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# Additive vs. Subtractive Manufacturing in Dental Laboratory Technology

Aneeza Hussain, AAS

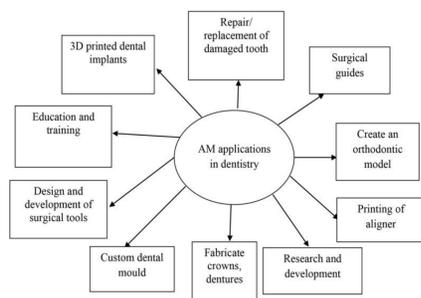
Mentor Prof. Daniel Alter MSc, MDT. CDT

New York City College of Technology



## Abstract

Have you seen technicians using milling and 3d printing machines yet? The development of computer-aided manufacturing and the medical application of this industrial technology have provided an alternative way of fabricating oral and facial prostheses. This narrative review aims to evaluate the different streams of computer-aided manufacturing in dental technology. To date, there are two streams: the subtractive and the additive approaches. The differences reside in the processing protocols, materials used, and their respective accuracy. In general, there is a tendency for the subtractive method to provide more homogeneous objects with acceptable accuracy that may be more suitable for the production of intraoral prostheses where high occlusal forces are anticipated. Additive manufacturing methods have the ability to produce large work pieces with significant surface variation and competitive accuracy. Such advantages make them ideal for the fabrication of facial prostheses.



## Materials and Methods

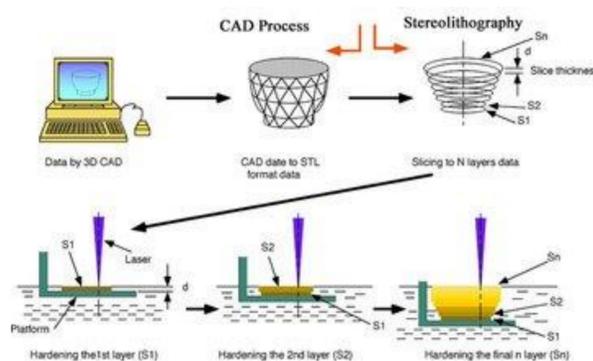
- Selected articles from the online research database. Scientific articles were selected.
- Key words: Additive manufacturing (AM), Subtractive manufacturing, CAD/CAM
- Selection criteria: books and articles associated with dental technology.
- Experts consulted: Professor Daniel Alter CDT/MDT

## Introduction

Digital technology such as computer-aided design and computer-aided manufacture (CAD/CAM) is rapidly expanding and transforming dentistry at an unprecedented pace. CAD/CAM technology in dentistry can be classified as either “subtractive” or “Additive” manufacturing methods. Subtractive manufacturing methods include machining and milling (CAM) and laser ablation technologies, while additive manufacturing methods includes 3D printing and laser melting technologies.

## Results

According to J Prosthet Dent the results of the overlap analysis of the dental restorations indicated that the root mean square (RMS) deviation observed in the restorations fabricated using the additive manufacturing methods were significantly different from those fabricated using the subtractive methods ( $P < .05$ ). However, no significant differences were found between restorations fabricated using stereolithography apparatus and selective laser sintering, the additive manufacturing methods ( $P = .466$ ). Similarly, no significant differences were found between wax and zirconia, the subtractive methods ( $P = .986$ ). The observed RMS values were 106  $\mu\text{m}$  for stereolithography apparatus, 113  $\mu\text{m}$  for selective laser sintering, 116  $\mu\text{m}$  for wax, and 119  $\mu\text{m}$  for zirconia. Microscopic evaluation of the surface revealed a fine linear gap between the layers of restorations fabricated using stereolithography apparatus and a grooved hole with inconsistent weak scratches when fabricated using selective laser sintering. In the wax and zirconia restorations, possible traces of milling bur passes were observed.



