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Why not Math in Prosthodontics

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Abstract

Aim: This study was aimed to highlight the role of geometric modeling in prosthodontics.

Methodology: A systematic literature search was performed electronically and hand-searched with terms of geometric modeling, geometric modeling in dental materials, geometric modeling in prosthodontics, and CAD-CAM. For articles published between 2015 and 2020, a search was carried out using Medline through Pubmed and Google Scholar. A total of 296 articles were found—critically appraised articles selected to evaluate their quality.

Results: Different articles described various fields included the application of geometric modeling, pertaining primarily to prosthodontics. The literature search revealed 115 articles in PMC. 153 articles in google search. Additional 28 articles were identified by hand search.

Conclusion: Accurate geometric modeling is essential for CAM processes and stress analysis checks. The designs interpreted by geometric modeling are more accurate and precise when compared to conventional techniques.

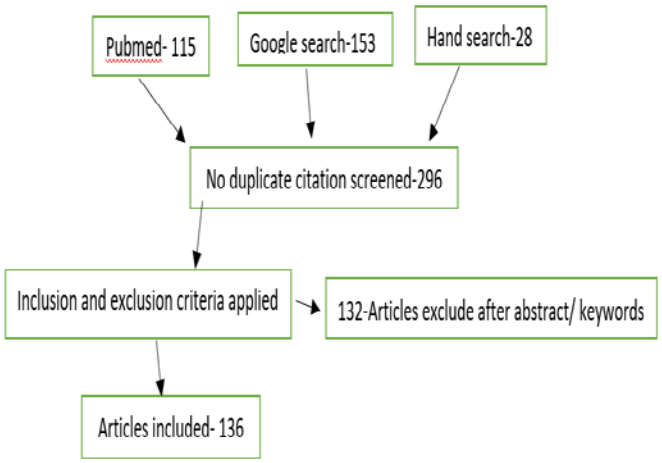
Keywords: Geometric modeling, Geometric modeling in prosthodontics, CAD-CAM, Geometric modeling in dental materials.

Introduction:

Geometric modeling is the mathematical representation of the database, and it captures the properties of an object using mathematical formulae. The shapes studied in geometric modeling are mainly two- dimensional or three-dimensional. Today most geometric modeling is done with computers and for computer-based applications. The geometric modeling with engineering Computer-Aided-Design (CAD) system(s) is highly satisfactory for further analysis or Computer-Aided-Manufacturing (CAM) processes. The new imaging, modeling, and analysis methods significantly improved treatment quality and success rates. Three-dimensional models are central to computer-aided design and manufacturing (CAD/CAM).[1] They are widely used in many applied technical fields such as civil and mechanical engineering architecture, geology, and medical image processing. Two significant applications depend on geometric modeling: stress analysis and production by computer-aided manufacturing (CAM). Engineering CAD/CAM software(s) are used to model new dental tools before implementing stress analysis and producing prototypes for testing. New versions of CAD/CAM software(s) include stress analysis module(s), while modeling modules in stress analysis packages have limited capabilities. Designers prefer to use CAD/CAM software for geometric modeling and transfer their model(s) to finite element packages. That Initial-Graphics-ExchangeSpecification (IGES) file format showed the best performance for surface transfer to FEA software(s). At the same time, Standard-ACIS-Text (SAT) file format is ideally used for transferring volumes (3D solid geometric model). As human teeth and bones have very complicated geometries, it is difficult to use conventional graphics and engineering modeling techniques to generate an accurate three-dimensional (3D) geometric model(s) for bio-tissues. The main aim of this study is to highlight the role of geometric modeling in prosthodontics [1]. There are different applications of geometric modeling available in Prosthodontics. This article enlightens a few of its applications.

Materials and Methodology

PubMed/Medline and Google search were the electronic resources used to review the biomedical literature, using the following keywords Geometric modeling, Geometric modeling in prosthodontics, CAD-CAM, Geometric modeling in dental materials. In total, we found 296 articles.



Flow chart 1

As a criterion for selecting these studies, we included only the articles published in English and full articles. Finally, 136 articles fit these criteria, with the publication dates ranging from 2015 to 2020 (flow chart 1).

