Journal of Research in Medical and Dental Science
2022, Volume 10, Issue 2, Page No: 253-257

Available Online at: www.jrmds.in
eISSN No. 2347-2367: pISSN No. 2347-2545

A Review–CAD/CAM in Orthodontics

Jyosthna A*, Xavier Dhayananth L, Evan A Clement, Piradhiba R, Navaneetha Nambi

Department of Orthodontics, Sathyabama Dental College and Hospital, TamilNadu, India

ABSTRACT

The use of 3 dimensional technologies in orthodontics has increased in recent years. 3D intraoral oral scanning, cone beam computed tomography, 3D printing and computer aided design and computer aided manufacturing technology (CAD/CAM) has been utilized to create personalized orthodontic appliances. 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 truly improve treatment efficiency and treatment quality? Therefore, to solve this dilemma this article will review the current published literature investigating the various methods and techniques of CAD/CAM technology.

Key words: CAD, CAM, Orthodontics, 3D printing

HOW TO CITE THIS ARTICLE: Jyosthna A, Xavier Dhayananth L, Evan A Clement, Piradhiba R, Navaneetha Nambi, A Review–CAD/CAM in Orthodontics, J Res Med Dent Sci, 2022, 10 (2):253-257.

Corresponding author: Jyosthna A

e-mail✉: jyosthnareddy31@gmail.com

Received: 07-Jan-2022, Manuscript No. JRMDS-22-51076;

Editor assigned: 10-Jan-2022, PreQC No. JRMDS-22-51076 (PQ);

Reviewed: 24-Jan-2022, QC No. JRMDS-22-51076;

Revised: 27-Jan-2022, Manuscript No. JRMDS-22-51076 (R);

Published: 03-Feb-2022

INTRODUCTION

Orthodontics as a speciality is going through a lot of technological revolution. During the last 30 years there were more new developments in orthodontics than in the whole history of the speciality. The rapid evolution of CAD/CAM (Computer Aided Design, Computer Aided Manufacture), has led to a dramatic impact on all disciplines of dentistry. It has provided ease, comfort, and quality of restoration to both the dentists and dental lab technician. Moreover, restorations which are being produced through CADCAM these days, are more durable, more marginally adaptive, more aesthetically pleasing and more faster in fabrication as compared to the conventional restorations [1,2].The advantages of CAD/CAM technology in orthodontics including digital impressions [3,4], digital models [5,6], and virtual articulators and facebow [7]. Therefore, the purpose of this study is to review the current published literature investigating the various methods and techniques of CAD/CAM technology.

CAD/CAM components

CAD/CAM systems are composed of three major parts: (1) A data acquisition unit, which collects the data from the area of the preparation, adjacent and opposing structures and then converts them to virtual impressions [8] through intraoral scanners or indirectly by means of a stone model generated through making a conventional impression; (2) Software for designing virtual restorations on a virtual working cast and then computing the milling parameters; and (3) A computerized milling device for manufacturing the restoration from a solid block of restorative material or additive manufacturing.

Orthodontic application of CAD/CAM

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. 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. Multiple orthodontic systems are now utilizing this technology with success, including labial and lingual fixed appliances as well as removable clear aligner systems. 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” [9].

CAD/CAM designed bracket system

The applications of CAD/CAM in orthodontics are undoubtedly growing; Manufacturers of customized orthodontic appliances delivered with milled indirect bonding jigs claim these appliances reduce total treatment time, improve treatment efficiency, and yield better overall treatment results. Weber et al. [10] investigated a commercially available CAD/CAM orthodontic system (Ormco's InsigniaTM), comparing treatment effectiveness and efficiency of the customized appliances to traditional twin appliances. The study reported significantly lower American Board of Orthodontic (ABO) scores, a reduced number of archwire appointments, and shorter overall treatment times with the CAD/CAM group.

Ormco insignia

One of the most comprehensive CAD/CAM orthodontic appliances on the market is Ormco's Insignia, which is available in standard and self-ligating applications with optional use of esthetic ceramic brackets. The process begins with a polyvinyl siloxane (PVS) impression or intraoral scan of the patient's dentition, which is sent to Ormco for creation of digital models of the dental arches. A virtual buccal-lingual boundary is constructed from the soft tissue outline of the intraoral scan [11]. The technicians then complete a virtual setup for ideal archform and occlusion that is sent to the clinician for approval. The Insignia software was one of the first in the market that allowed the clinician to manipulate the digital setup to refine the 3-dimensional position of individual teeth, adjust the archform, alter the smile arc when needed, and detail the dental contacts in final centric occlusion [12].

