CAD/CAM TECHNOLOGY IN OPERATIVE DENTISTRY IN THE FIELD OF CONSERVATIVE DENTISTRY

(TEKNOLOGI CAD/CAM DALAM OPERATIVE DENTISTRY DI BIDANG CONSERVATIVE DENTISTRY)

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ABSTRACT

The use of Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) in operative dentistry has been increasingly developed due to the precision, time efficiency, and aesthetic quality of the restorations produced. This study aims to review the latest evidence regarding the application of CAD/CAM in dental conservation. As the use of CAD/CAM in dentistry continues to rise, a systematic review is needed to assess its effectiveness, compare its advantages with conventional methods, and identify its implementation limitations. Secondary data were obtained from Google Scholar, PubMed, and Wiley Online Library. The included articles were peer-reviewed case reports, full-text, published between 2020 and 2025. Older studies (more than 5 years old) were excluded. From an initial 14,138 literature, a systematic selection yielded four articles that met the criteria, involving adult patients with CAD/CAM interventions including post-and-core, lithium disilicate veneer, ZLS onlay, and nano-ceramic onlay for the rehabilitation of worn dentition. The review followed the PRISMA approach, focusing on qualitative synthesis without meta-analysis. All studies demonstrated that CAD/CAM supports more precise, minimally invasive conservative restorations with good marginal adaptation, optimal aesthetics, and time efficiency (single-visit treatment). Modern materials such as ZLS and lithium disilicate yielded satisfactory results at 2 years of follow-up. Patients also reported increased comfort and satisfaction after rehabilitation. The findings are based solely on case reports with small sample sizes and short follow-up periods, thus limiting

generalization. CAD/CAM technology shows promise in modern restorative dentistry due to its precision, efficiency, and aesthetics. However, current evidence remains limited, so larger prospective studies with longer follow-ups are necessary. This technology has the potential to become the new standard in dental conservation, supporting digital-based dental education, and encouraging further research on its long-term clinical effectiveness.

Keywords: CAD/CAM; conservative dentistry; digital restorations; operative dentistry

ABSTRAK

Penggunaan Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) dalam operative dentistry semakin berkembang berkat presisi, efisiensi waktu, dan kualitas estetik restorasi yang dihasilkan. Kajian ini bertujuan meninjau bukti terkini terkait aplikasi CAD/CAM dalam konservasi gigi. Seiring meningkatnya penggunaan CAD/CAM dalam kedokteran gigi, diperlukan review sistematis untuk menilai efektivitasnya, membandingkan keunggulannya dengan metode konvensional, serta mengidentifikasi keterbatasan penerapannya. Data sekunder diperoleh dari Google Scholar, PubMed, dan Wiley Online Library. Artikel yang diikutsertakan berupa laporan kasus peer-rreviewed, full tetext, terbit 2020-2025. Studi lama (>5 tahun) dikecualikan. Dari 14.138 literatur awal, setelah seleksi sistematis diperoleh 4 artikel yang memenuhi kriteria, melibatkan pasien dewasa dengan intervensi CAD/CCAM berupa post-and-core, veneer lithium disilicate, onlay ZLS, dan onlay nano-keramik untuk rehabilitasi dentisi aus. Metode penelitian : Kajian dilakukan dengan pendekatan PRISMA, berfokus pada sintesis kualitatif tanpa meta-analisis. Seluruh studi menunjukkan CAD/CAM mendukung restorasi konservatif yang lebih presisi dan minim invasif, dengan adaptasi marginal yang baik, estetika optimal, serta efisiensi waktu (perawatan satu kunjungan). Material modern seperti ZLS dan lithium disilicate memberikan hasil memuaskan hingga dua tahun tindak lanjut. Pasien juga melaporkan peningkatan kenyamanan dan kepuasan setelah rehabilitasi. Temuan hanya didasarkan pada laporan kasus dengan jumlah kecil dan tindak lanjut pendek, sehingga generalisasi terbatas. CAD/CAM menjanjikan dalam restorative

dentistry modern karena presisi, efisiensi, dan estetika yang dihasilkan. Namun, bukti saat ini masih terbatas sehingga studi prospektif lebih besar dan jangka panjang diperlukan. Teknologi ini berpotensi menjadi standar baru dalam konservasi gigi, mendukung pendidikan kedokteran gigi berbasis digital, serta mendorong penelitian lanjutan mengenai efektivitas klinis jangka panjang.

