Case Report

The CAD/CAM Technology and Digital Smile Design for Fabricated Ceramic Veneers

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Abstract

Nowadays, the application of digital technologies and devices are widely used in dentistry. The explanation of the innovative and advanced digital technology for designing and fabricating the provisional restorations transfers to final restorations. Computer-aided design/computer-aided manufacturing (CAD/CAM) in digital dentistry has numerous advantages and greater efficiency and accuracy over the conventional techniques. The digital smile design (DSD) is used for esthetic dentistry especially in case of veneer and can be improved the effectiveness and efficiency of dentist to patient and dentist to technician communication. However, the applications of DSD and CAD/CAM require an understanding of the principal concept and digital technology to create the precise and esthetic outcome of the final restoration.

Keywords: computer-aided design/computer-aided manufacturing, digital smile design, veneer

Introduction

Computer-aided design and computer-aided manufacturing (CAD/CAM) systems are used in dentistry to design and fabricate dental restorations such as inlays, onlays, veneers, crowns, fixed partial dentures, implant abutments and full-mouth reconstruction. CAD/CAM systems typically consist of three main components.(1-3) First, digital data collecting from the patient's mouth or data from stone models by the conventional impression of the patient's teeth and surrounding structures which using intraoral scanners to create a digital model. Second, CAD software for designing the virtual restoration on a virtual working cast and calculating the milling parameters needed to fabricate the restoration. Third, computerized milling devices and additive manufacturing systems are used to fabricate the restoration by following the milling parameters that are calculated in the design phase of CAD software to shape the material into the desired restoration. The CAD/CAM systems can be classified into laboratory systems and chairside systems which the chairside CAD/CAM system is further divided into two categories: systems with their own milling units including the scanners and systems with their own only scanners without designing capabilities, therefore, to create a product or design the restoration they need to be connected to an opened lab scanner.(1,3,4) Additionally, CAD/CAM systems may be classified into opened and closed systems based on data communication. Closed systems provide completely CAD/CAM processes including data gathering, virtual design and manufacture for fabricating the restorations, performed by the same company. All processes are in closed systems, therefore, systems from the various vendors cannot be used interchangeably. Whereas, opened systems are enable the original digital data by CAM devices from several manufacturers and CAD software.(1,5,6) The laboratory CAD systems always are opened systems as the data must be stored in an STL file (STereoLithography or Standard Tessellation Language). For this reason, the different data formats from many companies that will not be compatible with each other can be sent to an opened laboratory CAM system, which supports the type of STL file from the laboratory CAD system, so the restoration will be fabricated.(1)

For fabricating the restoration, there are two primary methods, subtractive (milling and grinding) and additive manufacturing. Milling technology is a type of restoration fabrications that utilizes subtraction manufacturing from the large solid blocks.(1) The milling manufacturing is categorized into dry and wet milling. Wet milling process uses the milling diamond or carbide cutter that protected by spray of cool liquid against overheating within the milled of the milled material. To prevent heat-related damage, this type of processing is required for all metals and glass ceramic materials.(1,3) In dry milling process, the blocks or banks of resin material are placed into a computer-controlled milling machine, using rotary cutting tools to remove material from the blocks to create the desired shape. Dry milling process mostly uses for the fabrication of zirconia crowns from zirconium oxide blanks (ZrO_2) or milling resin material blanks such as PMMA (polymethyl methacrylate) banks for temporary crown restoration.(7)

Additive manufacturing is defined by the American Society for Testing and Materials (ASTM) as “the process of joining materials to make objects from 3D (three-dimensional) model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies”.(1,8) After the 3D model designed by CAD software is completed, it is segmented into multislice images.(1) Typically, in each millimeter of material, there are 5-20 layers in which the machine lays down successive layers of liquid or powder material that are fused to create the final shape.(1,9) There are several different technologies used in additive manufacturing and the varying specific processes depend on the type of 3D printer. Some technologies are commonly used in additive manufacturing such as Direct Metal Laser Sintering (DMLS), StereoLithogrAphy (SLA), Scan, Spin and Selectively Photocuring (3SP), PolyJet, and Direct Light Projection (DLP).(1,8) Printing a digital 3D model is more accurate than milling and conventional plaster models.(10) Moreover, additive manufacturing facilitates the production of complex geometries with fine details that cannot be reproduced by other methods.(11)

In dentistry, CAD/CAM was the favorable technique to fabricate fixed restoration especially veneers. Veneers have been used to improve the aesthetic and protection of teeth. One of the most common materials that used to fabricate laminate veneers is ceramic. The translucency of material results in color appearance of natural teeth. Ceramic veneers are used to correct many factors such as tetracycline staining, fluorosis, amelogenesis imperfecta and aging. The others are restoring fractured or worn teeth, abnormal tooth morphology and correction of minor malposition. However, the patients with parafunctional habits, edge to edge relation, and poor oral hygiene should be concern to the limitation of ceramic veneers.[12-14] The longevity and survival rate of ceramic veneers were reported for 5 years (98%), 10 years (96%), 15 years (91%) and 20 years (91%).[15] The survival rate of ceramic veneers depends on the remaining enamel and bonding systems. Therefore, the conservative preparation and cementation technique are required to ensure predictable outcome of ceramic veneers.[16,17]

There are four different designs of teeth preparations.[12-14] The first, window preparation (Figure 1A); the incisal edge of the tooth is preserved. This technique is favorable in case of slight correction of malposition and non-adjustment position of the incisal edge. Window preparation provides more than one path of insertion. Second, feather preparation (Figure 1B); the incisal edge of the tooth is prepared labio-palatal, but the incisal length is not reduced. This technique is favorable in case of slight correction of malposition and discolored teeth. Feather preparation provides more than one path of insertion. The third, bevel preparation (Figure 1C); the incisal edge of the tooth is prepared labio-palatal and the length of the incisal edge is slightly reduced (0.5-1.0 mm). This technique is favorable in case of correction of malposition, discolored teeth and provided one path of insertion. The last, incisal overlap preparation (Figure 1D); the incisal edge of the tooth is prepared labio-palatal, and the length is reduced (about 2.0 mm), so the veneer is extended to the palatal aspect of the tooth. The incisal overlap preparation technique is favorable in case of correction of malposition, discolored teeth and provided one path of insertion. This preparation created the most stability of restoration. Two millimeters of reduction is enough to create an opalescence effect of the restoration.

