cemented restoration was performed, and the newly finished restoration into the mouth. It is noteworthy that all crowns included in the study had the maximum grade after evaluation on the baseline day. In addition, periapical radiography was performed using a paralleling technique. The flowchart of the simplified technique proposed by this study can be seen in Figure 2.

Figure 2: The flowchart of the simplified technique.

EVALUATION CRITERIA AND STATISTICAL ANALYSIS

All patients who agreed to participate were invited to return two years later for a review that included dental prophylaxis and re-evaluation of the restoration. The clinical form was filled out again with an anamnesis update and information about the restoration status. Two blinded and calibrated experienced dentists performed a follow-up evaluation, following the UERJ criteria.[15]

Parameters for classification with the UERJ criteria are summarized in Table 3.

Table 3. Parameters for classification with the UERJ criteria.

PARAMETERS		POSSIBLE COMPLICATIONS
Structural Integrity	Material integrity	Crack Chip Fracture
	Tooth Integrity	Crack Chip Fracture Caries Noncarious cervical lesion
	Marginal Integrity	Gap Overcontour or subcontour marginal
Anatomic Form	Buccal and Lingual contour	Overcontour Subcontour Surface wear
	Proximal contour and contacts	Overcontour Excessive proximal contact Subcontour Poor or nonexistent contact
	Occlusal contours and contact	Occlusal/incisal overcontour Premature contacts/ interferences Subcontour occlusal/incisal wear Absence of occlusal contacts
	Smoothness of surfaces	Roughness Irregularities
Pulp Health		Postoperative sensitivity Pulp Necrosis Periapical Lesion
Aesthetic Harmony		Inadequate aesthetics Patient dissatisfaction

The survival rate was calculated as the percentage of restorations that did not need to be replaced at the end of the two-year follow-up. The success rate was calculated as the percentage of restorations that remained in the same conditions of the installation day until the end of the analyzed period.

All volunteers answer a questionnaire at the end of the session, using a visual analog scale (VAS), regarding satisfaction with the restoration under the following aspects: comfort, function, aesthetics, shape, and ease of cleaning. Statistical analysis at the baseline and follow-up criteria was performed with the McNemar test (p<.05) (SPSS; IBM).

STROBE INITIATIVE

The design of the prospective clinical study and the description of this research were carried out according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE – 2008) checklist.[18]

RESULTS

Twenty-two crowns were no longer in the M score but were possible for repair (R score). None of the restorations was in the S score, so the survival rate of indirect FC CAD-CAM restoration after 24 months was 100%. The results at baseline and follow-up evaluation are summarized in Table 4. Among the parameters analyzed, most of the restorations that presented a score change were due to problems detected in the proximal contour and contacts.

Table 4. Clinical evaluation of indirect feldspathic CAD/CAM restorations: criteria at baseline evaluation (0) and 24- month evaluation (24); UERJ criteria from best to worst (M) - (S).

Parameters		Time of evaluation	Score			Total Restorations	p-value*
			M	R	S		
Structural Integrity	Material integrity	0	40	0	0	40	1,000
		24	39	1	0	40	
	Tooth integrity	0	40	0	0	40	*
		24	40	0	0	40	
	Marginal integrity	0	40	0	0	40	,125
		24	36	4	0	40	
Anatomic Form	Buccal and lingual contour	0	40	0	0	40	1,000
		24	39	1	0	40	
	Proximal contour and contacts	0	40	0	0	40	,000
		24	31	9	0	40	
	Occlusal contours and contact	0	40	0	0	40	*
		24	40	0	0	40	
	Smoothness of surfaces	0	40	0	0	40	*
		24	40	0	0	40	
Pulp Health**		0	NA	NA	NA	NA	
		24	NA	NA	NA	NA	
Aesthetic Harmony		0	40	0	0	40	1,000
		24	39	1	0	40	

*** No statistics are computed because the factor is a constant.; ** Of the 40 restored teeth, only 4 of them had pulp vitality at the baseline. The others already had treatment endodontic performed, being framed as "Not Applicable" ("NA") and therefore were not considered for statistical calculation.**

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Data collection regarding patient satisfaction with the restoration over the two years of use revealed an overall satisfaction average above 9.7, with the comfort item presenting the highest standard deviation *(Figure 3)*.

SUCCESS AND SURVIVAL RATE AND STATISTICAL ANALYSIS

The indirect FC CAD-CAM restoration success rate was 35% after 24 months. Despite this, 26 restorations had to be repaired to remain as surviving restorations, thus achieving 100% survival.

The statistical comparison between criteria at baseline and follow-up, using the McNemar test ($p<.05$), revealed no statistically significant differences for all analyzed parameters except for the proximal contact.

