



EVALUATION OF THE STRENGTH OF NANOCERAMIC RESINS: A SYSTEMATIC LITERATURE REVIEW

Avaliação da resistência de resinas nanocerâmicas: uma revisão sistemática da literatura

ISSN: 2178-7514

Vol. 17 | Nº. 2 | Ano 2025

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ABSTRACT

Introduction: Composite resins are highly aesthetic restorative materials, with nanohybrid resins being the most indicated for anterior tooth restorations due to their excellent physical and mechanical properties, gloss, surface smoothness, and good wear resistance. The fabrication of restorations using the CAD/CAM system has become increasingly widespread in the field of Dentistry. CAD/CAM is a technology widely used in various industries and was introduced into Dentistry in the late 1970s. These technologies are based on three essential phases: digitization, virtual planning, and production. **Objective:** This study aimed to present, through a literature review, the nanohybrid resin fabricated using CAD/CAM technology. **Materials and Methods:** This literature review was based on a search and analysis of scientific publications in the PubMed, SciELO, and Cochrane databases, including articles, journals, and books in Portuguese and English, published between 2016 and 2022. **Results and Conclusion:** It can be concluded that advances in dental restorations drive manufacturers to develop products and technologies that enhance aesthetics and the final outcome of restorations. Studies have highlighted that marginal adaptation is essential for oral health. CAD/CAM systems enable the fabrication of restorations with adaptation gaps within clinically acceptable standards.

Keywords: CAD/CAM, nanohybrid resins, CAD/CAM technology.

RESUMO

Introdução: As resinas compostas são materiais restauradores altamente estéticos, sendo as resinas nanohíbridas as mais indicadas para restaurações de dentes anteriores devido às suas excelentes propriedades físicas e mecânicas, brilho, lisura superficial e boa resistência ao desgaste. A fabricação de restaurações utilizando o sistema CAD/CAM tem se tornado cada vez mais difundida na área da Odontologia. O CAD/CAM é uma tecnologia amplamente utilizada em diversas indústrias e foi introduzida na Odontologia no final da década de 1970. Essas tecnologias são baseadas em três fases essenciais: digitalização, planejamento virtual e produção. **Objetivo:** Este estudo teve como objetivo apresentar, por meio de uma revisão bibliográfica, a resina nanohíbrida fabricada utilizando a tecnologia CAD/CAM. **Materiais e Métodos:** Esta revisão bibliográfica foi baseada na busca e análise de publicações científicas nas bases de dados PubMed, SciELO e Cochrane, incluindo artigos, periódicos e livros em português e inglês, publicados entre 2016 e 2022. **Resultados e Conclusão:** Pode-se concluir que os avanços nas restaurações dentárias impulsionam os fabricantes a desenvolver produtos e tecnologias que melhoram a estética e o resultado final das restaurações. Estudos têm destacado que a adaptação marginal é essencial para a saúde bucal. Os sistemas CAD/CAM permitem a fabricação de restaurações com lacunas de adaptação dentro de padrões clinicamente aceitáveis.

Palavras-chave: CAD/CAM, resinas nanohíbridas, tecnologia CAD/CAM.

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INTRODUCTION

Oral rehabilitation involves several specialties within the field of Dentistry, aiming to restore function, aesthetics, and health. However, to achieve successful treatments, it is crucial to perform a proper and meticulous planning. In this way, the dentist can combine scientific knowledge with technological resources, which have increasingly been developed to provide more satisfactory results for patients, ensuring a better prognosis for the treatment⁽¹⁾.

There has been an increase in the demand for indirect treatments in Aesthetic Dentistry. This is due to the fact that they offer greater predictability by improving physical properties and involving the use of various materials available on the market. This demand is related to several factors, such as the media's influence on the pursuit of an attractive and harmonious smile, and the development of new techniques that have led to a wider adoption of restorative treatments. As a result, this has enabled the achievement of more appropriate aesthetic planning with excellent outcomes and clinical durability⁽²⁾.

Aesthetics, despite its undeniable importance, is just one of the requirements for treatment success. Therefore, the professional must not forget that regardless of the material used, marginal adaptation and resistance are some of the main factors involved in the longevity of a restoration. The better the marginal accuracy, the thinner the cement film, favoring adaptation to the cervical margin, an area susceptible to gingival inflammation, plaque retention, and recurrent caries, especially in subgingival preparations.

Furthermore, the more similar the structures are to a natural tooth, the greater their longevity⁽³⁾.

A class of materials known as nanohybrid resins consists of spherical zirconia and silica nanoparticles grouped and bonded by a resin matrix. This new class was introduced to use CAD/CAM technology to fabricate fixed restorations, showing fracture resistance comparable to glass ceramics and functional balance with enamel structures, with flexural modulus in the same range as dentin⁽⁴⁾.