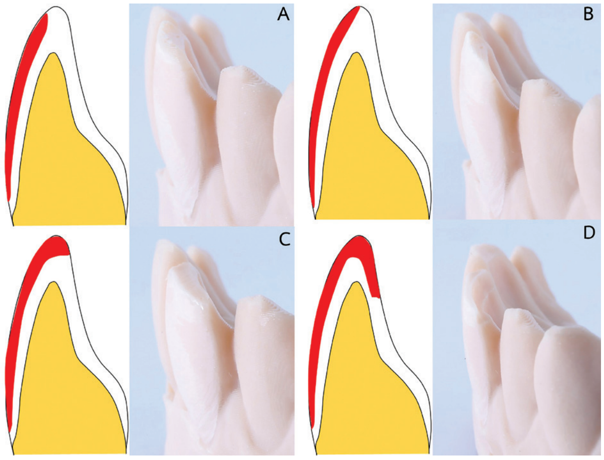

Figure 1: Representative type of preparation. (A) Window preparation. (B) Feather preparation. (C) Bevel preparation. (D) Incisal overlap preparation.

CAD/CAM materials for veneers

The conventional technique for fabricated feldspathic ceramic veneer requires a skilled and experienced of dental technician. In addition, feldspathic ceramic veneers are weaker and easily chip or crack more than other materials such as lithium disilicate ceramic and zirconia.[17,18]

CAD/CAM ceramic materials for manufacturing veneers can be classified into glass-matrix ceramics and resin-matrix ceramics. Resin-matrix ceramics include resin-based composites and polymer infiltrated ceramic networks (PICNs).[19] Glass-matrix ceramic materials include feldspar ceramics, the first CAD/CAM fine-structure feldspar ceramics (VITABLOCS® Mark II, VITA Zahnfabrik, Bad Säckingen, Baden-Württemberg, Germany) have developed from conventional feldspathic ceramics and are still used in clinical[19,20], leucite reinforced glass ceramics (IPS Empress® CAD, Ivoclar vivadent®, Schaan, Liechtenstein) are improved from early generations of CAD/CAM blocks containing leucite crystals up to 40% embedded in feldspathic glass-ceramic[21], lithium disilicate ceramics (IPS e.max® CAD, Ivoclar vivadent®, Schaan, Liechtenstein) the strength was significantly increased with a glass-ceramic by precipitating lithium disilicate crystals[15] and zirconia-reinforced lithium silicate glass-ceramics (VITA SUPRINITY® PC, VITA Zahnfabrik, Bad Säckingen, Baden-Württemberg, Germany), Celtra (Celtra Duo, Dentsply Sirona, Bensheim, Hessen, Germany).[19-21] The success of CAD/CAM ceramic veneers depends on many factors such as the case planning, the ceramics selecting, methods of cementation and preparation of teeth.[15] Moreover, the patient's occlusion and function must be taken into consideration when selecting the material.[15-17]

Lithium disilicate glass ceramic is the favorable material for CAD/CAM veneers because of the advantage of their significantly higher strength, which can be more than five times stronger than feldspathic porcelain.[17,19,20] The disadvantage is these veneers milled out of a single block of material, which limits the variation in achievable color. This can be modified by the external stain.[22,23]

Another problem is time consumption. One veneer takes thirty minutes for milling while the heat press technique can be achieved more than 6 veneers within 2 hours. Moreover, the CAD/CAM lithium disilicate discs can be used for multiple veneers to reduce costs and time. The alternative technique uses 3D printing of castable resin following the conventional heat press technique. The result is veneers can be as accurate than conventional heat press technique. In addition, using cut-back then hand layering ceramic over the surface to create better esthetics, especially the opalescence effect at an incisal edge area.(21,23,24)

CAD/CAM procedure for veneers

The digital smile design (DSD) concept aims to help clinicians by improving the esthetic visualization of the patient's concern, giving an understanding of the possible solution therefore educating and motivating them about the benefits of the treatment and increasing the case acceptance.(17,25) DSD is a digital mode software in CAD systems that helps us to create the new smile design by attaining a simulation and pre-visualization of the ultimate result of the proposed treatment. A design created digitally involves the participation of the patients on the designing process of their self-smile design, leading to customization of smile design as per individual needs and desires that complements with the morpho-psychological characteristics of the patient, relating the patient to an emotional level, increasing their confidence in the process and better acceptance of the anticipated treatment.(25,26)

The design is accomplished into a complete digital drawing on DSD software on a computer. This can easily be edited to achieve the final design balancing patients' aesthetic and functional requirements.(25,26) Therefore, the advantages of DSD software include simplifying the smile design, stepping through the gap between conventional and digital workflows especially ensuring that provisional restoration and final restoration serves both the functional and patient esthetic requirement.(27,28) The DSD can representative the predictably result, accordingly, reduce chairside time in dental clinic.(28)

DSD technology is carried out by digital equipment already prevailing in current dental practice like a computer with one of the DSD software, a digital SLR camera or even a smart phone. A digital intraoral scanner for digital impression, a 3D printer and CAD/CAM are additional tools for complete digital 3D workflow. An accurate photographic documentation is essential as complete facial and dental analysis rests on preliminary photographs on which changes and designing is formulated, a video documentation is required for dynamic analysis of teeth, gingiva, lips and face during smiling, laughing and talking in order to integrate facially guided principles to the smile design.(28,29) The intraoral scanners have become significantly better, faster, and smaller, with more intuitive design software surfaces. This virtual workflow with on-screen designing and computer-assisted production of prototyping, such as milling or the 3D printing, allows for the fabrication of various restorations without any conventional models.(20,29)

Case report

A female patient aged 31 years old reported to the dental department of Lamplaimat Hospital with a chief complaint of esthetic concern. She gave a history of spacing between anterior teeth 11/12 from orthodontics. Her major concern was an unesthetic appearance when smiling from the reverse curve of the left and right upper canine and she desired to close the gap between 11/12 teeth in a manner that resulted in a natural look. The patient had a healthy medical history and no drug allergies. Her oral hygiene was at a good level. The treatment began with a clinical examination, and a series of pre-operative intra and extra-oral photographs were taken. These photographs were used to determine and treatment planning about the smile design, gingiva zeniths, occlusal planes, tooth shape and color.

