Research, Society and Development, v. 11, n. 16, e529111636196, 2022
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i16.36196

Digital flow in the dental office and CAD/CAM system: 3 year-control

Fluxo digital no consultório odontológico e sistema CAD/CAM: controle de 3 anos

Flujo digital en el consultorio dental y sistema CAD/CAM: 3 año de control

Received: 10/06/2022 | Revised: 11/13/2022 | Accepted: 12/08/2022 | Published: 12/16/2022

Juliana de Souza Silva Zica
ORCID: https://orcid.org/0000-0001-9846-9613
Centro Universitário UNA, Brazil
E-mail: drajulianass@hotmail.com
Lidiane Cristina Machado Costa
ORCID: https://orcid.org/0000-0002-3843-1186
Centro Universitário Newton Paiva, Brazil
E-mail: lidiane.cmachadocosta@gmail.com
Sílvia de Pársia Montijo
ORCID: https://orcid.org/0000-0002-4792-6201
Consultório particular, Brazil
E-mail: silvia.parsia97@gmail.com

Abstract
Objective: The goals for this study were to present the history of the CAD/CAM system and the advantages of this system and other technological innovations in the clinician's daily dental practice. In addition to presenting a case report of a patient's treatment performed through DSD planning. Methodology: The entire aesthetic planning was demonstrated using the DSD and the patient additive mockup technique. After obtaining the 3D model, digital aesthetic planning was performed. In the manufacture of ceramic veneers, the CAD/CAM system was used. Then, the gingival removal and subsequent intra-oral scanning of the prepared region were performed. Photo-activatable adhesive cementation was used in the placement of the ceramic veneers, in addition to receiving a surface treatment, followed by the application of the adhesive system. Results: The result met the expectations of the patient, who was able to visualize the forecast of the final result. Conclusion: It was concluded that, although the CAD/CAM system has advantages, it is necessary for the professional's higher learning curve, with both techniques, both digital and analog, being adequate and efficient.
Keywords: CAD/CAM; Ceramic; Dental veneers.

Resumo
Objetivo**:** O objetivo do presente estudo foi apresentar o histórico do sistema CAD/CAM e as vantagens desta e de outras inovações tecnológicas na prática odontológica diária do clínico. Além do proposto, objetiva-se apresentar um relato de caso do tratamento de um paciente realizado através do planejamento DSD. Metodologia**:** Foi demonstrado todo o planejamento estético com o uso do DSD e da técnica de *mockup* aditivo à paciente. Após a obtenção do modelo 3D, foi realizado o planejamento estético digital. Foi utilizado o sistema CAD/CAM na confecção de laminados cerâmicos. Em seguida, foi realizado o afastamento gengival e posterior escaneamento intra-oral da região preparada. A cimentação adesiva fotoativável foi utilizada para cimentação dos laminados cerâmicos, que receberem previamente um tratamento de superfície, seguida da aplicação do sistema adesivo. Resultado: O resultado atendeu às expectativas da paciente que pôde visualizar a previsão do resultado final. Conclusão: Concluiu-se que, embora o sistema CAD/CAM apresente vantagens, é necessário à curva de aprendizado maior do profissional, sendo as duas técnicas, tanto digital quanto analógica, adequada e eficientes.
Palavras-chave: CAD/CAM; Cerâmica; Facetas dentais.

Resumen
Objetivo: Los objetivos de este estudio fueron presentar la historia del sistema CAD/CAM y las ventajas de este y otras innovaciones tecnológicas en la práctica dental diaria del clínico. Además de presentar un informe de caso del tratamiento de un paciente realizado a través de la planificación DSD. Metodológia: Toda la planificación estética se demostró con el uso de DSD y la técnica de maqueta aditiva al paciente. Tras la obtención del modelo 3D, se llevó a cabo la planificación estética digital. El sistema CAD/CAM se utilizó en la fabricación de laminados cerámicos. Luego, se realizó el aclaramiento gingival y la posterior exploración intraoral de la región preparada. La cementación adhesiva fotoativable se utilizó en la colocación de laminados cerámicos, además de recibir un tratamiento superficial, seguido de la aplicación del sistema adhesivo. Resultado: El resultado cumplío con las expectativas del paciente que fue capaz de predecir el resultado final. Conclusión: Se concluyó que, si bien el sistema CAD/CAM presenta ventajas, es necesario para la mayor curva de aprendizaje del profesional, y las dos técnicas son tanto digitales como analógicas, adecuadas y eficientes.
Palabras clave: CAD/CAM; Cerámica; Laminados dentales.

