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# Review of materials in digital dentistry

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## ABSTRACT

**Background:** Utilizing intraoral scanners and laboratory/chairside milling devices to make dental restorations and appliances from numerous materials including wax, metals, composite resins, and ceramics, CAD/CAM in dentistry is expanding and becoming more user- and patient-friendly.

**Aim's & Objectives:** When accessible, the various qualities and precision of CAD/CAM materials are compared to those of conventional materials/methods in order to evaluate the CAD/CAM materials.

**Methods & Materials:** The properties of these materials may differ from those of conventional and additively manufactured restorations. Understanding the distinctions between these qualities is crucial for selecting materials and fabrication techniques. In a growing number of contexts, additive manufacturing is replacing subtractive manufacturing. However, neither the chemical composition nor the mechanical and physical properties of these materials have yet been determined. The therapeutic efficacy of 3D-printed products requires a great amount of study and time.

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**Conclusion:** The present advancements and potential applications of CAD/CAM technology are exciting and revolutionising restorative dentistry. Before making definitive claims and judgements to replace traditionally created materials, it is of the utmost importance to guarantee that the various materials have been subjected to adequate testing and evaluation.

**Clinical Significance**: CAD/CAM materials are adaptable and quickly becoming the material of choice for a variety of dental restorations and appliances. Before suggesting recently launched CAD/CAM materials for patient care, it is necessary to ensure that adequate clinical and research-based information demonstrating the success and longevity of these materials is available.

**Keywords:** additive manufacturing, CAD/CAM dentistry, dental materials, digital dentistry, subtractive manufacturing.

## INTRODUCTION

Computer-aided design/computer-aided manufacturing (CAD/CAM) has been used in industry for decades and has recently gained appeal in dentistry for making impressions, casts, and models temporary fabrication to permanent repairs [1-2] Dental CAD/CAM systems include a scanner, software that processes the scanned data, and a fabrication device that converts the data into a restoration, denture, or appliance. This "digital process" captures both dentitions, enabling the doctor to assess and evaluate the tooth preparation and create a restoration that complies with the specified treatment plan.[3] A digital file can be uploaded to a cloud server for rapid communication with the technician, enabling any necessary adjustments to be made prior to proceeding to the next phase.

There are numerous scanning systems currently available on the market. Some require the addition of an oxide powder to improve the scan quality. Scanning is performed via either a series of static pictures or a video image stream are utilised to capture the geometry of tooth preparation. Each system's designing software permits the clinician or technician to design the restoration or appliance in respect to the opposing dentition. The processed data is subsequently

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produced chairside, in a laboratory, or at a central production centre. [4] Both subtractive and additive manufacturing processes exist.

To guarantee best treatment outcomes for patients, it is critical that the restorative team has a comprehensive understanding of the gamut of CAD/CAM materials now accessible. This review will focus on the materials that utilise CAD/CAM technology, the characteristics of these materials, and the accuracy of these materials in comparison to conventional procedures and materials used in restorative dentistry. Materials resulting from subtractive manufacture (SM) will be examined first, followed by those resulting from additive manufacturing (AM) (AM).

**SUBTRACTIVE MANUFACTURING**

SM typically entails milling the required volumetric shape from a presintered or sintered material using a wet or dry milling equipment that follows predetermined routes, referred to as toolpaths. as three, four, and five-axis milling systems.[5] The milling systems are either chairside or laboratory systems. A computer file (stl, which stands for "stereolithography") is used to digitally design the restoration or appliance, and the final design is submitted to the milling system for production. Wax, poly(methyl methacrylate) (PMMA), composite resins, high-performance polymers, metals, and ceramics, such as glass-ceramics, polymers reinforced with ceramic particles, also known as (resin-based ceramics), ceramics infiltrated with a polymer, also known as (hybrid ceramics), and polycrystalline ceramics, are contemporary millable materials. PMMA is a synthetic polymer that is created by polymerizing methyl methacrylate. PMMA is a block that can be milled and is utilised for long-lasting single crowns and fixed partial dentures. Recent research compared

The mechanical qualities and marginal fit of PMMA inlays are comparable to those of glass-ceramic inlays.[5-6] Increased interest in PMMA restorations led to the creation of PMMA blocks with improved optical and physical properties (e.g., Telio CAD, Ivoclar Vivadent, Shaan, Liechtenstein and VITA CAD-Temp MultiColor Blocks, VITA Zahnfabrik, Bad Sackingen, Germany). Restorations made from processed PMMA are easily polished to improve their aesthetics.