CAD for digital smile design (DSD)

All DSD software allows for aesthetic designing through the drawing of reference lines and shapes on extra- and intraoral digital photographs. Although the inclusions of aesthetic parameters are different in each DSD software, basic procedure of smile designing remains the same as follow.

1. The following photographic views in fixed head position are necessary:

Two frontal views:

• Full face with a full smile and the teeth apart. (Figure 2)

• Frontal view of the full maxillary and mandibular arch with teeth apart. (Figure 3)

2. Facial analysis is developed using the reference lines and parameters for the frontal view of the face. The horizontal reference line is the inter-pupillary that delivers a balance and horizontal overview in the aesthetically pleasing face. The vertical reference line includes the facial midline, passing the glabella, nose, and chin (Figure 4), and the canine line which indicated the total length of upper anterior teeth.

3. The boundary of upper and lower lip at smile position was located (Figure 5).

4. Figure 4 and Figure 5 from above mention were aligned with 2 corresponding points on each photo (Figure 6). The facial photograph with a wide smile and the teeth apart is moved behind superimposition with a retracted view of the full maxillary and mandibular arch to determine the ideal horizontal plane and vertical midline which permits a comparative analysis of the teeth and face.

5. Three vertical lines are marked on the teeth, two vertical lines drawn from the base of the nose to the canine, and one vertical line drawn from the midline to adjacent central incisors. Two horizontal lines represent the boundary of the upper and lower lips (Figure 7). This support reproducing the cross of the reference inter-pupillary, canine line and facial midline on the face onto the intraoral view.

6. The length of the upper lip at the smile is checked to determine the gingival display. A smile curve is established by correlating the curvature of the incisal edges of the maxillary anterior teeth. The longer incisal edge position is shown in Figure 7A. After adjusting the position of the incisal edge to above 1.0-2.0 mm from the lower lip was created smile curve (Figure 7B-C).

7. The ideal size of dental width to length ratio can be incorporated by any one of the published theories which include Golden proportion, Pound's theory, Recurring aesthetic dental proportion, Dentogenic theory, or Visagism. The adjustment is carried out with a digital ruler (Figure 8) which can be calibrated on the photograph by measuring the width of the central incisors in the study model. The tooth design can be modified, decreased, or adapted to different situations, depending on the aesthetic requirement and individual needs of the patient (Figure 9).

8. After the new smile design is attained it can be digitally presented to the patient to evaluate the appreciation and feedback (Figure 10). This digitally approved smile design at this stage can be used to create a physical mockup that can be tested aesthetically in the patient's mouth. The mock-up allows for not only visualization of the shape integrated into the gingiva, lips and face, but also phonetics during the evaluation period. Finally, the patient may evaluate, provide an opinion and approve the final shape of the new smile before any irreversible procedures are performed.

Figure 2: Full face with a full smile and the teeth apart.

Figure 3: Frontal view of the full maxillary and mandibular arch with teeth apart.

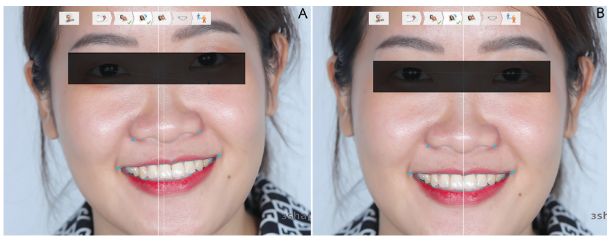

Figure 4: Representative the vertical reference line includes the facial midline, passing the glabella, nose, and chin. (A) Non-adjustment inter-pupillary line. (B) Adjustment inter-pupillary line.

Figure 5: The boundary of upper and lower lip at smile position (blue line).

Figure 6: Two photo were aligned with 2 corresponding points on each photo.

Advantage of DSD(29-31)

1. Digital smile imaging and designing help patients visualize the expected final result before treatment starts, enhancing the treatment's predictability.

2. The dentist can realize patients' concerns by showing digitally the final outcome, motivating and educating them about the benefits of the treatment.

3. Digital imaging improves dentist diagnosis and treatment plan by aesthetic visualization of patient's problem through digital analysis of facial, gingival and dental parameters that will analyze the smile and the face in an objective and standardized manner.

Limitation of DSD(29-31)

1. The treatment plan depends on photographic documentation, inadequacy of them may distort the reference image and may result in an incorrect diagnosis and planning.

2. For complete digital workflow, software with updates, intraoral scanner, 3D printer and CAD/CAM are required which makes it economically expensive.

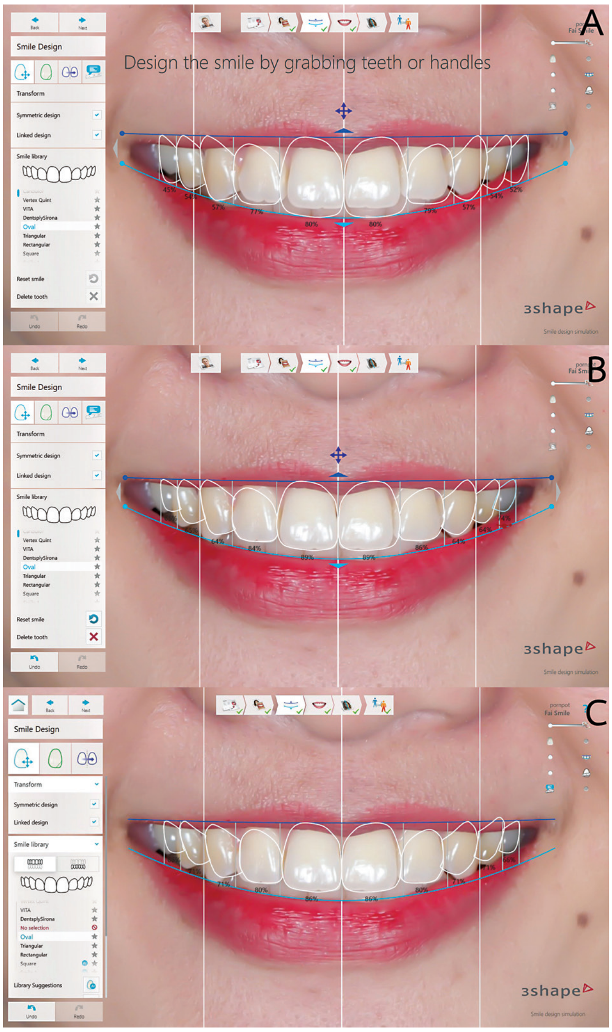

Figure 7: Representative digital smile design: three vertical lines are marked on the teeth, two vertical lines drawn from the base of the nose to the canine and one vertical line drawn from the midline to adjacent central incisors. (A) Before adjustment. (B) Adjustment the position of the incisal edge above 1.0-2.0 mm from the lower lip to create a smile curve. (C) Adjustment the proportion by decreasing in width of the anterior teeth.