1. Introduction

Technological innovation in the dental market aims to facilitate and optimize treatment, reduce consultation time and bring comfort to the patient. Likewise, such innovations improve the aesthetics and durability of the work carried out (Abduo et al., 2014). Dentistry is in transition between analog and digital techniques and the advantages and disadvantages of each technique are subjects in evidence in the current period.

Analog flow is a process carried out for decades and already well elucidated in the literature, in which traditional moldings are performed using materials such as alginates and elastomers to copy tooth structures. Obtaining a quality mold will depend on a number of factors, which include the professional's skill and knowledge (Ferreira et al., 2020). To help carry out the work in the analog flow, diagnostic wax-ups are performed with no prior analysis of the smile design, with no clear way of communication between the dentist and the laboratory, making the process difficult and potentially fraught with errors (Cattoni et al., 2016).

The technology has been progressively attributed to dental procedures since 1971. The Digital Flow involves a process that aims to obtain a three-dimensional mold of the oral cavity. Digital dental impressions are performed using an intraoral scan. From the 3D images obtained, the digital flow uses a method based on computer-aided creation and production systems that allow printing three-dimensional models with high copy fidelity and richness of details. 3D images are obtained either through intraoral scanning or even from scanning models made by the prosthesis laboratory et al., 2012).

To complement this digital process, the Digital Smile Design (DSD) method was recently created, which allows for excellent communication with the patient, in addition to being a tool that helps in the most correct therapeutic choice for each case. It is possible that the patient sees the final result even before starting the treatment (Cervino G, et al., 2019). The DSD can also be characterized as a digital tool that provides, from the facial point of view, the aesthetic planning of rehabilitation, improved communication between specialists and refining in the result expected by the patient. This dynamic smile documentation allows for a 2D and 3D digital design of the modified arch, which contributes to rehabilitation planning. The DSD can also be converted into a conventional or virtual diagnostic model to facilitate the preparation of restoration and milling using the Computer-Aided Design and Computer-Aided Manufactoring (CAD/CAM) system (Stanley et al., 2018).

The CAD/CAM system is one of the many digital dental tools used today. The acronym in the English language CAD/CAM means, respectively: computer-aided design and computer-aided manufacturing. Since the 1980's, different CAD/CAM systems have been developed. They evolved through a series of software and hardware (Bindl & Mörmman 2003). This technology aims to optimize the professional's work and promote greater effectiveness in the results (Bernardes, 2016 et al., Noort et al., 2012, Wittneben et al., 2019).

The CAD/CAM system promotes the three-dimensional scanning and mapping of the arches, and then the software designs the prosthetic structure and forwards it to making and milling the restoration (Moura & Santos, 2015). This system offers advantages over numerous analog restorative processes. It is possible to produce high quality prosthetic restorations with multiple options of restorative materials, in addition to different types of prosthesis (Bernardes et al., 2012). This study aims to discuss whether the advantages presented by the CAD/CAM system justify the replacement of analog processes for the execution of dental treatments by 2digital processes, based on a clinical case report with 1 year-control that used digital flow for its execution (Abduo et al., 2014).

The hypotheses observed are: (I) technological innovations and the CAD/CAM system have more advantages compared to the conventional process of performing dental work; (II) the digital or conventional processes for performing dental work do not interfere with the final result achieved.

2. Methodology

This study is a case report conducted in accordance with Declaration of Helsinki of 1975, revised in 2013 and according to the study methodology by (Estrela, 2018). The patient signed the free and informed assent form. The submission for evaluation by the Research Ethics Committee was not necessary, in accordance with CNS Resolution No. 510 of 2016, Art. 1, sole paragraph, "The CEP/CONEP system will not be registered or evaluated: VII - research aimed at theoretical deepening of situations that emerge spontaneously and contingently in professional practice, provided they do not reveal data that can identify the subject”.

