Marginal and internal fit of CAD/CAM fabricated all-ceramic restorations: a literature review

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Abstract

Objective: the aim of this article was to review the literature about the marginal and internal fit of CAD/CAM fabricated all-ceramic restorations. **Material and Methods:** a review of literature using Pubmed and Bireme database was executed and 37 articles in English and Portuguese were selected. The keywords were "Computer-Aided Design," "Dental marginal adaptation," "Dental restoration, permanent." **Results:** the results proved that this system can generate restorations with clinically acceptable marginal fit (≤100 μm). However, other parameters must be considered to achieve these results such as milling machine, bur diameter, software, design preparation, smooth preparation margins and incorporation of rounded line angles on the tooth preparation, learning curve of the operator and type of impression method. **Conclusion:** therefore, although some clinicians present concerns related to the internal fit of CAD/CAM system fabricated restorations, studies corroborate the success on the fit of these restorations, which justifies clinical use and indication of CAD/CAM system.

Keywords: Computer-Aided design; Dental marginal adaptation; Dental restoration permanent.

Introduction

The growing search for esthetic restorations by patients has increased the significance of all-ceramic restorations,[1] which have been making constant progress, guaranteeing better esthetics, biocompatibility and proper resistance to masticatory forces.[2]

In order to guarantee these restorations' durability and clinical success, it is essential that mechanical, biological and esthetic principles are followed, since tooth preparation until the fabrication of the restoration itself. Marginal and internal adaptations are significant factors, since they are directly related to these principles, as marginal integrity, structural rigidity, preservation of periodontal and pulp health.[3,4]

In this sense, increased marginal discrepancy is related to a higher exposure of cement to the oral cavity, which can lead to its dissolution, favoring the accumulation of tooth biofilm and, consequently, increasing the occurrence of caries, periodontal and pulpal diseases.[5,6] Besides that, the thicker resinous cement layer favors a higher concentration that can lead to microcracks, piece maladjustment and even to marginal fractures of loose ceramic.[7,8]

In its turn, internal adaptation reflects the fracture force of the prosthetic work. Thus, an overdone cement line creates a place of force concentration and it constitutes a local for the fracture initiation.[9,10]

Many factors reported in literature affect the restoration adaptation, as design preparation, restoration material, end localization, mold technique and material, fabrication method, among others.[11] Regarding the all-ceramic fabrication method, it is highlighted the techniques using lost wax, ceramic injection, and the systems of computer-aided design and computer-aided manufacturing (CAD/CAM).[12]

The CAD/CAM system is getting more prominence among dentists by simplifying many clinic and laboratorial phases and enabling an all-digital work flow.[13] Because of that many *in vivo* and *in vitro* studies are being performed to assess its parameters and clinical results.

Given this scenario, the aim of this study is to review, in literature, articles that discuss about marginal adaptation of ceramic restorations fabricated by the CAD/CAM system.

Material and Methods

A review of literature in the Bireme and Pubmed databases was performed with the keywords: Computer-Aided design, Dental marginal adaptation, and Dental restoration permanent. The selection criteria were articles in Portuguese and English that approached the studied theme between 2000 and 2017. Altogether, there were 38 articles selected, including classical articles complementary to the theme.

Literature Review

There is no consensus in literature on the limits of clinically acceptable marginal adaptation, some support a value lower or equal to 120 μm,[14-15] others concluded that it should be lower than 100 μm[16-18] and there are still those who argue for a maladjustment lower than 75 μm[19] or between 20-45 μm,[20] however, these last ones are rarely found in clinic.

The marginal adaptation promoted by the CAD/CAM system has been comprehensively studied and compared regarding different clinical situation and through different methodologies.

Keshvad *et al.*,[17] by comparing marginal and internal adaptation of ceramic inlays fabricated by CAD/CAM system and by injection technique concluded that there was a lower marginal maladjustment in those fabricated by CAD/

CAM, having no significant difference concerning the internal precision. On the other hand, Guess *et al*.[21] did not find any significant difference between the marginal adaptation of onlays fabricated by CAD/CAM or injection, while the internal maladjustment of the digital fabricated restoration was higher. The study performed by Neves *et al*.[22] showed that there was no significative difference between marginal adaptation, both vertical and horizontal, between the lost wax and CAD/CAM methods for total crowns of lithium disilicate. In their turn, Mosley *et al*.[23] had, as a result, a bigger marginal maladjustment in crown made by the CAD/CAM system; however, a different system was used in relation to the previous research.