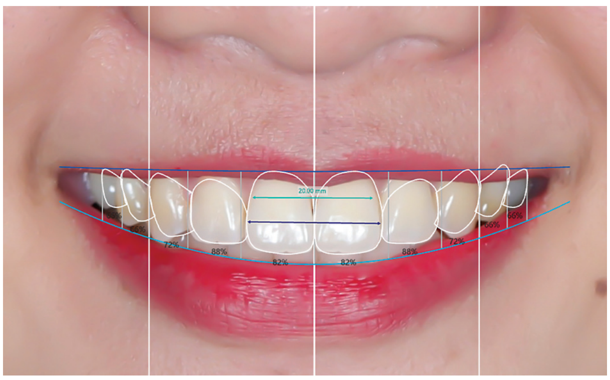

Figure 8: Representative a digital ruler by measuring the width of the central incisors.

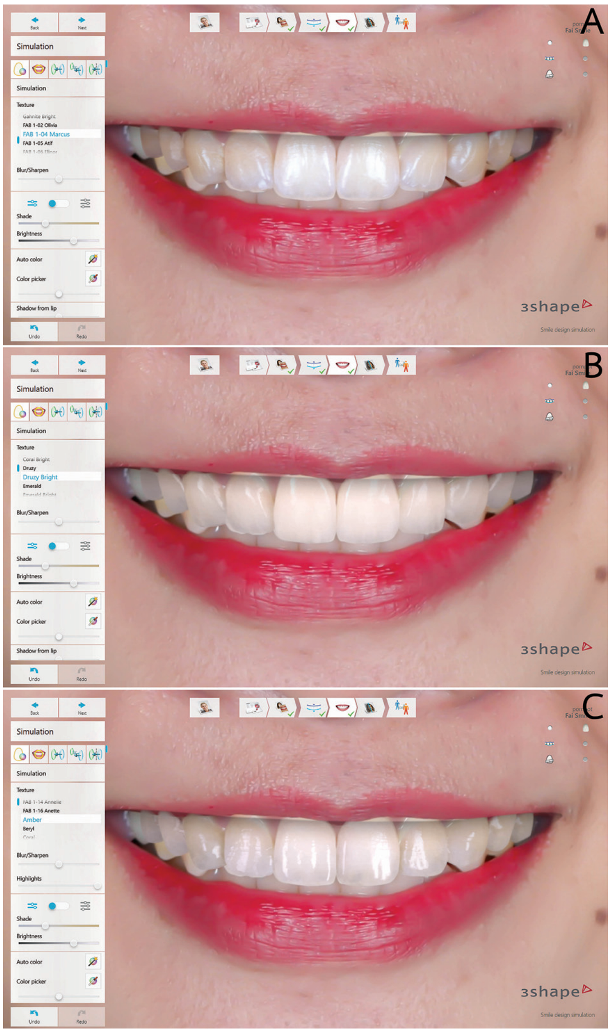

Figure 9: Representative the simulation of different surface texture styles on teeth depending on the aesthetic requirement and individual needs of the patient. (A) Fab 1. (B) Druzy Bright. (C) Amber.

3. Training for understanding software is necessary, which further increases chair time.

CAD procedure for provisional veneers

Digital impression for virtual diagnostic wax-up was performed using an intraoral scanner (Trios4, 3Shape/TRIOS®, Copenhagen, Denmark). In this case, level of the upper canine top cusp, is below the anterior plane. This results in a reverse anterior curve and represents sadness smile (Figure 11). The extraoral image indicated that the upper canine and first premolar submerge into the lower lip (Figure 12). CAD (3Shape Dental System 2020) was used to create a virtual diagnostic wax-up. The DSD image was used to superimposition and created the final virtual diagnostic wax-up (Figure 13-14). After design upper canine cusp tip was repositioned over the anterior plane.

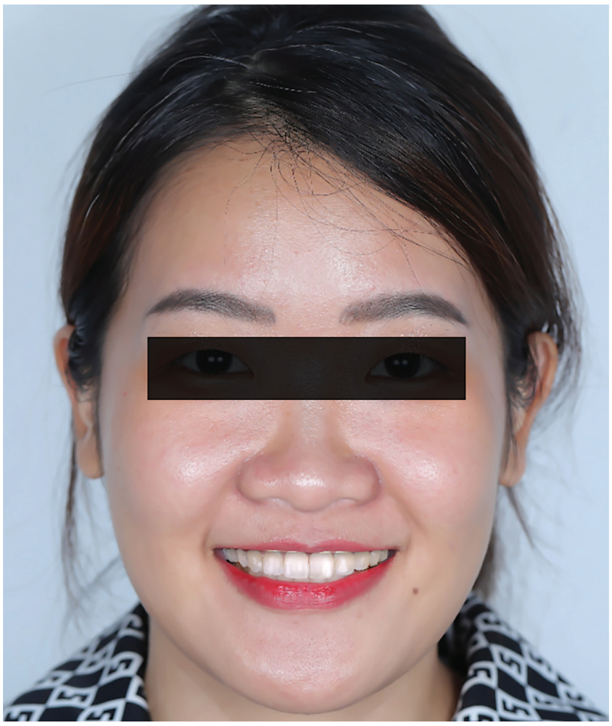

Figure 10: Representative final shape of the new smile design in full face.

The upper maxillary teeth simultaneously elevated with the lower lip when smiling and turned to a smile curve.

A 3D printing machine (Asiga MAX, Asiga, Sydney, New South Wales, Australia) was used for building a virtual diagnostic wax-up digital model (Asiga Denta-MODEL, Asiga, Sydney, New South Wales, Australia) (Figure 15). The clear acrylic sheet (Bioplast®, Scheu Dental GmbH, Iserlohn, Germany) was used to create a provisional veneer template. The hole at the incisal edge was created with cylinder steel bur (Figure 16).