3. Technique

Figure 1 shows the oral cavity of a 52-year-old female patient unsatisfied with her smile, who was attended in a private dental clinic for a general evaluation. During the clinical evaluation, the patient's Digital Smile Design (DSD) was performed, in order to give the patient the prediction of the treatment results before starting it (FIGURE 2). The 3D model of the patient's upper arch, was printed through the planned DSD, after patient’s approval of the planning and treatment proposal (FIGURE 3).

Figure 1. A - Initial aspect of the smile. Note the unsatisfactory composite resin restorations.

B - Intrabucal aspect; C - Upper arcade aspect. Source: Authors.

Figure 2 - Digital Smile Design (DSD) to predict the treatment results.

Source: Authors.

Figure 3 - Silicone guide for building the mockup on the left and the patient's upper arch 3D model on the right.

Source: Authors.

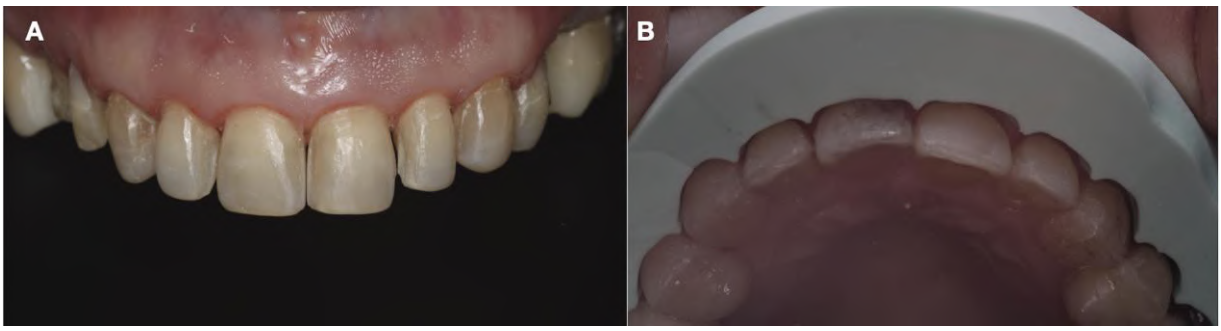
In addition to the DSD, an additive mockup was also made from the 3D printed model (Figure 4) using bisacrylic resin to give the patient the possibility to visualize the final result in her own mouth.

Figure 4 - A and B - Making the additive mockup from the 3D model Additive mockup from the 3D printed model. C - Immediate result after mockup.

Source: Authors.

Composite resin restorations were removed from teeth 14 to 24 and the natural teeth were prepared (FIGURE 5) with diamond burs conical fine to make room for the restorative material and the temporary material until the ceramic veneers were made.

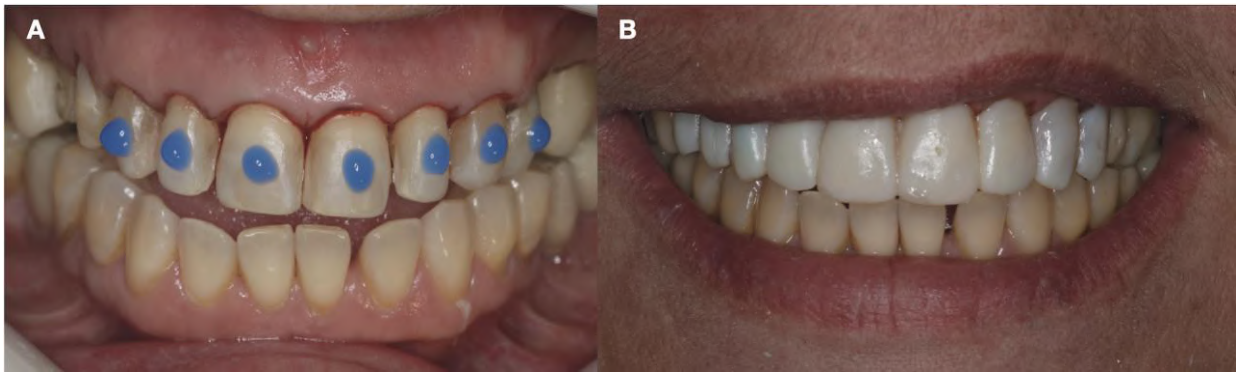
Figure 5. A -Minimally invasive preparation. B - Silicone guide for preparations performed using the 3D model.