The main advantages of these high-performance polymers are their low abrasion on opposing teeth and their modulus of elasticity, which allows for more functional impact absorption without deformation. Some permanent disadvantages of composite resin include discoloration, deterioration of surface finish, and color instability⁽⁵⁾.

Regarding the advantages offered by the CAD/CAM system, it includes the fabrication of a fixed prosthetic piece with excellent marginal adaptation to the preparation, satisfactory aesthetics, depth of field, high precision, minimal wall thickness, as well as impressions of entire quadrants. However, the system still presents the high cost of acquiring the equipment for manufacturing the pieces and requires training for its use⁽⁶⁾.

Among the disadvantages of indirect treatments are the high financial cost and the longer working time. However, this type of treatment has become simpler and faster with the development of CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) technology, which has modified the way restorations are performed. It is worth noting

that CAD/CAM technology has improved the prosthetic procedure and restorations in general, through the use of design and manufacturing aided by computing. Furthermore, CAD/CAM systems enable the integration of design tasks, simulation, and product refinement, as well as prototyping and manufacturing⁽⁷⁾.

METHODOLOGY

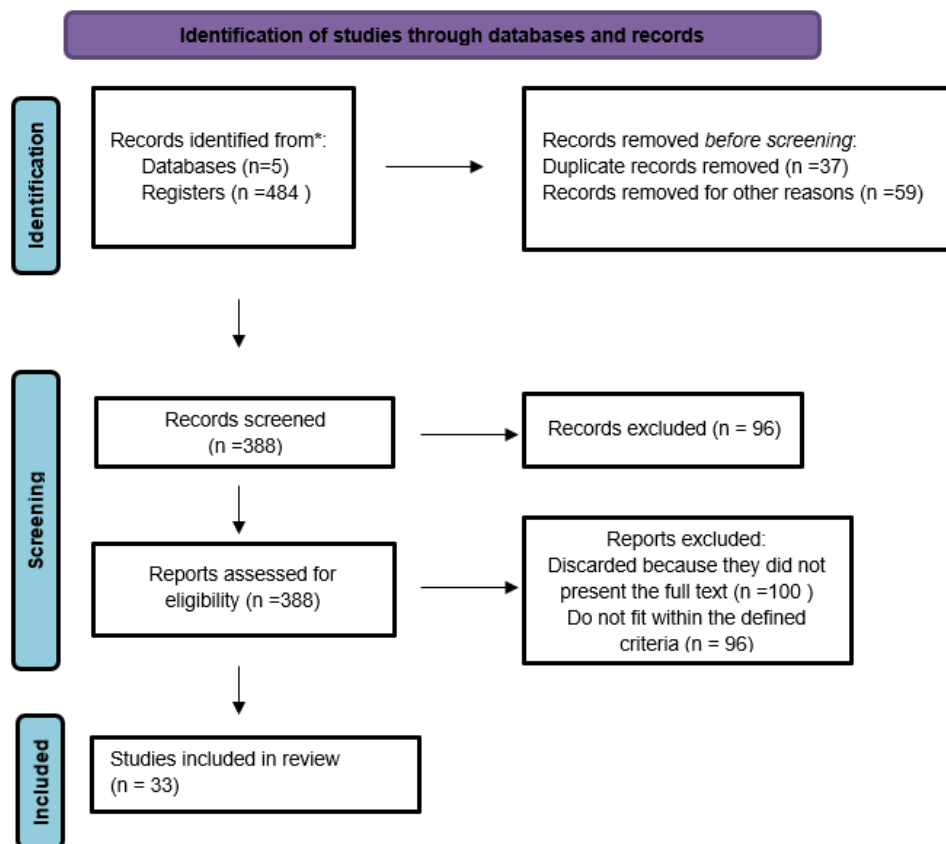
The aim of this study was to present, through a systematic literature review, a comparative study on the strength of CAD-CAM nanoceramic resins.

RESULTS AND DISCUSSION

The search strategy identified 484 articles, of which 451 were discarded for not having full text and for not meeting the defined criteria. Among the selected articles, only 33 met the established inclusion criteria, as shown in the PRISMA flowchart 1.

According to Page et al. (2022), the PRISMA flowchart is a representation of the entire process of searching and selecting articles and documents in databases, from the beginning, determining the number of articles retrieved with the application of search strategies in each database, to the end, outlining the number of articles that remained in our review sample⁽⁸⁾.

Flowchart 1 - Flowchart of Study Identification



Source: Page et al. (2021).

The concepts of restorative dentistry have been questioned due to technological advancements and the introduction of CAD/CAM systems in the field of dentistry. Numerous studies have been conducted in search of answers, and the current and growing use of CAD/CAM systems in the market has made indirect restoration procedures more practical, highly precise, and capable of being constructed in both laboratories and in the office during the same appointment^(4,5,9,10,11).