Adaptation of the putty silicone (Amcoflexplus, Amcorp, Hamburg, Germany) over the facial, occlusal, lingual surfaces, and palatal area on a digital model. Three horizontal slices (incisal, middle, cervical) and one vertical releasing incision on only one side. This silicone index was used as a preparation guide (Figure 17). Then, tooth preparation for upper maxillary 8 veneers using 3 designs of veneer preparations. Place the silicone index into the prepared abutment, resting it on the palate and the molars, and use an occlusal mirror to check the preparations. Each horizontal slice incisal, middle and cervical was used verify the amount of preparation on the incisal, middle, and cervical region respectively (Figure 18).

A digital impression for prepared abutment was performed using an intraoral scan (Figure 19). The provisional veneer was created with flowable composite resin (Filtek™ Supreme Flowable restorative, 3M ESPE, St. Paul, MN, USA) using a clear acrylic template (Figure 20) and evaluation as follows: First, level of incisal edge should be below upper lip 1-2 mm at rest position. Second, level of incisal edge should be above lower lip at smile position. Third, plane of anterior teeth should be parallel to inter pupil line. Finally, midline should be straight or parallel to mid face (mid-nose).

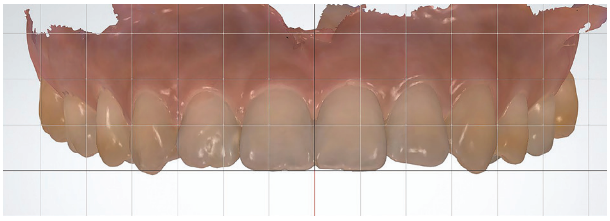

Figure 11: Digital impression showed level of upper canine cusp tip below anterior plane.

Figure 12: Extraoral image indicated that upper canine and first premolar submerge into lower lip.

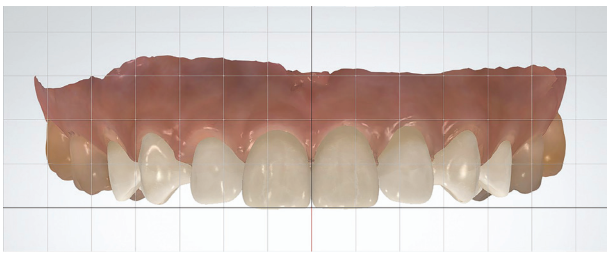

Figure 13: Representative virtual diagnostic wax-up.

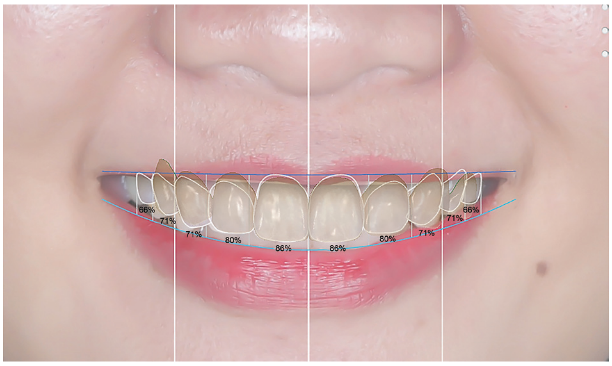

Figure 14: Representative digital smile design image superimposition with final design.

CAD procedure for veneers restorations

A digital impression for provisional veneer was created using intra oral scan. (Figure 21). CAD procedure for veneers was created using 3shape Dental System (3Shape Dental System 2020). Superimposition of the scan of provisional veneer and scan of the prepared abutment was completely created using 3 markers (16, 26, 27 mesio-lingual cusp tip) (Figure 22). All information from a scan of the provisional veneer was used for the design of the final veneer. The position of incisal edge, axis, alignment and contour, was simultaneous with a scan of the provisional veneer. The transparency mode of the final design indicated adequate clearance between preparation abutment and final design. The superimposition between the front view smile image and the final design was used for esthetic assessment (level of incisal edge, anterior plane, midline) (Figure 23). Then, the final design of the final veneer was exported in the STL file.

CAM procedure for veneers restorations

Additive manufacturing is used by the 3D printing machine for building castable resin (Asiga DentaCAST, Asiga, Sydney, New South Wales, Australia) (Figure 24). After building castable resin was cleaned using ultrasonic in isopropyl alcohol (PROPAN-2-OL, RCI Labscan Limited, Bangkok, Thailand). Post polymerization with light-curing machine unit for 3D printing material (Hi-Lite® power 3D, Kulzer GmbH, Berlin, Germany) was created for 20 minutes.

Procedure for fabricate veneers restorations

The castable resin was sprueing on the investment ring (Figure 25). Investment (IPS® PressVEST Premium

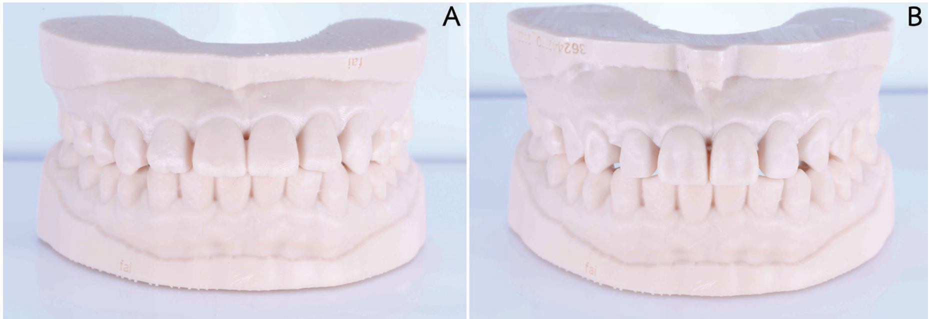

Figure 15: Representative: (A) Study digital model. (B) Virtual diagnostic wax-up digital model.