Source: Authors.

Since the CAD/CAM system was the method of choice for making the ceramic veneers, the next step was to perform gingival retraction and subsequent intraoral scanning of the prepared region (FIGURE 6).

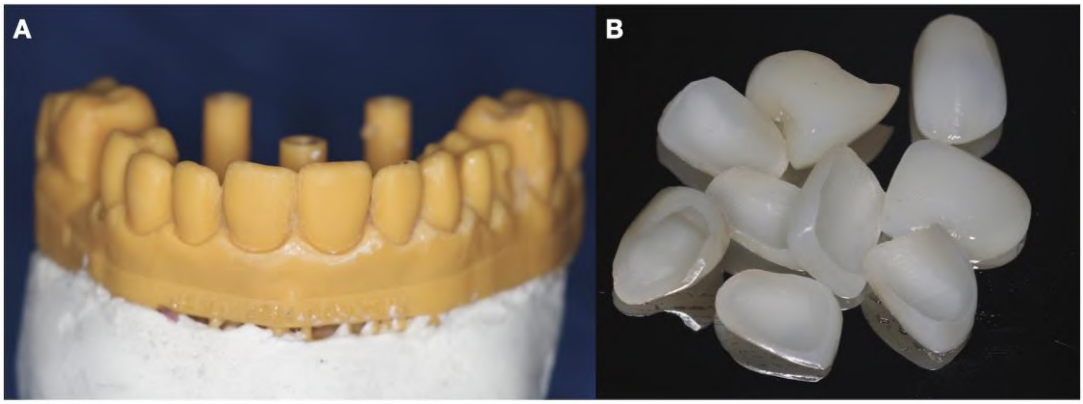
Figure 6. A- Substrate preparation for making temporary restorations. B - Temporary restorations installed.



Source: Authors.

Temporary restorations were made over the prepared teeth for greater patient comfort until the next session using bisacrylic resin (Figure 7). The ceramic tablets used were IPS e.max Press (Ivoclar Vivadent) by technique CAD/CAM. The ceramic veneers were made using the milling machines of the CEREC system (Figure 7).

Figure 7. A - 3D model. 7B - Finished ceramic laminates.



Source: Authors.

For the placement of the ceramic veneers and after testing with try in pastes, photoactivatable adhesive cementation of medium value was used (Variolink Veneer, Ivoclar Vivadent). After performing a modified absolute isolation in order to expose the gingival margins, two dental elements were conditioned at a time for 15-30 seconds (Figure 8) and application of the adhesive was performed (Tetric N-Bond Universal Ivoclar Vivadent). The ceramic veneers also received a surface treatment and after conditioning with 5% hydrofluoric acid for 20 seconds, a Monobond N primer system (Ivoclar Vivadent) and Tetric N- Bond (Ivoclar Vivadent) was applied previously to the cementation (Figure 9).

Figure 8 - Proof of ceramic laminates with try in paste.

Source: Authors.

Figure 9. A - Final aspect of smile. B - Smile side view. C - Upper arch final result.

Source: Authors.

Cementation was carried out judiciously on two teeth at a time, taking care to remove excess cement, and then light curing (Bluephase, Ivoclar Vivadent) was performed for 1 minute on the buccal surface of the laminates. Subsequently, the occlusion and disocclusion contacts were tested.

In a second moment, a work was carried out on the lower arch using ceramic laminates and the patient returned for evaluation after 3 years of cementation (Figure 10).

Figure 10 - A and B - Control after 3 year.

Source: Authors.

4. Discussion

New technologies involving the CAD/CAM system have emerged with the digital flow in order to assist Dentistry in various ways, with several devices and software being inserted that have decisively changed the profession (Omar & Duarte, 2017., Haddadi et al. 2019., Eleutério, 2019). This study presents a case report that used the fully digital flow technique for esthetic rehabilitation. The initial planning involved the use of DSD, which showed the before and after results in a two-dimensional way. Through the (DSD), the patient visualized the result from photos prior to the treatment. The 2D image gave rise to the 3D model made using Exocad software. After approval of the software images, the 3D model was printed and from it an additive mockup was performed as a physical model of the digital planning, which provided the patient with the possibility of visualizing the final result in mouth before it was executed (Cervino et al. 2019., Coachman & Calamita, 2012., Coachman C, et al., 2012).