Once the clinician approves the treatment plan and virtual setup, the Insignia system is reverse-engineered in one of several ways depending on the clinician's choice of bracket. The size and dimension of the virtual archform is precisely milled into metal plates and nickel titanium, stainless steel or beta-titanium wires are fabricated from these plates. The next step of the Insignia system is precisely delivering the customized brackets in the ideal position on each tooth to maximize the effectiveness of the individualized appliance. Bracket transfer jigs are custom milled to fit the occlusal surfaces of the teeth, allowing for indirect placement of the appliances. This step is crucial to the success of the system since imprecise bonding of brackets will not allow the custom straight wire to produce the planned tooth movement and the bracket transfer jigs to be highly accurate with error between 0.1-0.5mm with the largest bonding errors occurring at the lower 7s and high canines [13].

The main advantage of this system is the customization of 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 no longer depends on the position of the bracket, but on the position of the slot. The treatment theoretically can be achieved with straight wires that, if needed, allow sliding of teeth along the wire. Disadvantages include 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 [14].

ORAMETRIX- Sure smile process

OraMetrix has been working on its unique approach to CAD/CAM orthodontics since the early 2000s. Similar to other CAD/CAM orthodontic systems, OraMetrix' s SureSmile provides digital software that the clinician can utilize for diagnosing and treatment planning. The subsequent fabrication of robotically bent archwires is what separates Sure Smile from other customized appliances. Interestingly, the Sure Smile system can be used with any conventional orthodontic brackets and bands, with no special consideration during the delivery of the appliances [15].

The SureSmile (Ora Metrix, Dallas, Tex) [16] process begins with a direct 3D scan of the patient's dentition using the OraScanner (OraMetrix), a light-based imaging device that projects a precisely patterned grid onto the teeth. As the handheld scanner is passed over the dentition, reflected images of the distorted grid are recorded with a video camera built into the handle of the scanner. The scanner is passed over the teeth in a rocking motion to allow visualization of all tooth surfaces, including undercut areas. At this point, the operator can diagnose and plan the treatment with tools to measure tooth and arch dimensions, and create symmetric and asymmetric arch forms. Information regarding wire sizes, materials, and brackets is supplied for the treatment plan. The operator can consider various treatment alternatives by moving the teeth with the mouse or with selected menus, by extracting teeth, or by reducing teeth mesially or distally to simulate interproximal disking. Once a goal or a treatment target is chosen, the operator can implement therapy by "virtual bracket placement" and select the archwires sequence and progression. The archwires are produced with a wire-bending robot in the sizes and shapes selected by the orthodontist. Our investigations into the precision of the bends with stainless steel wire show less than 1° of error in bends and twists [17]. This level of precision is extremely difficult, if not impossible, to replicate by hand.

The main advantage of the Sure Smile system is that the orthodontist can use his/her preferred bracket system of choice and increase precision during the finishing stages [18]. Necessary positional information to create the customized wires can be obtained through intra-oral scans of the dental arches or cone beam computed tomography (CT) acquisition. It remains to be seen whether the increase in precision warrants the additional radiation exposure associated with cone beam CT acquisition. Disadvantages include potential for accidental debonding after arch wire customization and before completion of treatment, and the potentially long and technique-sensitive intraoral scanning procedure [19].

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. It is started in 1970's when Fujita in Japan and Kurtz in the USA used lingual brackets for the first time. Fujita described his original lingual concept in 1979 as the "mushroom archwire" [20]. To reduce the number of bends, mainly in the anterior area, several laboratory techniques—including the CLASS [21], BEST [22] and Hiro [23] systems—have positioned the incisor brackets at the same distance from the labial surfaces as the canine brackets.

A landmark study was published in 2001, by Scuzzo et al. [24], which gave new perspective to lingual orthodontics describing the possibility of permanently eliminating compensating bends, with a Straight-Wire system, based on differential bracket positioning, placed more to the cervical region of the tooth. Within this context, the PSWb [25] (Prieto Straight-Wire brackets), a Brazilian bracket that is now 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),

Anterior bracket profile slightly increased (compensation for the StraightWire technique can be possible);

Distal offset in the canine bracket, the second premolar bracket with its profile slightly higher than the first premolar bracket.

Virtual bracket positioning

Virtual brackets are selected from the software library and initially placed by the software on a plane parallel to the occlusal plane. Bracket positioning with the Orapix system has two objectives: to place the brackets as close as possible to the enamel, and to permit the use of straight wires [26]. The virtual brackets are first moved vertically to the ideal slot heights, which are 0.5-1mm more gingival than in the mushroom archwire technique. Next, the central incisor brackets are moved horizontally toward the lingual surfaces until contact occurs. To eliminate the bends between canines and premolars, the upper canine brackets must be rotated 10-15° and placed at a slight distance from the virtual tooth surfaces (mean=0.6mm).