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IvoBase CAD, Ivoclar Vivadent) followed by milling of teeth from double cross-linked resin material that are glued to the denture base (eg, SR Vivodent CAD, Ivoclar Vivadent). The strength and surface roughness parameters of CAD/CAM and conventional heat-cured PMMA dentures were examined. The higher strength and surface properties of CAD/CAM PMMA indicated a more durable denture. 7-9 Different brands of CAD/CAM PMMA possess inherent qualities that vary. Fitting of CAD/CAM dentures was superior to that of traditional dentures, resulting in increased retention and decreased occurrence of traumatic ulcers with CAD/CAM dentures. [10-13] contains the composition, characteristics, and preparation requirements.

**Table 1: CAD/CAM poly(methyl methacrylate) (PMMA) composition, properties, and preparation requirement**

| **Properties** | **Telio CAD** | **VITA CAD-Temp** | **artBloc Temp** | **Dentokeep** |
|---|---|---|---|---|
| **Composition** | 99.5% PMM polymer | PMMA, inorganic microfillers | PMMA, organic fillers | PEEK (80%) and $TiO_2$ (20%) |
| **Flexural strength (MPa)** | 135[a] | ≥80[a] | 93[a] | NP |
| **Modulus of elasticity (GPa)** | 3.10 | 2.80[a] | 2.68[a] | 3.43 ± 0.29[11] |
| **Water sorption (μg/mm³)** | 23.20 ± 0.10[12] | NP | NP | ~2.20 |
| **Fracture load (Newton)** | ~900 | ~500 | ~700 | NP |
| **Vickers hardness (VH)** | NP | NP | NP | 27.74[11] |
| **Wear(two-body) (mm³)** | ~115[13] | ~105[13] | NP | NP |
| **Minimum wall thickness occlusal** | 1.50 mm | 1.50 mm | 1.00 mm | NP |
| **Minimum wall thickness circumferential** | 0.80 mm | 0.80 mm | 1.00 mm | NP |

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## AM of ceramics

Due to the high melting point of ceramics, the AM process is highly difficult, leading to the creation of cracks during the cooling phase and an increase in porosity inside the ceramic. Failure propagation .The porosity of a ceramic reduces its mechanical characteristics. Attempts to create a zirconia crown were made using zirconia ceramic suspensions and direct inkjet printing. It was possible to make samples comparable to traditionally manufactured zirconia material, however the output was not flawless. 17 SLA processing techniques have been used to produce zirconia crowns with superior results to inkjet printing techniques and mechanical and surface qualities comparable to milled zirconia. Additionally, 58 SLA printing techniques have been used to produce zirconia implants. The dimensional precision of the printed implant was great, and its mechanical parameters demonstrated flexural strength (943 MPa) comparable to those of conventionally manufactured ceramics (milled zirconia 800-1000 MPa). With encouraging results, [17-19] AM has been investigated with various ceramics and calcium phosphate compositions as scaffolds primarily used for bone regeneration. However, the inherent difficulties of 3D printing cannot be ignored. Surface quality, dimensional accuracy, and mechanical qualities must be enhanced to enable the production of high-quality products. Further advancements in AM technology are anticipated to significantly reduce production costs, enhance the characteristics of created materials, and make manufacturing processes more efficient and competitive. [20]

## AM Metals

Utilizing selective laser sintering, metal-based appliances made mostly of titanium, chrome-cobalt, and other alloys are manufactured. Initial experiments with this technology produced porous, poorly finished, and ineffective load-bearing products. The focus of this technology's development has been on overcoming these shortcomings, resulting in metallic structures with superior mechanical properties and minimal surface imperfections that improve implant osteointegration. [22-24] As there is no active force application, direct metal laser sintering has been utilised successfully to address challenges with chrome-cobalt appliances, such as shrinkage during casting and high CoCr hardness during milling.

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Composition, characteristics, and preparation requirements of AM materials can be found. Several unreported qualities have been highlighted to draw attention to the missing properties and encourage additional study to fill the void.

## CONCLUSIONS

CAD/CAM technology has altered the practise of dentistry and the delivery of care. Deficiencies that demand finesse will unavoidably be corrected as technology and quality continue to evolve. Laboratory and chairside milling devices are more adaptable and capable of milling a variety of materials with qualities that may guarantee long-term therapeutic effectiveness. AM is an alternative and promising dental restoration and appliance manufacturing technology. Compared to SM approaches, additive techniques enable the manufacture of more complex structures without excessive strain and with far less non-recyclable waste.

SM-produced materials have a longer history of clinical data than AM-produced materials, however freshly introduced materials still need significant clinical evidence. Before claiming clinical outcomes, in vitro testing of the basic mechanical, physical, and optical qualities should be read with caution. As further clinical trials examining both SM and AM materials are required, these materials should be utilised with caution.

## CONFLICT OF INTEREST

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