DSD complements the digital flow and is considered a multipurpose conceptual tool, according to Coachman and Calamita (2012). This technology can strengthen diagnosis, improve communication and increase predictability during treatment. In addition to allowing a careful analysis of the patient's facial and dental characteristics to improve the aesthetic result. In addition, this tool favors the understanding of the treatment steps. Furthermore, they allow the possibilities of treatment to be visualized during the consultations, which favors a more enlightening communication with the patient and enables their participation in the planning of their treatment. This tool becomes extremely important for patients, whose demand commonly calls for services with the most natural and most aesthetic possible characteristics (Cervino G, et al., 2019; Stanley M, et al., 2018; Omar & Duarte C, 2017; Coachman & Calamita, 2012; Coachman C, et al., 2012; Alghazzawi, 2016).

According to Garcia et al. (2020), although DSD is simple, it requires training. The combination of both techniques allows for better aesthetic manipulation, therefore, better predictability to support the treatment plan. However, it is important to draw up an accurate photographic protocol. The photographs obtained provided relevant information for aesthetic planning, but if the photographs are not adequate, they can distort the reference image and result in incorrect diagnosis and planning. These findings corroborate the study by Omar and Duarte (2017) who claim that DSD offers predictable and highly satisfactory results.

After approval of the mockup by the patient, the intraoral preparations were made on teeth 15 to 24. In the same session, the intraoral scanning of the prepared teeth, the implant of tooth 25 and the entire upper and lower arches were performed, as well as the preparation of temporary restorations with bisacrylic resin.

The CAD phase begins with the intraoral scanning used in this clinical case, being a tool that aims to reproduce three-dimensional structures such as teeth or implants, increasingly used in restorative dentistry. Its use has been a new trend in the last decade (Filgueiras et al., 2018; Wittneben et al., 2009). The reduction of working time and the reduction of errors is essential for the final result, in the physical, emotional and financial scope. In the search for efficiency, intraoral scanning and materials

that can be worked with CAD/CAM, aim to obtain a better quality of molding, and reduce work steps, expenditure on materials and less wear on the tooth structure (Cattoni F, et al., 2016; Alghazzawi, 2016; Grünheid et al. 2014; Ting-Shu & Jian, 2015). However, it is essential to assess accuracy whenever there is a technology available in Dentistry, comparing it with the existing standard. When comparing the intraoral scanner to a high-resolution plaster model scanner, it is clear that alginate impressions that precede the making of the plaster model are still the preferred model acquisition method in relation to chair time and patient acceptance (Grünheid et al. 2014; Costa et al., 2010; Syrek rty al., 2010; Brawek et al., 2013).

Digital flow has brought drastic changes in the way dentists work, requiring a new learning curve for clinicians to use a series of new tools that are available to facilitate the clinical routine. This learning curve can initially increase the clinical time to perform the procedures and, therefore, bring resistance from the patient and even from the professional. In addition to what has been reported, it is important to emphasize that the intraoral scanner is not able to mill retentive areas and sharp angles, in addition to the fact that it is difficult to copy edges when milling the prosthetic piece, and there may be internal and cervical misfit. Thus, it is important to emphasize that the cavity preparation has specificities when the CAD/CAM technique is used (Garcia, et al., 2018; Goujat, 2018).

It is believed that the use of digital methods such as those used in this clinical case tend to reduce errors in the prosthesis manufacturing process, so that they can have greater precision and quality, in addition to speeding up the process. Thus, the choice of the type of software for 3D printing is an investment that must be taken into account, as it allows the identification of imperfect fits, anatomical adjustments, failures, with regard to functionalities incapable of being completed in the visual impact and above all to recognize general problems. It is also up to the professional to decide how the software will be used according to the functionalities required by it in clinical practice. In addition, it is essential to have professional knowledge and investment possibilities (Haddadi et al., 2019).