When compared with metal-ceramic restoration, all-ceramic crowns fabricated by CAD-CAM had lower imprecision.[24]

Besides that, a parallel reported in literature concerns the association between a software tool that allows to adjust cement spacing and marginal adaptation.[25-27] For the CAD/CAM E4D system (E4D Dentist system; D4D Technologies), according to Mosley *et al*.,[25] the best spacing would be of 30 μm or 60 μm in terms of marginal maladjustment. The spacing of 50 μm is also supported in literature.[25-27]

Despite being still controversial, a difference can also be noticed concerning the way that tooth preparation digitalization occurs. According to Ahrberg *et al*.,[28] direct digitalization shows a better result for marginal precision in relation to indirect ones, when a conventional mold is done and the plaster model is scanned. However, other articles did not report significant differences.[29,30]

Association between the CAD/CAM system's commercial brand and the adaptation was also established,[22,31] given that each brand has its particularities in relation to the prosthesis' production phases, that is, scanning, design, and milling.

As it was already defined for conventional restorations, the preparation end also affects marginal adaptation by enabling cement drainage in a bigger or lower scale. According to the research by Souza *et al*.,[9] the beveled shoulder finishing produces a smaller marginal maladjustment, while deep chamfer is associated with a better internal adaptation. On the other hand, Jalali *et al*.,[32] did not observe any difference among the group of teeth that received a shoulder finishing and the other group, in which a shoulder finishing was made in the vestibular wall associated with chamfer in the proximal and lingual walls.

An advantage to be highlighted is that CAD/CAM also allows the fabrication of temporary restorations, having more adequate adaptation than the ones fabricated by conventional methods, which would be interesting in clinical situations where a stronger tooth resistance and protection are necessary.[33]

It is important to highlight that in all cited articles the average for marginal adaptation values was inside the clinically acceptable limit of 100 μm.

Discussion

Since the introduction of CAD/CAM systems in the dentistry market, many advances in software, algorithm design and milling units have arose, contributing for an improvement in restoration's precision.[21]

Dental preparation for CAD/CAM is more critical than for injection technique, since they can create imprecisions during the milling,[4] due to the drills' size. Thus, it is essential for the preparation to have rounded angles and smooth and plain walls.[34] In this sense, corrections are more easily made in the injection and lost wax techniques, which can partially explain its lower precision. The adaptation differences in restorations done by injection or CAD/CAM are related to the different phases each process includes.

Other factors should be considered when analyzing the restorations' overlapping, some of those are inherent to the operator, for example, the learning curve in the restoration fabrication process by this new system. Other factors are related to the system itself, since many successive phases can result on imprecisions, among them: scanning, digital margin localization, design software and milling.[35] Even the size of the milling drill used will interfere on the ability of copying the pieces' details,[36] besides that, the milled material affects the milling precision. Harder materials, such as titanium and densely sintered zirconia, require more strength and make the drill more susceptible to mistakes. Because of that it is also essential to always keep the drill sharp.[37]

Despite the variety of available articles on the theme, there is no standardization regarding the methodology employed in the articles used, thus, the results found cannot be compared. Given that factors as: prepared tooth design, localization and number of the maladjustment measure points, measurement technique, kind of resinous cement (if used), and method of restoration fabrication are directly related to marginal discrepancy value found.[38]

Reported marginal adaptation was inside the acceptable clinical parameters, considering it as below 100 μm.

Despite having many *in vitro* studies on the theme, it is necessary to perform future clinic studies and to do a long-term follow-up to try to associate these values found with a clinical correlation of restoration durability.

Final Remarks

From this literature review, it is concluded that CAD/CAM restorations show marginal adaptation within the acceptable clinical limits, being able to be used in clinical routine as long as the technique is mastered.

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Mini Curriculum and Author's Contribution

1. Brenda Gonçalves de Carvalho – DDS. Contribution: bibliographical research and manuscript writing.
2. Mariana Silva Thiel Ribeiro – DDS. Contribution: bibliographical research and manuscript writing.
3. Leonardo Rocha Brasil – DDS. Contribution: bibliographical research and manuscript writing.
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