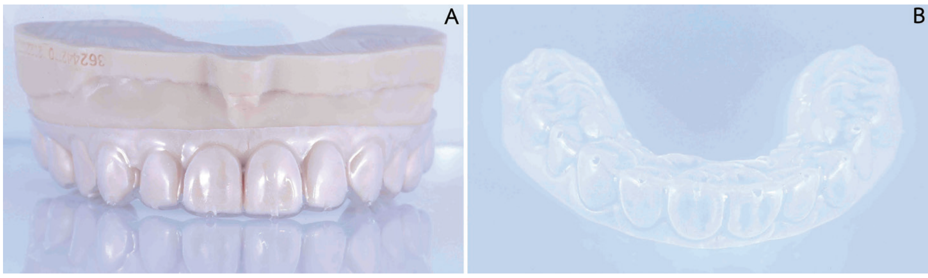

Figure 16: Representative: (A) Provisional veneer template in study digital model. (B) Provisional veneer template with hole for injection of flowable composite resin.

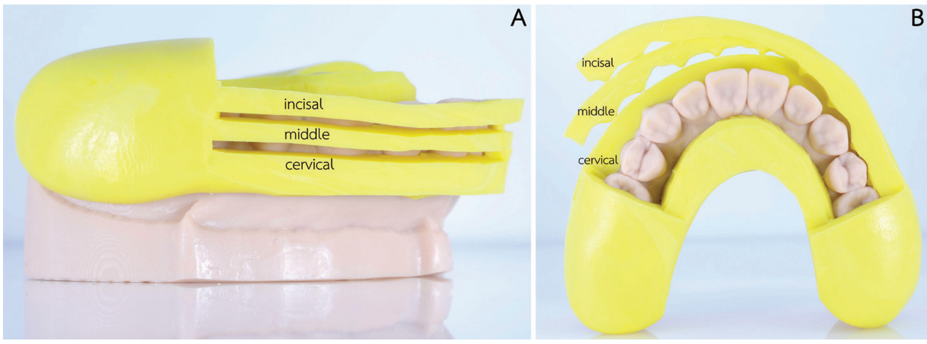

Figure 17: Representative silicone index. (A) Lateral view. (B) Top view

Figure 18: Representative silicone index for verify amount of preparation. (A) Incisal, (B) Middle, (C) Cervical

Figure 19: Digital impression.

Figure 20: Provisional veneer was created with flowable composite resin.

Figure 21: Digital impression for the provisional veneer.

Speed, Ivoclar vivadent®, Schaan, Liechtenstein) is caries out in a silicone ring for 30 minutes. After setting the time of the investment material, the investment ring is prepared for preheating at 850°c for 60 minutes. Then, remove the investment ring from the preheating furnace immediately after completion of the preheating cycle. Place the lithium disilicate ingot (IPS e.max® Press, Ivoclar vivadent®, Schaan, Liechtenstein) and alox plunger into the investment ring. Place the loaded investment ring in the center of the hot press furnace. After the end of the press cycle, divest the investment ring with polishing beads at 4 bars (Figure 26). Finally, clean the veneer with Al_2O_3 at 2 bars following a steam jet. In the cut-back layering technique, layering materials (IPS e.max Ceram, Ivoclar vivadent®, Schaan, Liechtenstein) are applied. The anatomical shape is completed and the individual esthetic appearance is achieved. Place the layered veneer on the firing tray and fire. Finish the veneer with diamonds and heatless stone (Figure 27). The stain firing is conducted with color (IPS Ivocolor Shade Kit®, Ivoclar vivadent®, Schaan, Liechtenstein) and special color (IPS Ivocolor Essence Kit®, Schaan, Liechtenstein), then glaze firing (IPS Ivocolor Glaze Paste, Ivoclar vivadent®, Schaan, Liechtenstein) (Figure 28).

Porcelain veneers have become increasingly popular as a method for restoring diastema, discolored, fractured and worn teeth. For several years, conventional feldspathic ceramics have been considered as one of the materials in providing aesthetic outcomes. Nowadays, lithium disilicate glass ceramics have been commonly recommended for porcelain laminate veneers because of their

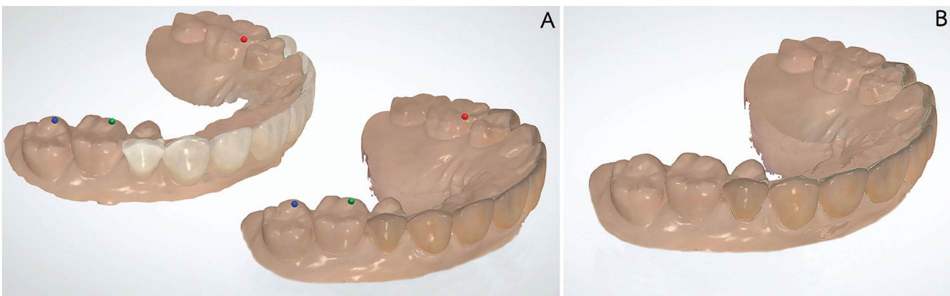

Figure 22: Representative: (A) Superimposition of the scan of provisional veneer and the scan of prepared abutment were completely created using 3 markers (16, 26, 27 mesio-lingual cusp tip). (B) After superimposition.

high flexural strength, excellent esthetics and can be fabricated with either a CAD/CAM or heat pressed technique.(32) Major advantages of the CAD/CAM technology over the conventional technique are faster in design, patient's preferences and the most important thing is excellent marginal and internal fit of fixed restoration.(32,33) Due to the application of homogeneous blocks and heat press of castable resin, fewer material failures are likely to occur during fabrication and clinical application.(24) In comparison with hand-built materials, CAD/CAM blocks and heat press of castable resin reveal a decreased presence of flaws and pores, resulting in increased reliability.(33,34) In addition, DSD helps the dentist create and plan a treatment course by providing a virtual simulation of the result, especially in the predictability of final plan results or the final esthetic result. Besides, it is a tool that facilitates improved communication and discussion between the dental team, dental laboratory technicians, and patients.(26,29,34)

