# CAD/CAM IN ORTHODONTICS

**Orthodontics**

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## ABSTRACT
The CAD/CAM systems that are now in use around the globe will be covered, although the primary focus of this study will be the orthodontic application. Personalized orthodontic appliances have been produced using 3D intraoral scanning, cone beam computed tomography, 3D printing, and computer-aided design and computer-aided manufacturing technologies (CAD/CAM).CAD/CAM technology in orthodontics includes digital impressions, digital models, virtual articulators, face bow, wires, brackets, etc.While all this technological improvements to orthodontic field seem promising, but do they really enhance the treatment efficiency and quality of treatments? As a result, this article will review the current published literature investigating the various methods and techniques of CAD/CAM technology

## INTRODUCTION
The field of orthodontics is undergoing a significant technological change. There have been more advancements in orthodontics over the past 30 years than in the specialty's entire history. The rapid evolution of CAD/CAM (Computer Aided Design, Computer Aided Manufacture), has led to a dramatic impact on all disciplines of dentistry.

The term "CAD-CAM technology" refers to a group of linked processes used to create three dimensional physical models.[1] The advantages of CAD/CAM technology in orthodontics including digital impressions, digital models, and virtual articulators and facebow. The technology allows for the layer-by-layer development of a medical model that replicates practically every kind of external and internal anatomical structure based on 3D input. Subtractive and additive manufacturing are used to create the end product. Therefore, the purpose of this article is to review the current published literature investigating the various methods and techniques of CAD/CAM technology.

### A Brief Background Of CAD/CAM In Dentistry
CAD/CAM was discovered between 1966 and 1968 by an engineer named Pierre Bezier (Arts et Metiers Paris Tech, Renault), and it was first applied in dentistry by Duret et al.[2] in the 1970s when they developed an intraoral grid surface mapping method in 1977 using optical instruments.

### An Overlook Of Dental CAD/CAM
To create a proper model, CAD/CAM methods such as digitising (optical impression), restoration or prosthesis design, milling, sintering, and polishing are used. Digitizing is to create a 3D unique image, an optical scanner will digitally record the teeth and surrounding structure. [Table/Fig-1].[3] The dental practitioner will next use CAD software and those 3D pictures to design the final device or restoration. The design is then used by a milling machine to carve a single ceramic block into the shape of the appliance. The restoration or item is stained or coated before being polished to make it appear more natural. Restorations that are permanently affixed to the mouth with the use of cements to complete the smile include veneers, crowns, and bridges.



[Table/Figure-1]: Flowchart of CAD/CAM process[3]

### CAD/CAM Components
The CAD/CAM systems consist of three components:
1- A scanner to transform the geometry of a real object into a digital data.
2- Software for data processing.
3- A production technology able to realize the desired product.[4]

A data acquisition unit that collects data from the preparation area, adjacent and opposing structures, and then converts it to virtual impressions[4] via intraoral scanners or indirectly via a stone model generated by making a conventional impression; software for designing virtual restorations on a virtual working cast and then computing the milling parameters; and a computerised milling device for manufacturing the restoration from a solid block of restorative material or additive manufacturing.

### Applications Of CAD/CAM In Orthodontics
This technology can be used in a variety of ways in orthodontic diagnosis. The production of 3Dimensional digital study models using Ortho CAD software has changed the diagnosing procedure.

It is possible to determine the precise location of an impacted canine and how it relates to nearby structures. A recent study cited orthodontic CADCAM applications that now include aids for diagnosis and treatment planning, clear aligner treatment, lingual appliances, and titanium Herbst appliances, customized brackets with patient-specific torque, machine-milled indirect bonding jigs, and robotically bent archwires, digital models are among the newest CAD/CAM advances in the speciality. [Table/Fig-2].[3] In addition to precise and customized milling of orthodontic appliances, the application of 3D technology allows the practitioner and patient to utilize virtual treatment planning software to better identify case objectives and visualize treatment outcomes. Practitioners are able to evaluate different treatment plans, including extraction versus non extraction treatment options or substitution versus prosthetic replacement in cases of missing teeth.