***Kata Kunci** : CAD/CAM; konservasi gigi; operative dentistry; restorasi digital*

INTRODUCTION

Restoration in dental conservation is generally performed using conventional techniques that involve physical impressions and gypsum models. This process includes multiple laboratory stages and requires several patient visits. Materials such as metal, porcelain, and resin can meet the restoration needs, but their precision is limited, and the aesthetic outcomes are often suboptimal. These limitations have led to the emergence of Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technology, which offers a more precise, efficient, and aesthetic solution in modern restorative treatments [1].

The terms "Computer-Aided Design" and "Computer-Aided Manufacturing" (CAD/CAM) refer to the use of computer software for the design and manufacture of dental restorations. The use of CAD/CAM in dentistry began in the 1980s and has since seen significant advancements [2]. CAD/CAM in dentistry improves the efficiency of time and labour required for creating dental restorations. It allows for the digital design and fabrication of dental restorations, enhancing precision, efficiency, and aesthetics in dental care [3].

The application of CAD/CAM in operative dentistry includes the design and fabrication of restorations such as inlays, onlays, veneers, and endocrowns. CAD/CAM technology has rapidly evolved and become an essential part of modern dental practice, particularly in operative dentistry. As the use of CAD/CAM continues to increase in dentistry, a systematic review is needed to evaluate its effectiveness, assess its advantages over conventional methods, and identify potential shortcomings in its practice [4].

Despite its advantages, this technology still has limitations. The need for training and the potential for technical errors if not executed correctly present challenges in its implementation. Therefore, a deep understanding of the technology, operator skills, and appropriate case selection are crucial factors for clinical success [4].

METHOD

The analysis in this study follows the PRISMA (Preferred Reporting Items for Systematic Reviews

and Meta-Analyses) guidelines for evaluating systematic reviews and meta-analyses. Secondary data were obtained through literature searches in databases such as Google Scholar, PubMed, and Wiley Online Library. The data were analysed and synthesised using the PRISMA approach. The data used are secondary, consisting of literature and scientific evidence on the application of CAD/CAM technology in Operative Dentistry within Dental Conservation.

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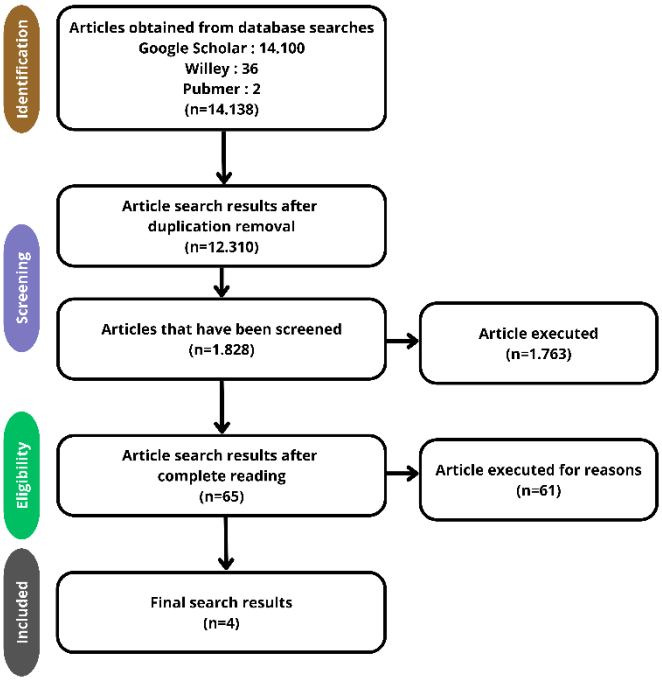

Figure 1. PRISMA Method

DATA SOURCE

The design used is a literature review, which is a study aimed at summarising and synthesising various literature within a specific field without collecting or analysing primary data. The data processed and synthesised in this method are secondary data, comprising literature and evidence already available on the use of CAD/CAM technology in Dental Conservation, particularly in operative dentistry. Secondary data were collected through searches across several sources, including Google Scholar, PubMed, and Wiley Online Library, and analysed and synthesised using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) extension.

STUDY ELIGIBILITY CRITERIA

This study meets the feasibility standards by applying a systematic literature review using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method. The articles analysed are from peer-reviewed journals listed in trusted academic databases. Study selection was carried out using inclusion and exclusion criteria to ensure the research included is relevant and valid.