Basic Geometric Modeling Techniques

- 2-D Projection (Drawings)
- Wireframe Modeling
- Surface Modeling
- Solid Modeling

Wireframe models (and 2D Projection) contain points, lines, and curves, that topological data are not included. On the other hand, surface models store topological information of the containing objects. However, surface models can't support a full range of engineering activities such as stress analysis on the internal body. Solid models have complete, valid, and unambiguous spatial addressability. [2] Additionally, it can extract wireframe and surface models from solid ones (s), and the reverse process is not valid. [3]

On the other side, extracting 3D model(s) from digitizers (scanners, CT, MRI, micro-CT, CBCT, 3D Ultrasound, Confocal Microscopy) requires significant effort be recognized. Software(s) like Mimics (Materialise, Leuven, Belgium) can manipulate medical format pictures as brightness threshold and mask to separate the image parts (organs). That can generate models for various engineering applications, and3D models and anatomical landmark points can be directly exported to third-party software such as CAD or FEA packages. [4]

The Role of Geometric Modeling in a CAD System

Geometric modeling is essential to develop a database supporting engineering design (Figure 1) that demonstrates the role of geometric modeling in a CAD system(s) as it links the user interface and the mathematical representation (database). [1]

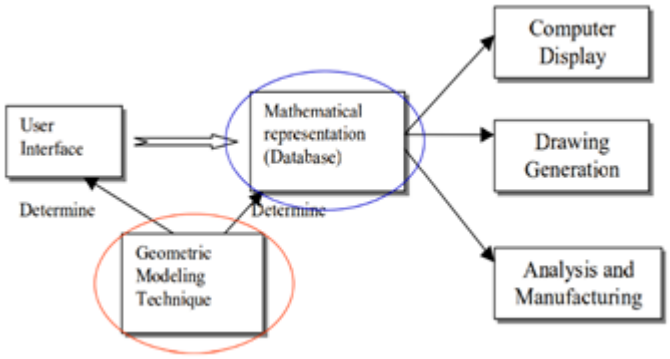


Figure 1

Applications in Prosthodontics

A) Complete dentures: For the Design and fabrication of complete dentures, computer-aided Design and computer-aided manufacturing (CAD/CAM) has emerged as a new solution. [5]. With this CAD/CAM technology, only two appointments are needed for patients to get their complete dentures. Could finish all impressions, jaw relations, occlusal plane orientation, tooth mold, shade selection, and maxillary anterior tooth positioning in 1 patient visit to manufacture complete dentures, saving a lot of time and materials for both patients and dentists. Figure 2 shows the Design and fabrication of complete dentures using CAD/CAM technology. [6,7]