The studies categorized that the use of CAD-CAM technology enhances treatment due to the use of computer-aided design and fabrication. However, the fact that these are computerized technologies requires that both the clinical professional and the laboratory staff are proficient in utilizing the technology to maximize the return on investment^(4,5,12,13).

Nanoceramic resins produced through milling have a homogeneous distribution of their constituent materials, increasing their resistance. This is due to the industrial production process, where production control is automated, ensuring greater strength compared to direct composite materials⁽¹⁴⁾.

It was inferred that, through a high-precision scanner, it is possible to obtain an image of the model or even the patient's own dental arch for the computer. In this way, a faithful copy of the preparation is obtained, without the need for the molding step, speeding up the treatment, which is often completed in a single session. Many systems currently available on the market

offer various methods and the ability to design in three dimensions from a digitized plaster model or intraoral preparation⁽¹³⁾.

Some authors have discussed that the 3D virtual image is edited by a professional who constructs a digital apparatus, and the design is created in a computer program according to the clinical case. Then, the piece is directed to the printer, which is a milling unit that, using pre-fabricated blocks such as zirconia, nanoceramic resin, or ceramic, will reproduce the piece designed on the computer^(7,15).

Resins for the CAD/CAM system require little finishing after milling, needing only pigmentation for aesthetic characterization and gloss through chemical glazing. Their resistance and properties are compared to ceramic blocks, but there is no consensus on which is the best⁽¹⁰⁾.

The authors agreed that the development of the CAD/CAM system enabled the milling of blocks through computerized systems, ensuring greater control over the quality of the pieces. They explain that since its introduction in Dentistry, the system has been used to simplify, automate, and ensure quality levels with micrometric adaptations of dental prostheses and control of the block components for manufacturing, maintaining the resistance tested by its manufacturers^(1,13,16,17,18).

It was highlighted in this review that among the benefits of using the system is the opportunity to choose the most convenient CAM system for the purposes, given the possibility of transmitting the CAD file to another computer.

Open systems receive images from any scanner, as well as being able to send data to any machine. The patient benefits from the opportunity to skip several stages of manufacturing and can complete the treatment in just two appointments, with the possibility of creating restorations using the CAD/CAM system^(4,5,13,17).

There was a consensus that the digitizing devices and CAD software can come from different manufacturers. In contrast, closed systems can only receive and send data to specific machines, making the procedure one where there is no communication between different processes, and all equipment must be purchased from the same manufacturer^(3,13).

Moreover, the deficiencies and disadvantages are almost eliminated by the CAD/CAM systems, which is considered a benefit of the system—the possibility of altering the restoration using the design software. If a significant marginal discrepancy occurs, it can be corrected by modifying the program. One of the disadvantages of the CAD/CAM system is the requirement for expensive equipment. Additionally, the restorations offer advantages in terms of color, adaptation, as well as control over the processing done on a computer^(1,12,20).

However, the studies evaluated that CAD/CAM technology requires data acquisition in some manner, especially in systems designed for Dentistry. This is because the characteristics of each patient make digitalization the first step in the manufacturing process, as the primary purpose

of digitalization is to allow the data systems to be edited in a CAD software. The use of CAD-CAM technology enhances the production of prostheses due to the use of design and fabrication, assisted by computers. However, the fact that these are computerized technologies demands that both clinical professionals and laboratory technicians know how to use the technology effectively to maximize the investment^(2,4,5).

Moreover, it was shown that restorations made using CAD/CAM technology are a viable alternative, as they possess a high success rate, color stability, flexural strength, good marginal adaptation, and clinically acceptable wear. As a result, we have observed an exponential increase in the use of this strategy in recent years (SCHUBERT et al., 2023)⁽³⁾.

Regarding nanohybrid resins, the studies discussed revealed that these resins have particles ranging from 0.04 to 3.0 μm , showing a strong resemblance to microhybrid resins. Other positive properties of these resins include the simplicity of their characteristics, the ability to maintain anatomy for long periods, good optical outcomes of the restorations, and long-term resistance^(2,5).

The studies analyzed have shown that, in addition to the components of the resin and the particle size, it is essential for the professional to understand and know how to choose the right material for each situation. The viscosity and robustness of the resin directly affect the clinical handling of the composite. Resins for indirect restorations are increasingly used in various

situations, such as inlay/onlay restorations, full crowns, fixed prostheses, and veneers. In turn, laboratory resins undergo several improvements, resulting in resins with reliable clinical performance. Due to the high demand for aesthetic procedures, there has been an increase in the use of metal-free restorative materials, among which are the second-generation indirect resins^(4,5,21).