PARTICIPANTS AND INTERVENTIONS

The literature search was conducted via journal portals using keywords such as "CAD/CAM", "conservative dentistry", "operative dentistry", and "digital restorations", yielding 14,138 articles. After screening and identification based on titles, abstracts, and keywords, the number of relevant articles decreased to 12,310. The literature was further selected based on inclusion and exclusion criteria and duplicate removal, resulting in 65 articles.

The inclusion criteria included literature in the form of case report journals discussing the application of CAD/CAM technology in operative dentistry within dental conservation. The literature

should be accessible in full text and published between 2020 and 2025. The exclusion criteria included studies published more than 5 years ago and literature that presented similar themes in the cases discussed, such as veneers and onlays. After further screening of the journals' content, four articles were identified as meeting the criteria.

RESULT

Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) aim to improve clinical time efficiency and reduce treatment time. The use of CAD/CAM optimizes the precision of restorations such as inlays, onlays, crowns, and veneers [5]. This technology allows the restoration process to be completed more quickly with a lower risk of errors compared to conventional methods [6].

The use of CAD/CAM technology significantly reduces the time required for restorative procedures. With the ability to perform restorations in a single visit, CAD/CAM technology can reduce the number of patient visits, enhancing patient comfort and satisfaction. The digital workflow in CAD/CAM technology also enables precise design and fabrication of restorations, improving the fit and aesthetic quality of the restorations [7].

Explore the use of digital CAD-CAM in post-endodontic restoration for a premolar with significant coronal loss. The post and core are designed virtually using intraoral scans, eliminating the need for physical gypsum models [8]. This method allows for precise, anatomically customized restorations with optimal root canal adaptation, offering a more conservative and efficient approach than conventional techniques. Accurate post-and-core design is vital for long-term success, enhancing retention and reducing the risk of fractures and other complications [9].

Table 1. Synthesis of the Study

Journal Name and Title	Research Design	Results	Reference
CAD-CAM Customized Glass Fiber Post and Core with Digital Intraoral Impression: A Case Report	Case Report	Tooth 45 underwent root canal treatment. Subsequently, a post and core restoration will be fabricated for the endodontically treated tooth. The use of CAD/CAM technology with digital intraoral impressions allows for the creation of highly precise and anatomically accurate fibre-reinforced resin posts and cores. The digital process transforms the concave surface of the root canal into a convex post surface that fits optimally against the dentin walls.	[3]
Full Digital Workflow for Aesthetic Rehabilitation of the Upper Teeth: A Case Report	Case Report	A male adult patient presented with a gummy smile, along with the shape, color, and position of the upper anterior teeth not meeting the patient's expectations. Lithium disilicate veneers were fabricated using CAD/CAM technology and cemented with transparent composite resin (RelyX Universal). The use of a digital workflow enabled the achievement of both aesthetic and functional results in a shorter working time, while reducing the likelihood of errors.	[4]
A Clinical Evaluation of Zirconia Reinforced Lithium Silicate Glass-Ceramic CAD/CAM Onlay: A Two-Year Case Report	Case Report	A large direct composite restoration on tooth 15 has lasted for almost two years. However, due to bruxism and aesthetic concerns, it was recommended to replace the restoration with an indirect ceramic onlay. A digital scan was performed to design the restoration using CAD software. The ceramic onlay was fabricated using CAD/CAM technology from ZLS (Zirconia Reinforced Lithium Silicate) blocks. The onlay restoration showed high clinical success after two years of use.	[9]
Rehabilitation of Worn Dentition with CAD-CAM Restorations: A Case Report	Case Report	The upper anterior teeth, which experienced severe wear along with dentin hypersensitivity and aesthetic concerns, were treated to restore the anatomical shape of the teeth and improve the patient's quality of life. Restoration design was carried out using CAD software. A nano-ceramic composite onlay (LAVA Ultimate, 3M Oral Care) was fabricated using CAD/CAM technology. The patient reported a significant improvement in oral quality of life following the treatment.	[5]

CAD/CAM in the fabrication of post and core restorations offers several advantages, such as precise adaptation to the root anatomy, high bond strength, time efficiency due to the digital process, and the use of materials that closely resemble dentin properties for better load distribution. Additionally, this method reduces manual errors and enhances aesthetic outcomes [10].