Archwires design

Once bracket positioning is complete, the software shows the virtual straight wire passing through the center of each slot. Because the upper incisor brackets are closer to the lingual surfaces, the anterior part of the maxillary straight wire is flatter than that of the mandibular wire. In other systems, overcorrections are made by modifying the positions of the teeth on the wax setup. With the Orapix system, overcorrections are incorporated into the virtual setup by adjusting the virtual bracket positions for angulation, inclination, height, and rotation.

The current evidence on lingual orthodontics shows that any case that can be treated with labial orthodontic appliance can also be treated effectively with 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 which has an advantage of complete invisibility and 3D control of orthodontic tooth movement. It is advantageous that lingual fixed appliances are associated with reduced incidence of WSLs as compared to labial fixed appliance. And, It is very important to emphasize that the diagnosis is paramount in any system, as well as establishing an individualized plan according to the characteristics and needs of each case, in order to achieve the satisfactory completion with excellent results.

Piezocision: Assisted orthodontic treatment using CAD/CAM customized orthodontic appliances

Corticotomies have been described as accelerating orthodontic treatment [27]. 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 [28], micro-osteoperforations [29], or piezocision [30].

The flapless piezocision procedure is based on a localized piezoelectric alveolar decortication that combines buccal incisions and corticotomies performed with a piezotome [31]. 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 [32]. 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

Developments in 3D imaging technology enabled the creation of new computerized tools to assist in preoperative planning and manufacture of surgical splints [33]. There is a paradigm shift from a 2D imaging concept towards the use of a proper 3D scenario to plan the treatment of 3D deformities and the importance of 3D virtual surgical planning increases with the complexity of the deformity and reconstruction needed to correct it. As a result, surgeons are provided with extra information that could not be obtained from lateral cephalogram alone, improving the quality of the preoperative planning [34].

Multiple software programs are available for 3D planning, allowing an interaction with the 3D images to simulate the surgery and visualize the prediction of postoperative outcomes in soft and hard tissues. 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 [35]. CBCT technology also enhances the evaluation of the outcomes of combined orthodontic and surgical treatment. The study was carried out in a 19-year-old female who had a left craniofacial microsomia which required a combined orthodontic-orthognathic surgery treatment. Preoperative orthodontic treatment was performed for correction of dental compensations, enabling the occlusal coordination of both dental arches. The surgical treatment objectives were planned. The surgical plan and acrylic surgical splints generated by conventional planning methods were available as backup during the surgery. At the same time, the process of obtaining 3D images was initiated, in order to develop a 3D treatment plan and manufacture the CAD/CAM surgical splints. The process followed involved:

3D image generation.

3D surgical planning.

Designing CAD/CAM Surgical splints.

After these steps, in the CAD/CAM Centre the virtual splints (STL files) were exported to a milling machine which milled the surgical splints on polymethyl methacrylate (PMMA), a transparent rigid thermoplastic material.

CONCLUSION

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 goal is to develop an aid system for designing orthodontic devices that is quick, easy to use, cost-effective and reliable in terms of final results. So, Significant advances in orthodontic technology have occurred in recent decades, largely due to the incorporation of CAD/CAM technology into the design and fabrication of orthodontic appliances. The clinical evidence to support the efficiency and effectiveness of these appliances is varied, with no single system emerging clearly superior. Further research into the advantages and disadvantages of the available CAD/ CAM orthodontic appliances is needed to gain a better understanding of the technology and how it should be best utilized.