Composite resins have undergone numerous modifications since their inception, enabling their application in various clinical procedures, contributing to restorations with satisfactory aesthetic appearance and adequate resistance. On the other hand, these constant transformations of composite resins are responsible for the difficulties professionals face when selecting them, as they require correct indications and the availability of techniques for using different materials on the market, due to the professionals' lack of knowledge about these innovations^(12,13).

Currently, most materials used in dental restoration are hybrid, meaning they are composed of several different phases. These materials consist of an organic polymer matrix reinforced by ceramic or vitreous particles, or by a three-dimensional ceramic porous structure to increase strength and longevity. Only an effective interfacial interaction can strengthen both phases. It is necessary for the phases to be chemically compatible or for another material to interact between them for this to occur⁽³⁾.

Resin blocks offer several advantages over ceramics, as they do not suffer milling damage,

allowing for faster, more efficient, and higher-quality manufacturing with increased resistance. Additionally, resin blocks do not require post-milling, allowing for easier modifications and adjustments for proper occlusion. A large portion of indirect resin systems have complementary polymerization schemes, resulting in a higher conversion of monomers into polymers. Different modes of additional polymerization can be performed through thermopolymerization, photopolymerization simultaneous with thermopolymerization, and thermopolymerization under pressure related to vacuum or nitrogen^(1,4,5,13).

Its elastic nature allows for easier milling and intraoral repairs in an economical and conservative manner, maintaining its strength, as well as providing shock absorption and distribution of masticatory forces, demonstrating similarity when compared to ceramic materials^(22,23,24,25,26).

To achieve polymerization of the superficial resin layer, slightly heated light is typically used for the process, resulting in increased rigidity, flexural strength, fracture toughness, abrasion resistance, and greater color stability. Furthermore, less marginal infiltration is observed, as heat promotes better photopolymerization, ensuring complete crosslinking of the resin matrix^(3,27).

It was emphasized in the studies that the characteristics of the restoration include: a high risk of caries and bruxism, so factors can affect longevity, regardless of the type of material used.

The use of composite resin as a cementing agent has a key characteristic, which is the benefit of being a photopolymerizable restorative material, possessing excellent characteristics in terms of workability, color stability, wear resistance, and radiopacity. After being thermally heated, this composite resin becomes more viscous, which stabilizes the restoration and simplifies the removal of excess material^(2,4,5).

It was discussed that the dentist can choose the most suitable materials for each situation due to the wide variety of materials available with CAD/CAM. This innovative method allows the dentist to provide high-quality indirect restorations to patients in a single appointment, reducing chair time, avoiding the use of impression materials, and thus reducing laboratory costs. With the use of the intraoral scanner, the dental preparation is processed on a computer, where the piece is designed and ultimately milled. Teeth obtained through additive manufacturing can be applied, as they have shown similar results in resistance to chipping when compared to conventionally pre-fabricated resin prosthetic teeth^(4,5,12,13,28).

There was unanimity in the studies that revealed that due to the challenges presented by ceramics, hybrid materials, such as polymer-infiltrated ceramics, have been used in CAD/CAM. This is due to the better modulus of elasticity and Vickers hardness of these materials, which reduces the propagation of cracks and fractures. Hybrid resins have a modulus of elasticity similar to that of dentin, making the

stress distribution very different from that of feldspathic ceramics, which are more brittle. Hybrid materials are more precise and internally adaptable compared to ceramics due to their hardness and modulus of elasticity^(29,30).

The selection of any restorative material requires a thorough analysis of its advantages and limitations to inform the best clinical decision on a case-by-case basis⁽¹⁷⁾.

Cementation resources must be carefully analyzed, as the use of thermally heated resins or resin cements may or may not alter the flexural strength of CAD-CAM nanoceramic resins^(31,32,33).

CONCLUSION

CAD/CAM systems have gained traction in the field of Dentistry due to the ability to produce pieces with high precision, biocompatibility, predictability, excellent marginal adaptation, mechanical resistance, flexural strength, and aesthetics. However, their excellence is dependent on the proper clinical steps, accurate scanning, piece fabrication, strict quality control, and laboratory work.

According to what has been presented in this study, it can be concluded that the advancement of dental restorations amplifies manufacturers' search for the development of products and technologies that enhance aesthetics and the final outcome of the restorations. The studies highlighted that marginal adaptation is essential for oral health. CAD/CAM systems enable the

fabrication of restorations with adaptation gaps within the clinically satisfactory range.

It is concluded that, due to their resistance, marginal adaptability, translucency, and durability, dental nanoceramic resins are an option for indirect restorations.

By working in conjunction with digital dentistry, precise adjustments can be made, resulting in restorations with satisfactory longevity. The introduction of the CAD/CAM system into the routine of dental professionals has enabled shorter working time, greater accuracy in the fabrication of dental prostheses, and increased patient comfort.

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Observação: os/(as) autores/(as) declaram não existir conflitos de interesses de qualquer natureza.