The use of 3D models of the jaw in orthognathic surgery assists the physician in surgical process planning and execution, as well as the fabrication of splints for use during surgery. By using prediction tools to create 3D models, patients may see the anticipated surgery outcomes. The installation of TADs and corticotomy-assisted orthodontic treatment can both be done utilising surgical guidance created using CAD-CAM technology.[5] It also aids in indirect bonding, a form of bonding used in fixed mechanotherapy . This technology aids in the retention phase of orthodontics as well as diagnosis and treatment planning. It is now possible to design and build CAD-CAM retainers using a scan of the dentition after the braces have been removed. The ultimate goal of incorporating CAD/CAM technology into the field of orthodontics can be best summed up as "improving reproducibility, efficiency, and quality of orthodontic treatment.[6]
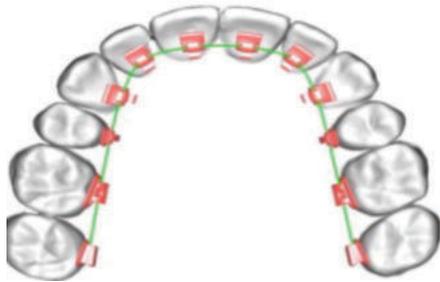
**[Table/Fig-2]:** Straight wire lingual technique using CAD/CAM [3]

## CAD/CAM Designed Bracket System

CAD/CAM applications in orthodontics are undoubtedly growing; manufacturers of customised orthodontic appliances delivered with milled indirect bonding jigs claim to minimise total treatment time, improve treatment efficiency, and deliver superior overall treatment results. Weber et al.[7] compared the treatment effectiveness and efficiency of customised appliances to typical twin appliances using a commercially available CAD/CAM orthodontic system (Ormco's InsigniaTM). The CAD/CAM group had considerably lower American Board of Orthodontic (ABO) scores, fewer archwire appointments, and shorter overall treatment times, according to the study.

## ORMCO Insignia

Ormco's Insignia, which is available in standard and self-ligating applications with optional use of esthetic ceramic brackets, is one of the most comprehensive CAD/CAM orthodontic appliances on the market.

A polyvinyl siloxane (PVS) impression or intraoral scan of the patient's dentition is taken and sent to Ormco for the production of digital models of the dental arches. A virtual buccal-lingual boundary is constructed from the soft tissue outline of the intraoral scan.[8]

After that, the technicians build a virtual setup for ideal archform and occlusion, which is then sent to the clinician for approval. The Insignia software was among the first in the market that allowed clinicians to manipulate the digital setup to refine the 3-dimensional location of individual teeth, correct the archform, alter the smile arc as needed, and detail the dental contacts in final centric occlusion.[9]

Once the clinician has approved the treatment plan and virtual setup, the Insignia system is reverse-engineered in one of many methods, depending on the bracket selected by the clinician. The virtual archform's size and dimensions are precisely milled into metal plates and nickel titanium, stainless steel, or beta-titanium wires are fabricated from these plates. The Insignia system then accurately delivers the customised brackets in the ideal position on each tooth to maximise the effectiveness of the individualized appliance.

Bracket transfer jigs are custom milled to fit the occlusal surfaces of the teeth, allowing the appliances to be placed indirectly. This step is critical to the system's success because imprecise bracket bonding will prevent the custom straight wire from producing the desired tooth movement and the bracket transfer jigs from being highly accurate with errors ranging from 0.1 to 0.5mm, with the largest bonding errors occurring at the lower 7s and high canines.

### Advantage

The key advantage of this technique is the ability to customise the bracket slot. Cutting a slot into a bracket blank is potentially more precise than a slot created by injection moulding . The movement of the tooth is now determined by the position of the slot rather than the position of the bracket. The treatment can theoretically be accomplished with straight wires that, if necessary, allow teeth to slide along the wire.

### Disadvantage

One disadvantage is the potential for error in bracket positioning, either virtually or during transfer to the mouth.Given that a customized bracket is used, if a bracket is lost, a new one must be ordered.[10]

## Orametrix- Sure Smile Process

Since the early 2000s, OraMetrix has been developing its unique approach to CAD/CAM orthodontics. OraMetrix's sure smile is similar to other CAD/CAM systems.