REFERENCES

1. Arias DM, Trushkowsky RD, Brea LM, et al. Treatment of the patient with gummy smile in conjunction with digital smile approach. Dent Clin North Am 2015; 59:703–716.
2. Lin WS, Zandinejad A, Metz MJ, et al. Predictable restorative work flow for computer-aided design/ computer-aided manufacture-fabricated ceramic veneers utilizing a virtual smile design principle. Oper Dent 2015; 40:357–63.
3. Zandparsa R. Digital imaging and fabrication. Dent Clin North Am 2014; 58:135–58.
4. Sannino G, Germano F, Arcuri L, et al. CEREC CAD/CAM chairside system. Oral Implantol 2015; 7:57–70.
5. Pradıes G, Zarauz C, Valverde A, et al. Clinical evaluation comparing the fit of all-ceramic crowns obtained from silicone and digital intraoral impressions based on wavefront sampling technology. J Dent 2015; 43:201–208.
6. Ahrberg D, Lauer HC, Ahrberg M, et al. Evaluation of fit and efficiency of CAD/CAM fabricated all-ceramic restorations based on direct and indirect digitalization: A double-blinded, randomized clinical trial. Clin Oral Investig 2015.
7. Solaberrieta E, Mı´nguez R, Barrenetxea L, et al. Comparison of the accuracy of a 3- dimensional virtual method and the conventional method for transferring the maxillary cast to a virtual articulator. J Prosthet Dent 2015; 113:191–197.
8. Galhano GA, Pellizzer EP, Mazaro JV. Optical impression systems for CAD-CAM restorations. J Craniofac Surg 2012; 23:575–579.
9. https://automaterials.files.wordpress.com/2018/09/cad-cam-by-p-n-rao.pdf
10. Weber DJ, Koroluk LD, Phillips C, et al. Clinical effectiveness and efficiency of customized vs. conventional preadjusted bracket systems. J Clin Orthod 2013; 47:261-6.
11. Larson B, Vaubel C, Grunheid T. Effectiveness of computer-assisted orthodontic treatment technology to achieve predicted outcomes. Angle Orthod 2013; 83:557-62.
12. Nguyen T, Jackson T. 3D technologies for precision in orthodontics. In Seminars in Orthodontics 2018; 24:386-392.
13. Gracco A, Tracey S. The insignia system of customized orthodontics. J Clin Orthod 2011; 45:442-51.
14. Mayhew MJ. Computer-aided bracket placement for indirect bonding. J Clin Orthod 2005; 39:653-60.
15. Mah J, Sachdeva R. Computer-assisted orthodontic treatment: The sure smile process. Am J Orthod Dentofac Orthop 2001; 120:85-87.
16. Alford TJ, Roberts WE, Hartsfield JK, et al. Clinical outcomes for patients finished with the SureSmile™ method compared with conventional fixed orthodontic therapy. Angle Orthod 2011; 81:383-8.
17. Scholz RP, Sachdeva RC. Interview with an innovator: SureSmile chief clinical officer Rohit CL Sachdeva. Am J Orthod Dentofac Orthop 2010; 138:231-238.

18. Sachdeva RC. Sure Smile technology in a patient-centered orthodontic practice. J Clin Orthod 2001; 35:245-53.
19. Fujita K. New orthodontic treatment with lingual bracket mushroom arch wire appliance. Am J Orthod 1979; 76:657-75.
20. Goraya KS. Customization in Lingual Orthodontics. J Dent Sci 2017; 5:8-12.
21. https://www.semortho.com/article/S1073-8746(06)00032-6/references
22. Poon KC, Taverne AA. Lingual orthodontics: A review of its history. Australian Orthod J 1998; 15:101-4.
23. Scuzzo G, Takemoto K, Mostardi G. Simplified approach to lingual orthodontics – STb bracket light lingual system. Rev Orthop Dento Faciale 2007.
24. do Lago Prieto MG, Ishikawa EN, Prieto LT. A groove-guided indirect transfer system for lingual brackets. J Clin Orthod 2007; 41:372-376.
25. Fillion D. Lingual straightwire treatment with the Orapix system. J Clin Orthod 2011; 45:488-97.
26. Wilcko W, Wilcko MT. Accelerating tooth movement: the case for corticotomy-induced orthodontics. Am J Orthod Dentofacial Orthop 2015; 47:47-50.
27. Kim YS, Kim SJ, Yoon HJ, et al. Effect of piezopuncture on tooth movement and bone remodeling in dogs. Am J Orthod Dentofac Orthop 2013; 144:23-31.
28. Alikhani M, Raptis M, Zoldan B, et al. Effect of micro-osteoperforations on the rate of tooth movement. Am J Orthod Dentofac Orthop 2013; 144:639-648.
29. TV A. Piezocision: A minimally invasive, periodontally accelerated orthodontic tooth movement procedure. Compendium 2009; 30.
30. Charavet C, Lecloux G, Bruwier A, et al. Selective piezocision-assisted orthodontic treatment combined with minimally invasive alveolar bone regeneration: A proof-of-concept. Int Orthod 2018; 16:652-64.
31. Brown MW, Koroluk L, Ko CC, et al. Effectiveness and efficiency of a CAD/CAM orthodontic bracket system. Am J Orthod Dentofac Orthop 2015; 148:1067-74.
32. Metzger MC, Hohlweg-Majert B, Schwarz U, et al. Manufacturing splints for orthognathic surgery using a three-dimensional printer. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008; 105:e1-7.
33. Xia J, Ip HH, Samman N, et al. Computer-assisted three-dimensional surgical planning and simulation: 3D virtual osteotomy. Int J Oral Maxillofac Surg 2000; 29:11-7.
34. Bansal N, Singla J, Gera G, et al. Reliability of natural head position in orthodontic diagnosis: A cephalometric study. Contemp Clin Dent 2012; 3:180–183.