DISCUSSION

This preliminary study demonstrates that feldspathic ceramic FC CAD/CAM restorations exhibit a high clinical survival rate after 24 months when assessed using the UERJ criteria. These criteria have proven effective for clinical evaluations grounded in the adhesive principles of contemporary dentistry, aligning with established clinical parameters developed specifically for this purpose over time.

There is great difficulty in comparing the rates found by such follow-up studies, as they were carried out with different materials, using other criteria, where the concepts of failure differ. The UERJ criteria is a recent method for evaluating indirect restorations, which can be applied to ceramic restorations.[15] The fact that it considers any repairable complication as an intermediate category, allows restoration not being counted as a failure. Furthermore, the new criteria standardize definitions, which are essential for comparison purposes between longitudinal studies. It is known that restorations with minor complications are not commonly condemned and removed in clinical routine. In the domain of adhesive dentistry, sometimes, the experienced clinical eye and the knowledge supported by the possibility of repairs[19] possibility dentist to repair and monitor those restorations for years. Categorizing an event just as a failure or a success does not reflect what clinically happens in a high-demand public service like the one in which this study was carried out. In this sense, the UERJ criteria have better sensitivity for application, and the survival rate is more compatible with the clinical reality experienced today. From the results collected over the 24 months, none of the restorations had to be declared as a clinical failure. The most common repaired complications were deficiencies in marginal integrity, contour, and proximal contact, also found by other authors.[8,20,21,22]

Studies report that the most observed failures in CAD/CAM restorations were documentation[8,23,24] fractures[8,19,23,24] and recurrent caries.[20] Deficiency in marginal integrity detected as the presence of a gap may also be related to the presence and condition of proximal restorations in the adjacent teeth. Another essential factor to consider is the patient's periodontal health over the years of followed. The deficiency in the proximal contour can be confirmed by the reduced score in the cleaning question detected in the assessment of the satisfaction questionnaire. Monitoring these parameters in the continuity of this preliminary study can generate answers that control biases about poor proximal contact.

The most relevant data from this study was the 100% survival rate of CAD/CAM crowns in thin FC produced with a simplified technique over two years. Even considering restorations that presented minor complications, 35% of restorations cemented 2 years ago are intact, according to UERJ criteria. Reviewed studies show diverse follow-up results, most based on survival rate. A study[20] found 95% survival for CAD/CAM LD crowns over a

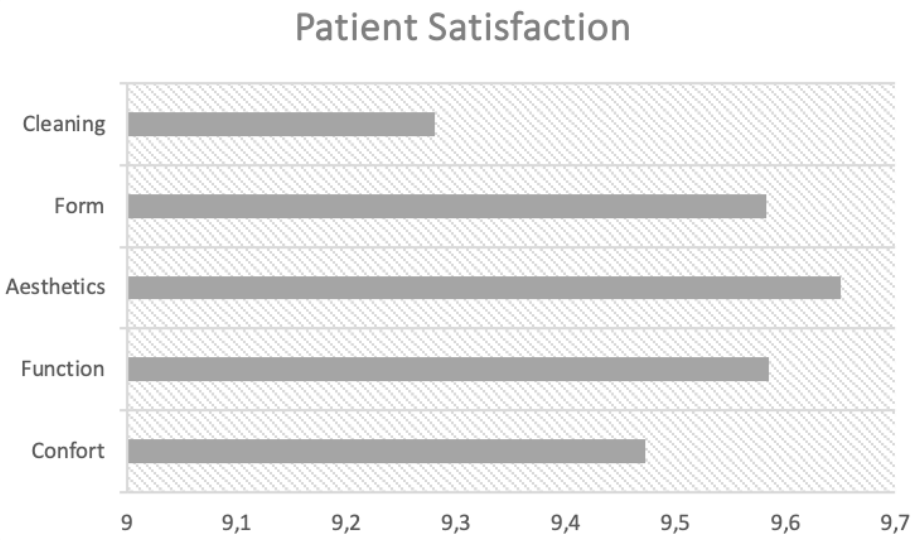

Figure 3: Patient satisfaction regarding the restoration over the two-year period.

4-year follow-up. A recent study[19] reported 85% survival in their zirconia infrastructure fixed bridges and glass ceramic covering over ten years. Another study[13] reported an estimated 5-year survival rate of 89.7% in a systematic review with CAD/CAM ceramic restorations. Authors[25] followed inlays and onlays made from the polymer-infiltrated ceramic network (PICN) type ceramic composites for three years of study, finding survival rates of 97.4% and 95.6% for each type, respectively. Another recent study[23] observed a 3-year survival rate of 97% for PICN restorations and 90.7% for FC CAD/CAM restorations.