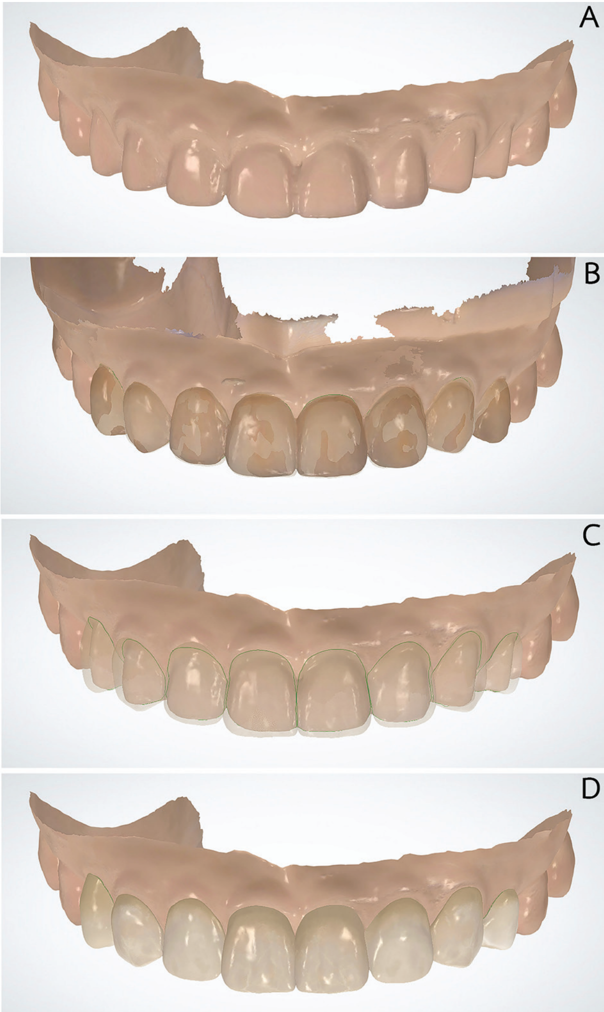

Figure 23: Representative: (A) Digital impression. (B) Superimposition of the scan of provisional veneer and final design. (C) Transparency mode of final design. (D) Final design in surface texture mode.

Conclusions

Digital dentistry is now developing rapidly and many more systems. Consequently, these new technologies should be up to date, adequately understanding and fully educated in order to return the excellent outcome for your patients. DSD utilizes photographic information to create an esthetic treatment plan and then, the castable resin veneer serves as confirmation and demonstration of the final porcelain veneer restorations. The combination of DSD and castable resin veneer for diagnosis and treatment planning has positive results in the esthetic of the anterior teeth. When used in combination, these techniques offer predictable results and highly satisfactory results.

Acknowledgment

Thank you Faculty of Dentistry Naresuan University and NU dental lab for fabricated restoration.

Conflicts of Interest

The authors declare no conflicts of interest.

Figure 24: Castable resin from 3d printing.

Figure 25: Representative: (A) The castable resin sprueing on investment ring. (B) Pouring investment.

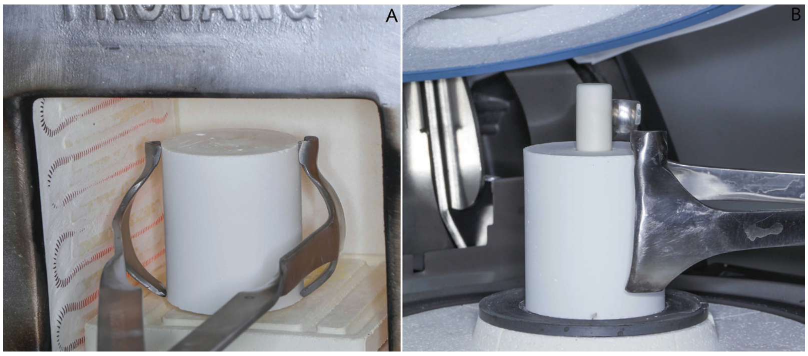

Figure 26: Representative: (A) Preheating investment ring in furnace. (B) Place the loaded investment ring in the press furnace.

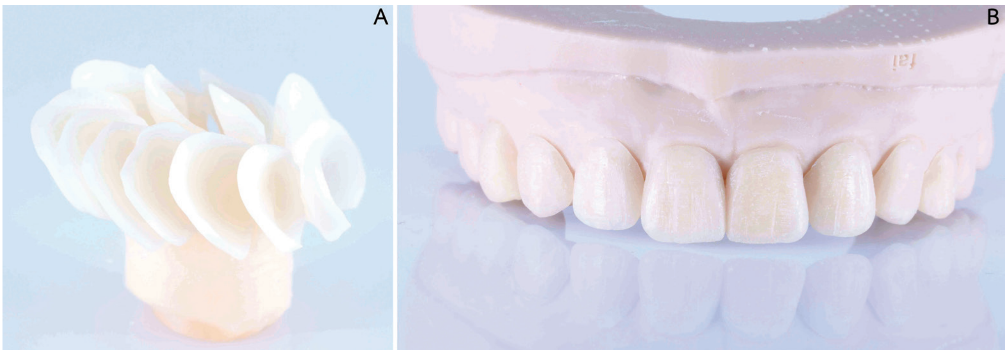

Figure 27: Representative: (A) After sandblast with Al_2O_3 following a steam jet. (B) After anatomical shape.

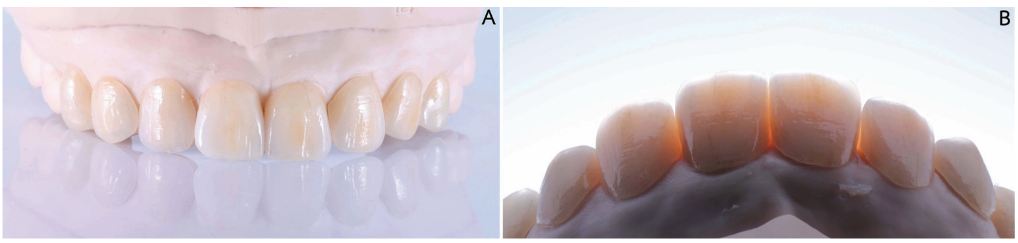

Figure 28: Representative final restorations after staining and glazing.