## Advantages of CAD/CAM

**Additive manufacturing** processes build objects by adding material layer by layer, while **subtractive manufacturing** removes material to create parts, the advantages using CAD/CAM in dental applications in comparison of conventional dental laboratory are high accuracy, standardized manufacturing process, efficient quality control system, increased production capacity, fast production, enable the new material such as zirconia and titanium, and transforming laboratories from simple fabrication sites into computerized production centers.

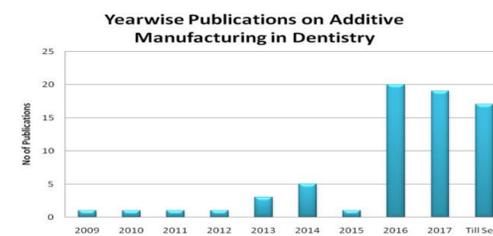


## Disadvantages of CAD/CAM

The disadvantages using CAD/CAM in dental applications in comparison of conventional dental laboratory are the initial cost of a CAD/CAM system can be higher than the traditional dental equipment, machining and milling is very wasteful procedure in which more material is removed compared to what is used in the final product (subtractive manufacturing), the milling procedure accuracy is dictated by the diameter of the milling bur will be over milled, and it will contribute to low retention of the restoration, the possible uses in CAD/CAM are limited by the capability of the software and the digital scanners available, many current CAD/CAM technologies still require conventional laboratory processing such as zirconia frameworks fabricated by CAD/CAM in machine require manual veneering with conventional porcelain by dental technicians.



Considering the advantages of milling and machining, the application of this technology has become essential in providing appropriate treatment to patients. With the cost of manufacturing units dropping, many laboratories and clinics are acquiring CAD/CAM units for faster fabrication of dental restorations. However, this method of manufacturing is very wasteful as more material is removed compared to what is used in the final product. Around 90% of a block material is removed to create the dental restoration. Accordingly, there has been a major transition from subtractive manufacturing to what is referred to as additive manufacturing. Using additive manufacturing is more advantageous as many problems associated with milling can be readily overcome. The main advantage of this type of manufacturing is the ability of the technique to create fine detail. However, additive manufacturing is incapable of procedure restorations with certain materials such as zirconia, glass ceramic, and composite.



## Discussion

Additive manufacturing is an innovative technique moving towards the customized production of dental implants and other dental tools using computer-aided design (CAD) data. This technology is used to manufacture elaborate dental crowns, bridges, orthodontic braces and can also various other models, devices and instruments with lesser time and cost. With the help of this disruptive innovation, dental implants are fabricated accurately as per patient data captured by the dental 3D scanner. The application of this technology is also being explored for the precise manufacturing of removal prosthetics, aligners, surgical templates for implants and produce models that for the planning of treatment and preoperative positioning of the jaws.

## Conclusion

Computer-aided manufacturing continues to undergo significant and regular improvements so that it is very likely that, in the near future, wide acceptance of its use in dentistry will occur. Currently, subtractive milling is the most widely implemented computer-aided manufacturing protocol in dentistry and it has been shown to be a suitable method for fabricating intraoral prostheses. Additive manufacturing is currently an exponentially growing fabrication method and will most likely be used more frequently in dentistry in the future as its accuracy and range of applications develop. In terms of material processing, both techniques introduce material defects. The subtractive methods, however, currently produce more homogenous objects making this method more suitable for the production of intraoral prosthesis that can withstand higher occlusal loads. Additive methods have the advantage of producing large objects, with surface irregularities, undercuts, voids, and hollow morphology that makes them suitable for manufacturing facial prostheses and metal removable partial denture frameworks. Computer-aided manufacturing procedures will indisputably change many aspects of dentistry in the future, particularly in relation to treatment simplicity and production time. It is therefore critical for clinicians and technicians to be familiar with the advantages and disadvantages of computer-aided manufacturing as these procedures continue to develop and become an integrated part of dentistry.

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