Discuss the use of a full digital workflow in the aesthetic rehabilitation of upper anterior teeth in an adult patient with a gummy smile due to an unfavorable ratio between the upper lip length and gingival/tooth exposure, along with dissatisfaction regarding the shape, color, and position of the teeth. The planning procedure was performed virtually using a digital PMMA guide for gingivectomy with the assistance of soft tissue SOGA laser, followed by preparation control using a digitally designed plastic guide in Exocad, which was 3D printed. Both dental arches and maximum intercuspation were digitally scanned [11]. Next, lithium disilicate veneers were fabricated using CAD/CAM technology and cemented with translucent light-cure resin, followed by occlusion adjustment and final polishing. This approach enabled the achievement of optimal aesthetic and functional results with reduced working time and errors, thereby enhancing patient satisfaction and the accuracy of complex aesthetic rehabilitation treatments [12].

Discuss the clinical evaluation of Zirconia Reinforced Lithium Silicate (ZLS) glass-ceramic onlay restorations over two years in cases of posterior tooth structure loss due to fractures and extensive carious lesions. The restoration design process was carried out digitally using the CAD/CAM system, allowing for optimal margin precision and internal adaptation. ZLS material was chosen for its combination of high mechanical strength from zirconia and superior aesthetics from lithium silicate, making it an ideal choice for posterior restorations with high chewing forces. The conservative design of the onlay minimizes the need for tooth preparation, preserving as much tooth structure as possible compared to conventional metal or full-ceramic restorations. Good marginal adaptation and strong adhesive bonding to the tooth substrate support the long-term integrity of the restoration and reduce the risk of clinical failure, such as fractures, delamination, or secondary damage [13].

The restoration design, particularly in the fabrication of onlays, must consider several factors, including marginal adaptation, internal adaptation, minimally invasive preparation, pressure distribution, fracture risk, and the thickness of the restoration and isthmus [14]. Therefore, the application of current technology, such as CAD/CAM, in onlay design significantly enhances high accuracy in marginal and internal adaptation, enables more complex and precise designs, and improves both clinical performance and aesthetic outcomes [15].

Describe a clinical case of severe tooth wear rehabilitation in a 40-year-old male patient using CAD/CAM nano-composite resin restoration (LAVA Ultimate, 3M Oral Care) through a minimally invasive digital workflow. This approach

was designed to restore tooth anatomy and improve the patient's quality of life, particularly for grade 3 wear (according to the Tooth Wear Index), predominantly occurring in the upper jaw and associated with chemical erosion factors. The process involved digital intraoral scanning, creating a mock-up to determine the vertical dimension of occlusion (VDO), and fabricating highly precise CAD/CAM restorations, followed by gradual placement in the occlusal and anterior aesthetic zones. The results showed a very accurate fit, with minimal post-placement adjustments, and this approach proved to be a workable, effective, and minimally invasive treatment modality for rehabilitating severe tooth wear, both functionally and aesthetically [16].

Anterior and posterior tooth wear is a common clinical condition caused by factors such as bruxism, acid erosion, and chronic occlusal disorders. This wear leads to a reduction in bite height or Vertical Dimension of Occlusion (VDO). This condition can also result in gradual enamel and dentin loss, affecting the patient's quality of life. A decrease in VDO can disrupt occlusal relationships, increase the risk of further wear, and impact the comfort and masticatory function of the patient. To address this issue, onlay restorations using CAD/CAM technology are an effective choice. Onlay restorations can help open the VDO, create sufficient restorative space, and support both the functional stability and aesthetic appearance of worn teeth [17].

DISCUSSION

Avoid extensive citations and discussion of published literature only, instead discuss recent literature to compare your work to highlight the novelty of the work in view of recent development and challenges in the field. The discussion must be related to the problem stated in the background and directed to an answer to the research hypothesis. No more statistical or other mathematical symbols in the discussion. Emphasis was placed on similarities, differences, or the uniqueness of the findings obtained. It is needed to discuss the reason for the findings.

CONCLUSION

CAD/CAM technology plays a crucial role in enhancing accuracy, efficiency, and quality of restorations in operative dentistry. The application of CAD/CAM enables more precise, aesthetically pleasing restorations that can be completed more quickly than with conventional methods. As a result, this technology has the potential to become the standard in modern dental conservation.

CONFLICT OF INTEREST

CAD/CAM has the potential to become the new standard in dental conservation due to its ability to enhance the precision, efficiency, and aesthetics of restorations, as well as enable more comfortable single-visit treatments for patients. This technology requires digital skills from practitioners, making its integration into dental education essential. However, long-term studies with larger samples are still needed to ensure its clinical effectiveness. In the

future, the integration of CAD/CAM with other digital technologies, such as intraoral scanning and 3D printing, could further expand its applications.

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