SureSmile provides digital software that clinicians can use for diagnosing and treatment planning. Sure Smile is distinguished from other customised appliances by the subsequent fabrication of robotically bent archwires. Interestingly, the Sure Smile system can be used with any conventional orthodontic brackets and bands, requiring no extra care during appliance delivery.[11]

SureSmile[12] (Ora Metrix, Dallas, Texas) starts with a direct 3D scan of the patient's dentition using the OraScanner (OraMetrix), a light-based imaging technology that projects a precisely patterned grid onto the teeth. As the portable scanner is moved over the dentition, reflected images of the distorted grid are captured using a video camera incorporated into the handle of the scanner.

The scanner is passed over the teeth in a rocking motion to provide visualisation of all tooth surfaces, including undercut areas. At this point, the operator can use instruments to measure tooth and arch dimensions and build symmetric and asymmetric arch forms to diagnose and plan the treatment. Information regarding wire sizes, materials, and brackets is supplied for the treatment plan.

The operator can consider numerous treatment options by moving the teeth with the mouse or selected menus, by extracting teeth, or teeth can be reduced mesially or distally to simulate interproximal disking. Once a goal or treatment target has been determined, the operator can begin therapy via "virtual bracket placement" and selecting the archwire sequence and progression. A wire-bending robot creates archwires in the sizes and shapes selected by the orthodontist. Our investigation into the precision of bends with stainless steel wire show less than 1° of error in bends and twists.[13] This level of precision is extremely difficult, if not impossible, to replicate by hand.

### Advantage

The main benefit of the Sure Smile system is that the orthodontist can use his/her preferred bracket system and increase precision during the finishing stages.[14] Intra-oral scans of the dental arches or cone beam computed tomography (CT) acquisition can provide the necessary positioning information to create the customised wires. It remains to be seen whether the increase in precision warrants the additional radiation exposure associated with cone beam CT acquisition.

### Disadvantage

Disadvantages include the possibility of accidental debonding following arch wire customization and before treatment completion, as well as the potentially long and technique-sensitive intraoral scanning procedure.[15]

## CAD/CAM in Lingual Orthodontics

Lingual orthodontics has been gaining space around the world due to its particularity to offer a discreet treatment option, "invisible", in "secret" for the correction of malocclusion, combining biomechanical efficiency and enhancement of the smile during treatment.

Scuzzo et al.[16] published a landmark study in 2001 that provided a new perspective to lingual orthodontics by describing the possibility of permanently eliminating compensating bends, with a Straight-Wire system based on differential bracket positioning, placed closer to the cervical region of the tooth. In this regard, the PSWb[17] (Prieto Straight-Wire brackets), a Brazilian bracket in its third generation, was developed based on three principles:

- More cervical bonding (base without gingival extension beyond the slot, higher gingival wing far from the gums),
- slightly increased anterior bracket profile (compensation for the StraightWire technique can be possible);
- distal offset in the canine bracket, second premolar bracket with a slightly higher profile than the first premolar bracket.

## Virtual Bracket Positioning

Virtual brackets are chosen from the software library and first positioned on a plane parallel to the occlusal plane by the software. The Orapix system's bracket arrangement has two objectives: to locate the brackets as close to the enamel as possible and to allow the use of straight wires.[18] The virtual brackets are first vertically moved to the ideal slot heights, which are 0.5-1mm more gingival than the mushroom archwire technique.

The central incisor brackets are then moved horizontally towards the lingual surfaces until contact occurs. Upper canine brackets must be rotated 10-15° and set at a slight distance from the virtual tooth surfaces (mean=0.6mm) to eliminate bends between canines and premolars.

## Archwires Design
When the brackets are properly positioned, the software displays the virtual straight wire that runs through the centre of each slot. Because the upper incisor brackets are more closer to the lingual surfaces, the anterior part of the maxillary straight wire is flatter than the mandibular wire.