The images that were obtained from the intraoral scanning in the exposed clinical case served as the basis for the creation of the digital mold and followed to a specific software that planned and carried out the modeling of the prostheses. Finally, the project information was sent to the dental milling machine (CAM), which produced the ceramic veneers in lithium disilicate. A 3D model with prepared teeth was also printed for final adaptation and finishing touches of the created restorations.

Computer-aided milling is commonly used in production processes in dental laboratories, as well as 3D printing and rapid prototyping technologies. Unlike the milling process, 3D printing technology is an additive process, which involves superimposing layers of material to create the final product. The use of rapid prototyping allows the 3D printing to be made with greater precision for different cases, in addition to helping the clinician to carry out a better treatment planning (Eleutério, 2019). According to the literature, 3D printing combined with CAD/CAM technology brings many benefits in terms of time and agility (Filgueiras et al., 2018, Gouja et al., 2018).

It is important to highlight that the CAD/CAM system provides only the basic forms of dental morphology, requiring, in most cases, that some manual changes and necessary modifications are made, since each patient is unique and each tooth has its own morphological characteristic. On the other hand, the analog flow in the manufacture of prostheses allows the adjustment of discrepancies between models and patients. In this way, the characteristics can be rehabilitated by harmonizing them with the patient. Both the analog and the digital flow can restore the harmony of the smile, the digital flow is with the patient's collaboration and the analog flow with a partnership work by the dental surgeon and the prosthesis laboratory. The decisive factors refer to the planning and predictability of the case, proper execution of the technique, control and periodic maintenance (Ferreira et al., 2020). The viable alternative to avoid manual alteration in the final denture design is to use the biogenetic tooth morphology database, in order to make it similar, reproducing the patient's individual occlusal morphology. However, the implementation of this technology is considered expensive, contradicting the statement by Tavares (2014), who believes that the cost is reasonable, but corroborates with the author regarding the need for personnel training.

The construction of the prosthesis until adaptation by the CAM system is carried out with specific trays of the system and instruments that differ from conventional equipment, which requires practical training and a trained team. Although the available CAD/CAM prosthesis manufacturing systems offer a variety of advantages making them more attractive to clinicians and patients (Bosch et al., 2014) the need for staff training and the high cost are perhaps the biggest challenges for the higher prevalence of this technique in the dental offices (Garcia et al. 2018). It is observed that this technique is more present in prosthesis laboratories. These mostly acquired bench scanners and dental milling machines to make the prosthetic work.

5. Conclusion

It is concluded that the use of CAD/CAM technology is prosperous in Dentistry, due to its greater precision, time savings and comfort for the patient, which are the main benefits corroborated in the literature. The intraoral scanner, as well as DSD and 3D printing have been attributing many benefits to the dental practice. However, it is important to determine the best methodology, according to the needs of each patient, taking into account the cost-benefit. Regardless of whether the flow used is analog or digital, it is extremely important for the professional to master the technique, in order to minimize the possibility of errors in the planning and manufacturing process of the prostheses.

Based on the clinical case presented and the discussion presented about the digital flow and the CAD/CAM system, further research must be carried out in order to clarify doubts and confirm the importance of using these techniques in dental offices.

References

Alghazzawi T. F. (2016). Advancements in CAD/CAM technology: Options for practical implementation. J Prosthodont Res. 6(2): 72-84.

Abduo J., Lyons K. & Bennamoun M. (2014). Trends in computer-aided manufacturing in prosthodontics: a review of the available streams. International Journal of Dentistry.(1): 1-15.

Bernardes S. R., Tiossi, R. & Sartori, I. A. M., et al. (2012). Tecnologia CAD/CAM aplicada a prótese dentária e sobre implantes: o que é, como funciona, vantagens e limitações - uma revisão crítica da literatura. Journal ILAPEO. 6(1): 8-13.

Brawek P. K, Wolfart S., Endres L., et al. (2013). The clinical accuracy of single crowns exclusively fabricated by digital workflow--the comparison of two systems. Clin Oral Investig. 17(9): 2119-2125.

Bindl A. & Mörmman W. H. (2003). Clinical and SEM evaluation of all ceramic chair-side CAD/CAM-generated partial crowns. European Journal of Oral Sciences. 111(2): 163-169.