Within the restorations installed and monitored during the period, 75% were manufactured with a maximum occlusal thickness of 1200 µm, without any failure in the occlusal structure or failure due to the reduced FC thickness. The literature has recommended measurements between 1500 µm and 2000 µm of occlusal thickness in preparations for CAD/CAM ceramic crown in posterior teeth.[21,22-29] However, it is not always possible to achieve such a measure clinically due to limitations in the teeth' vitality, loss of interocclusal space, or preparation peculiarities.[30] A recent study[31] provides recommendations for ceramic thicknesses supplied by the manufacturer, ranging between 1.0 and 2.0 mm for the occlusal surface. Posterior CAD/CAM partial coverage restorations of minimally invasive monolithic (0.5 and 1.0 mm) resulted in upper failure load values compared to minimally invasive crowns in a recent *in vitro* study.[32] Teeth with reduced interocclusal space challenge clinicians when recommending restorative material for indirect restoration. The results of this research corroborate with a recent study,[30] who argue that ceramic restorations, even with reduced thicknesses of 1200µm, and even if FC, combined with adhesive procedures have shown sufficient resistance to chewing loads,[25,33-34] promoting function and aesthetics in tooth rehabilitation.[30,35] Other studies[31] highlight that adhesion improves the resistance of thin pieces in posterior teeth. Adhesive cementation leads to an increase in the mechanical strength and resistance of the ceramic against fracture. Furthermore, it also balances the strength of less strong ceramics, such as feldspathic (FC) and leucites (L) restorations, compared to more robust ceramics, such as lithium disilicate (LD). A new study[6] highlights that adhesion gives the cementation procedure an essential role in dental treatments using CAD-CAM ceramics.

Using a simplified technique to obtain these CAD/CAM restorations, which did not include the glaze step, further accelerated production time without affecting patient satisfaction (9.7 out of 10). The results obtained by the satisfaction questionnaire demonstrated high satisfaction with the technique and material offered for teeth rehabilitation. These findings agree with report,[19] in which 80% of patients were satisfied with the aesthetics and restoration function. An author reported high patient satisfaction regarding shape and color. Another study[23] also observed high levels of general satisfaction (average VAS 8.78) with the onlays installed in their patients. The overall average satisfaction in this study is above 9.7, with comfort presenting the highest standard deviation, justified by the occurrence of some complications related to the proximal contact point, which may have culminated in difficulty in cleaning. In addition to providing restorations with a high-quality standard, the technology involved and the velocity of ending these prosthetic works have brought considerable gains to the high-demand restorative treatment.

The reduction of technical steps, based on the absence of temporalization and the elimination of the ceramic makeup and glaze phases, simplifies the fabrication of the restoration, promoting satisfactory rehabilitation for high-demand services. In terms of time, this technique requires approximately 10 minutes of milling time and an additional 5 minutes of finishing and manual polishing of the restoration. Other methods that require at least one step for polymerization of the glaze, even using feldspar ceramic blocks, will require approximately 25 more minutes (application and oven time). This saving in time, material, and labor has a significant impact on offering aesthetic rehabilitation services of this type.

Although promising, the present findings should be analyzed considering the limitations of this preliminary clinical study. One limitation is the 2-year follow-up period, although some clinical changes were observed. Another limitation is the new criterion chosen, which is based on more realistic concepts about the terms "success" and "survival" of indirect restorations but lacks robust support in the literature. Monitoring these cases over the next few years will provide insights that align with the study's speculations on the longevity of CAD/CAM restorations in FC blocks. Additionally, Kaplan Meier analysis can help predict the expected success rate over time. An analysis of the periodontal condition of patients before and during follow-up, as well as the presence and quality of proximal restorations of adjacent teeth, may be of interest in the control of biases. Furthermore, the research group is currently conducting more studies using the UERJ criteria, and future publications with comparable results may bring exciting answers to the clinical findings of scientific relevance.

The introduction of technological innovations into daily life at a breathtaking speed often prevents us from fully utilizing the potential of each product or input. The short lifespan of materials in the market, constantly being replaced by supposedly superior ones, hinders long-term research efforts. The pressure imposed by technology may only consider using materials like FC, which have specific advantages with proper scientific evidence. The findings of this prospective study on clinical performance validate the investment in a CAD/CAM system. Additionally, it demonstrates that adopting a simplified technique using lower-cost materials for chairside digital flow conversion can be advantageous for a service with high demand for restorative care.

It should be noted that this study only represented the clinical performance of one clinician, and a more extended clinical evaluation period is necessary to draw further conclusions.

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CONCLUSION

The clinical result of indirect FC CAD-CAM restorations obtained using a simplified technique and evaluated after 24 months using the new criteria (UERJ criteria) clinically demonstrates 100% survival of the restorations and 35% success. Also, average patient satisfaction was above 9.7.

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