Overcorrections are made in other systems by modifying the positions of the teeth on the wax set up. Overcorrections are incorporated into the virtual setup with the Orapix system by altering the virtual bracket locations for angulation, inclination, height, and rotation.

The present research on lingual orthodontics indicates that any case that can be properly treated with a labial orthodontic appliance may also be adequately treated with a lingual orthodontic appliance. As the number of adult patients seeking orthodontic treatment is increasing,the demand for esthetic orthodontic appliance is also increasing.

Lingual orthodontics is the only orthodontic appliance that offers total invisibility as well as 3D control of orthodontic tooth movement. When compared to labial fixed appliances, lingual fixed appliances are associated with a lower incidence of WSLs.

Furthermore, it is critical to emphasise that diagnosis is paramount in any system, as well as establishing an individualised plan according to the characteristics and needs of each case, in order to obtain good results.

## Piezocision: Assisted Orthodontic Treatment Using CAD/CAM Customized Orthodontic Appliances
Corticotomies have been described as accelerating orthodontic treatment.[19] These interventions are based on the Rapid Acceleratory Phenomenon (RAP), which is characterized by an intensification of bone turnover and a diminution in the mineral content of the bone. Corticotomy surgery, however, involves full thickness flaps and, therefore, certain morbidity. More recently, minimally invasive and flapless alternatives have been developed such as piezopuncture[20], microosteoperforations[21], or piezocision.[22]

The flapless piezocision procedure is based on a localized piezoelectric alveolar decortication that combines buccal incisions and corticotomies performed with a piezotome.[23] Computer-aided design and computer-aided manufacturing (CAD/CAM) allow the manufacturing of custom-made orthodontic appliances, and it has been suggested that CAD/CAM appliances decrease treatment duration.[24] The combination of piezocision with customized appliances may therefore be relevant. Second, the surgical protocol of piezocision without sutures induces scars in 50 per cent patients, which leads to a contraindication in patients with a high smile line.

## 3d Virtual Planning In Orthognathic Surgery And CAD/CAM Surgical Splints
CAD/CAM surgical splints are built from computed tomography or cone beam computed tomography which leads to have more detailed points of references and a better valuation of the involved anatomic structures compare to the 2D images. Surgical splints comes from a computerized process that allows reproducibility and reduction of craft errors.[25] About the orthodontics the CAD/CAM system has been used for the orthodontics appliances production too.[26]

Surgical splints, manufactured using Computer Aided Design/ Computer Aided Manufacturing (CAD/CAM) technology, have been developed to avoid errors in the traditional model process that can lead to suboptimal outcomes. The evaluation of the results of combined orthodontic and surgical therapy is also improved by CBCT technology.

The process followed involved for the fabrication of CAD/CAM surgical splint :
• 3D image generation.
• 3D surgical planning.
• Designing CAD/CAM Surgical splints.

## Advantages Of CAD/CAM
• No need for traditional impressions when intra-oral scanners are used.
• Fewer visits.
• Needs less manual procedures in laboratory.
• Quality control: CAD/CAM technology helps quality check of dental appliances by creating optimum forms according to material properties.

## Limitations Of CAD/CAM Systems
• High cost.
• Need to know the technology.[4]

## CONCLUSION(S)
Currently the digital technologies such as the CAD/ CAM system are increasingly taking hold in the design and implementation of dental appliances, leading the dentistry to a new era. The decrease of craftsmanships replaced by the computer and the implementation of a precise and reproducible method has allowed a reduction of the errors by providing to the patient a better quality of treatment. The objective is to provide a tool system for developing orthodontic devices that is rapid, easy to use, cost-effective, and reliable in terms of results. Therefore, significant advancements in orthodontic technology have taken place in recent years, mostly as a result of the use of CAD/CAM technology in the creation of orthodontic appliances.

There is a variety of clinical evidence to support the efficacy and efficiency of different appliances, and no one system stands out as being much more successful. To further understand the technology and how it should be applied, more study into the benefits and drawbacks of the various CAD/ CAM orthodontic appliances is required.

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