Bosch G., Ender A. & Mehl A. (2014). A 3-dimensional accuracy analysis of chairside CAD/CAM milling processes. Journal of Prosthetic Dentistry. 112(6): 1425-1431.

Cattoni F., Mastrangelo F. & Gherlone E. F., et al. (2016). A new total digital smile planning technique (3D-DSP) to fabricate CAD/CAM mockups for esthetic crowns and veneers. International Journal of Dentistry. 2016(1):1-5.

Cervino G., Fiorillo L. & Arzukanyan A. V., et al. (2019). Dental restorative digital workflow: Digital Smile Design from aesthetic to function. Dentistry Journal. 30(7): 1-12.

Coachman C. & Calamita M. C. (2012). Digital smile design: A tool for treatment planning and communication in esthetic dentistry. Quintessence Den Technol. 35:01-09.

Coachman C., Eric V. & Dooren, G. G., et al. (2012). Smile Design: From digital treatment planning to clinical reality. In: Cohen M (ed). Interdisciplinary treatment planning, Comprehensive Case Studies. Quintessence. 2: 119-174.

Costa J. B., Pelogia F. & Hagedorn B., et al. (2010). Evaluation of different methods of optical impression making on the marginal gap of onlays created with CEREC 3D. Oper Dent. 35(3): 324-329.

Eleutério D. (2019). The moment of 3D printing in dentistry. Prosthes Esthet Sci. 8(31): 63-68.

Ferreira, J. M., Santos, A. C. M. & Nogueira, P. L., et al. (2020). Estética dental por meio do uso de coroa e facetas metal free: relato de caso. Rev. Eletrônica Acervo Saúde. 56(56): 01-09.

Filgueiras A., Pinto D. G. & Ferrarez, L. L., et al. (2018). Aplicabilidade clínica dos avanços da tecnologia CAD-CAM em Odontologia. HU Revista. 44(1): 29-34.

Garcia L.O. R, Santos, F. P. & Passos, L. F., et al. (2020). Fluxo híbrido: a odontologia analógica e digital caminhando em sintonia no curso de odontologia do Centro Universitário. Ciência Atual. 15(1): 90-95.

Garcia P. P., da Costa R. G., Calgaro M., et al. (2018). Digital smile design and mock-up technique for esthetic treatment planning with porcelain laminate veneers. Journal of Conservative Dentistry. 21(4): 455-458.

Goujat A., Abouelleil H. & Colon P., et al. (2018). Marginal and internal fit of CAD/CAM inlay/onlay restorations: a systematic review of in vitro studies. The journal of prosthetic dentistry. 121(4): 590-597.

Grünheid T., Mccarthy S. D. & Larson B. E. (2014). Clinical use of a direct chairside oral scanner: an assessment of accuracy, time, and patient acceptance. Am J Orthod Dentofacial Orthop. 146(5): 673-682.

Haddadi Y., Bahrami G. & Isidor F. (2019). Accuracy of intra-oral scans compared to conventional impression in vitro. Primary Dental Journal. 8(3): 34-9.

Moura R. B. B. & Santos T. C. (2015). Sistemas cerâmicos metal free: tecnologia CAD/CAM – revisão de literatura. Revista interdisciplinar. 8(1): 220-226.

Noort R. V. The future of dental devices is digital. (2012). Dental Materials Journal. 28(1): 3-12.

Omar D. & Duarte C. (2017). The application of parameters for comprehensive smile esthetics by digital smile design programs: A review of literature. Saudi Dental Journal. 30(1): 7-12.

Stanley M., Paz A. G. & Miguel I., et al. (2018). Fully digital workflow, integrating dental scan, smile design and CAD/CAM: case report. BMC Oral Health. 134(18): 1-8.

Syrek A., Reich G. & Ranftl D., et al. (2010). J. Clinical evaluation of all-ceramic crowns fabricated from intraoral digital impressions based on the principle of active wavefront sampling. J Dent. 38(7): 553-559.

Ting-Shu S. & Jian, S. (2015). Intraoral digital impression technique: a review. Journal of Prosthodontics. 24(4): 313-321.

Wittneben J. G., Wright R. F. & Weber H. P., et al. (2009). A systematic review of the clinical performance of CAD/CAM single-tooth restorations.The International journal of prosthodontics. 22(5): 466-471.