References

1. Alghazzawi TF. Advancements in CAD/CAM technology: options for practical implementation. J Prosthodont Res. 2016;60(2):72-84.
2. Antov H, Jablonski RY, Keeling A, Nixon P. CAD/CAM techniques for the conservative and efficient management of tooth wear. Br Dent J. 2019;227(9):791-6.
3. Beuer F, Schweiger J, Edelhoff D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. Br Dent J. 2008;204(9):505-11.
4. Zimmermann M, Mehl A, Mörmann W, Reich S. Intraoral scanning systems-a current overview. Int J Comput Dent. 2015;18(2):101-29.
5. Tapiea L, Lebonb N, Mawussic B, Chabouisd HF, Durete F, Attalf J. Understanding dental CAD/CAM for restorations–the digital workflow from a mechanical engineering viewpoint. Int J Comput. 2015;18(1):21-44.
6. Abdel-Azim T, Zandinejad A, Metz M, Morton D. Maxillary and mandibular rehabilitation in the esthetic zone using a digital impression technique and CAD/CAM-fabricated prostheses: a multidisciplinary clinical report. Oper Dent. 2015;40(4):350-6.
7. Jassim ZM, Majeed MA. Comparative evaluation of the fracture strength of monolithic crowns fabricated from different all-ceramic CAD/CAM materials (an *in vitro* study). Biomed Pharmacol J. 2018;11(3):1689-97.
8. Methani MM, Revilla-León M, Zandinejad A. The potential of additive manufacturing technologies and their processing parameters for the fabrication of all-ceramic crowns: a review. J Esthet Restor Dent. 2020;32(2):182-92.
9. Abdulla MA, Ali H, Jamel RS. CAD-CAM technology: a literature review. Al–Rafidain Dent J. 2020;20(1):95-113.
10. Kim JH, Kim KB, Kim WC, Kim JH, Kim HY. Accuracy and precision of polyurethane dental arch models fabricated using a three-dimensional subtractive rapid prototyping method with an intraoral scanning technique. Korean J Orthod. 2014;44(2):69-76.
11. Uçar Y, Aysan-Meriç İ, Ekren O. Layered manufacturing of dental ceramics: fracture mechanics, microstructure, and elemental composition of lithography-sintered ceramic. J Prosthet Dent. 2019;28(1):e310-8.
12. Kallala R, Daly MS, Gassara Y, Dakhli R, Touzi S, Hadyaoui D, *et al*. Rationalizing indication of ceramic veneers: a systematic review. EAS J Dent Oral Med. 2021;3(2):51-8.
13. Alothman Y, Bamasoud MS. The success of dental veneers according to preparation design and material type. Open Access Maced J Med Sci. 2018;6(12):2402-8.
14. Sisler ZS. Preparation guides: 10 steps to maximize success for veneer preparation. J Cos Dent. 2020;35(4):26-33.
15. AlJazairy YH. Survival rates for porcelain laminate veneers: a systematic review. Eur J Dent. 2021;15(2):360-8.
16. Durán OG, Henríquez GI, Guzmán MÁ, Báez RA, Tisi LJP. A step-by-step conservative approach for CAD-CAM laminate veneers. Case Rep Dent. 2017;2017:1-6.
17. Li RWK, Chow TW, Matinlinna JP. Ceramic dental biomaterials and CAD/CAM technology: state of the art. J Prosthodont Res. 2014;58(4):208-16.
18. Marchesi G, Camurri PA, Nicolin V, Turco G, Di LR. Chairside CAD/CAM materials: current trends of clinical uses. Biology (Basel). 2021;10(11):1-11.
19. Su Y, Xin M, Chen X, Xing W. Effect of CAD-CAM ceramic materials on the color match of veneer restorations. J Prosthet Dent. 2021;126(2):255.e1-7.
20. Spitznagel FA, Boldt J, Gierthmuehlen PC. CAD/CAM ceramic restorative materials for natural teeth. J Dent Res. 2018;97(10):1082-91.
21. Höland W, Schweiger M, Watzke R, Peschke A, Kappert H. Ceramics as biomaterials for dental restoration. Expert Rev Med Devices. 2008;5(6):729-45.
22. Bona DA, Nogueira AD, Pecho OE. Optical properties of CAD-CAM ceramic systems. J Dent. 2014;42(9):1202-9.
23. Alghazzawi TF, Lemons J, Liu PR, Essig ME, Janowski GM. Evaluation of the optical properties of CAD-CAM generated yttria-stabilized zirconia and glass-ceramic laminate veneers. J Prosthet Dent. 2012;107(5):300-8.
24. Belli R, Wendler M, Ligny Dd, Cicconi MR, Petschelt A, Peterlik H, *et al*. Chairside CAD/CAM materials: part 1. measurement of elastic constants and microstructural characterization. Dent Mater. 2017; 33(1):84-98.
25. Us Y, Yüzbasioioglu E, Albayrak B, Özdemir G. Digital smile design: predictable results. J Exp Clin Med. 2021;38(3):123-8.
26. Jreige CS, Kimura RN, Segundo ÂR, Coachman C, Sesma N. Esthetic treatment planning with digital animation of the smile dynamics: a technique to create a 4-dimensional virtual patient. J Prosthet Dent. 2022;128(2):130-8.
27. Zarina R, Jaini J, Raj R. Evolution of the software and hardware in CAD/CAM systems used in dentistry. Int J Prev Clin Dent Res. 2017;4(4):284-91.
28. Chochlidakis KM, Papaspyridakos P, Geminiani A, Chen CJ, Feng IJ, Ercoli C. Digital versus conventional impressions for fixed prosthodontics: systematic review and meta-analysis. J Prosthet Dent. 2016;116(2):184-90.
29. Coachman C, Georg R, Bohner L, Rigo LC, Sesma N. Chairside 3D digital design and trial restoration workflow. J Prosthet Dent. 2020;124(5):514-20.
30. Veneziani M. Ceramic laminate veneers: clinical procedures with a multidisciplinary approach. Int J Esthet Dent. 2017;12(4):426-48.
31. Lee S, Kim JE. Evaluating the precision of automatic segmentation of teeth, gingiva and facial landmarks for 2D digital smile design using real-time instance segmentation network. J Clin Med. 2022;11(3):1-12.

32. Yuce M, Ulusoy M, Turk AG. Comparison of marginal and internal adaptation of heat-pressed and CAD/CAM porcelain laminate veneers and a 2-year follow-up. J Prosthet Dent. 2019;28(5):504-10.
33. Gallardo YR, Bohner L, Tortamano P, Pigozzo MN, Lagana DC, Sesma N. Patient outcomes and procedure working time for digital versus conventional impressions: a systematic review. J Prosthet Dent. 2018;119(2):214-9.
34. Zhang Y, Kelly JR. Dental ceramics for restoration and metal veneering. Dent Clin North Am. 2017;61(4):797-819.