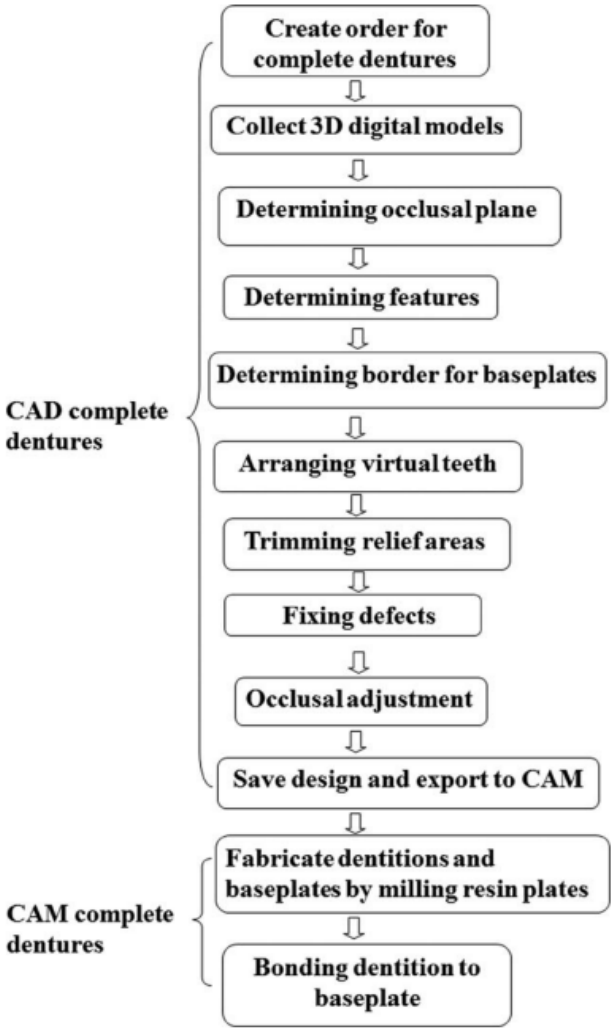


Figure 2

B) Removable partial dentures: Using CAD/CAM technologies, William et al. demonstrated a method of fabricating removable partial denture structure design. The removable partial denture structure is designed using CAD/CAM software based on a three-dimensional scan of the patient's cast. [8,9] Current innovations and developments in dental technology allow the fabrication of removable dentures using CAD/CAM technologies from start to finish, thus decreasing the chairside and working time for patients and dentists and providing superior or satisfactory functional and esthetic outcomes. [10]

C) Fixed partial dentures: CEREC in Lab system - A non-contact laser captures data while the scanning platform is secured with the tooth preparation die. CAD-CAM technologies can be used to fabricate cast partial dentures from Co-Cr alloys, commercially pure Titanium, and Ti-6Al-4V alloy. In the milling chamber, a ceramic block (ingot) is mounted. Two milling diamonds work together to produce a precise reconstruction. A porcelain build-up is completed, resulting in a pleasing restoration. The fit is then checked in the patient's mouth, and any necessary changes are made. [10]

Usually, the designing of FPD for subgingival contours is intricate. So, in that case, it is retracted with retraction cords, and the tip of the intraoral scanner is placed & this is transferred to the system, and the Design is obtained or made by geometric modeling.

D) Implant prosthodontics: In the last decade, computers in implant placement (navigational technique) have increased. Through the use of CAD/CAM software, this has recently become possible. Can fabricate patient-specific abutments. These CAD/CAM forged custom abutments are designed by computer and manufactured by computer-operated machines for obtaining unsurpassed accuracy and precision. They are milled from medical-grade Titanium. They have superior biocompatibility and the best possible integration with implant fixtures. Precision, milled from Titanium, ideal coronal preparation, the proper direction of insertion, perfect emergence profile, 6° angled implant axis, formed like a natural tooth, and reduced chair time are some benefits of CAD/CAM fabricated custom abutments. Computerized designing of the abutment is done, and The primary abutment is made using a computerized milling technique from commercially pure Titanium. A duplicate abutment is milled that is functionally similar to the primary abutment, resulting in a reduction in chair time. [11]

E) Maxillofacial prosthodontics: Maxillofacial prostheses, extraoral radiation devices, individual respiratory masks, and facial safety devices, among other things, are all made using CAD/CAM technology. CAD software is used to create three-dimensional surface imaging. This 3-D surface image is used to help in the Lithographic technique's fabrication of the resin model, after which a wax pattern is formed. Of this completed wax pattern, once again, computer-assisted three-dimensional imaging is done. Data is entered into the computer, and the computer-aided milling machine mills the prosthesis. As a result, CAD/CAM technology is used to make a silicone maxillofacial prosthesis. [10]

Discussion

New technologies help dentists to introduce new treatment techniques. The new imaging, modeling, and analysis methods significantly improved treatment quality and success rates. geometric modeling and stress analysis of the restorative materials, prosthesis, and new dental tools are used as a preliminary step before commercial usage. [1] Mormann & Brandestinni in Germany were the first to introduce CAD/CAM technology into dentistry in1989, and it is now commonly used in all branches of prosthodontics. CAD/CAM technologies allow for the

accurate and precise Design of different forms of restorations and dental prostheses. [12] The uses of CAD/CAM in various fields of Prosthodontics are continuously increasing for the past two decades. This technology is not only used in dental laboratories but is also being used in dental clinics to make chair-side restorations. This technology is used to create both small restorations such as inlays, onlays, veneers, crowns, and more extensive restorations such as fixed partial dentures and removable partial dentures maxillofacial prostheses, implant abutments, and full-mouth restorations.[13]

Conclusion

Accurate geometric modeling is essential for CAM processes and stress analysis checks. Engineering CAD/CAM packages may not be suitable for many dental applications but will never be replaced in designing new tools/instruments for dentistry. On the other hand, imaging teeth and transfer them into a wireframe model before CAM is currently available. New dental solutions systems offered many features for dentist and laboratory operators about implant types and size databases, locations of high dens bone, etc.

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