Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 68 Issue 02 | 2025
DOI: 10.5281/zenodo.14862723

DIGITAL PRODUCTION OF INDIRECT LAMINATE VENEERS USING MILLING AND 3D PRINTING TECHNIQUES

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Abstract

Indirect dental veneers are a common treatment option which is installed on the outer surface of the front teeth to improve aesthetic appearance. Veneers can be used to treat cracked teeth, discoloration, stains in the teeth, caries between teeth and close gaps between teeth. The purpose of this project is to describe the digital process of designing dental veneers and demonstrate the fabrication methods of indirect laminate veneers. A digital image of the patient's mouth is taken, then transferred to the computer and appropriate veneers are designed using a special program called Exo-CAD software. A milling and 3D printed machines were used to fabricate the designed veneers. Glass ceramic and nanocomposite materials were used to obtain the resulted veneers. A comparison between the two digital fabrication methods was made on the veneers in terms of fabrication time and material consumption. In addition to taking the notes for the technical processing of the manufacturing methods, physical appearance and retention on the models and the patient of the two veneer groups were evaluated. Digital approach has made the availability of making dental veneers possible with different materials and methods. Physical appearance with a precise adaptation on the teeth seems to be promising when the veneers are made using digital techniques. Despite the long processing production of Lithium desilicated milled veneers, but it seems that they exhibit better aesthetic outcomes.

Keywords: Laminate Veneers, Glass Ceramic, Nanocomposite Resin, Milling, 3D Printing.

INTRODUCTION

Veneer restorations (VR) have gained a reputation as one of the most successful treatment modalities in the modern dentistry [1]. Indications for dental veneers include: 1) teeth whitening due to various factors, such as fluorosis, tetracycline, age, amelogenesis imperfecta, and others 2) restoration of broken and worn teeth 3) abnormal tooth morphology 4) correction of mild displaced teeth 5) intraoral repair of broken crowns and bridge veneers [2,3,4]. Composite direct veneers are one of the least invasive treatment options available to rejuvenate and restore a patient's smile; they can bond to the tooth

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structure and aesthetically reproduce the optical characteristics of natural teeth. However, microleakage, marginal discoloration, wear and marginal fractures are all common problems with composite restorations, and this circumstance leads to a progressive deterioration of the aesthetic result [5]. Porcelain restorations, especially porcelain laminate veneer (PLV), are popular among dentists and patients for their ability to replicate the realistic look and shine of natural teeth.

Ceramic materials has been introduced in the dental field through press technology [6,7. Pressable ceramics are produced by burning wax models using the conventional lost wax technique and melting and pressing the ceramic ingots under controlled pressure, temperature, and vacuum using a computer-programmed press. These furnaces are equipped with a pneumatic press that activates an aluminum piston that is used to compress the molten ceramic ingots. Pressed ceramic allows accurate reproduction of the anatomical features sculpted on the wax model and controlled processing of the ceramic material, resulting in a precise restoration with minimal internal structural defects. Today, computer-aided design and computer-aided milling (CAD/CAM) technology requires nothing more than a few keyboard clicks to design and manufacture accurate restorations [8,9]. Up to the authors knowledge's, there are no clarification in the literature evaluating the fabrication techniques when veneers are produced by milling or 3D printed methods.

Accordingly, this paper discusses the aspects of how to design dental veneer with Exo-CAD software and then demonstrating the fabrication methods of the veneers when milling and 3D printing techniques are used.

MATERIALS AND METHODS

A twenty four years old male volunteered to participate in this study to do the veneers on his upper six anterior teeth. Digital approach was used in the study to acquire data from the patient’s mouth, designing the prosthesis and finally producing the restorations. The steps will be described in great details in the following points:

1-Digital intraoral scanner (DIOS)

Medit i500 scanner (Medit, Korea) was used to take a digital impression from the patient’s mouth. The procedure was preferred over the conventional impression to avoid inaccurate impression or changes in the dimensions (Figure 1). After scanning, standard triangle tanguage (STL) files were sent to the laboratory via an email. Upper and lower STL files have been downloaded and opened on the computer that is allocated to do the lab work (Figure 2).

2-Designning laminate veneer

The digital upper and lower jaws are imported to the Exo-CAD software for designing the laminate veneers for upper anterior teeth. Figure 3 demonstrates the icon of the front page of the software, where the information of the patient and the type of the restoration we need to design were registered.

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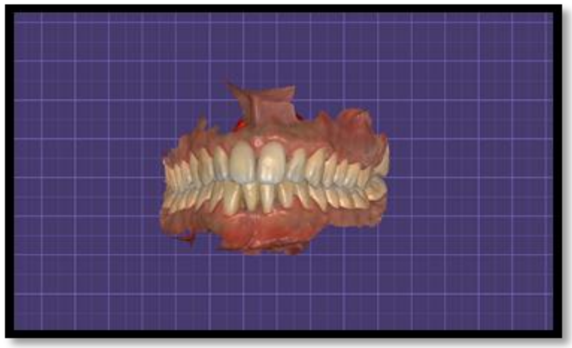

Figure 2: digital scan of patient's mouth

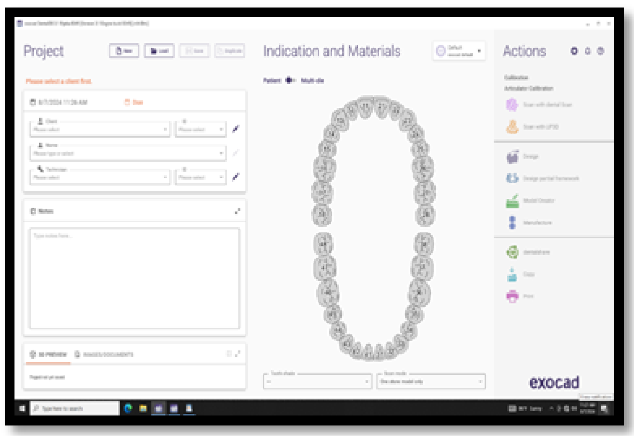

Figure 3: Exo CAD Software

After data registration, the designing steps in the software can be described as follows:

A-Finishing line detection for the veneers (marking finish line): Figure 4 illustrates the drawing of the upper right central incisor out line for the veneer. The software offers manual and automatic drawing for the expected finish line of the restoration. This procedure is applied for all upper anterior teeth.

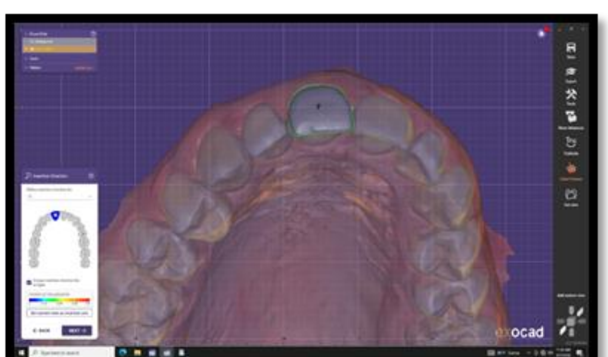

Figure 4: Marking the finish line for veneer design

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B-Designing the appropriate anatomy of laminate veneer. The software has many libraries for the teeth and we can choose the appropriate anatomy design for each case (Figure 5)

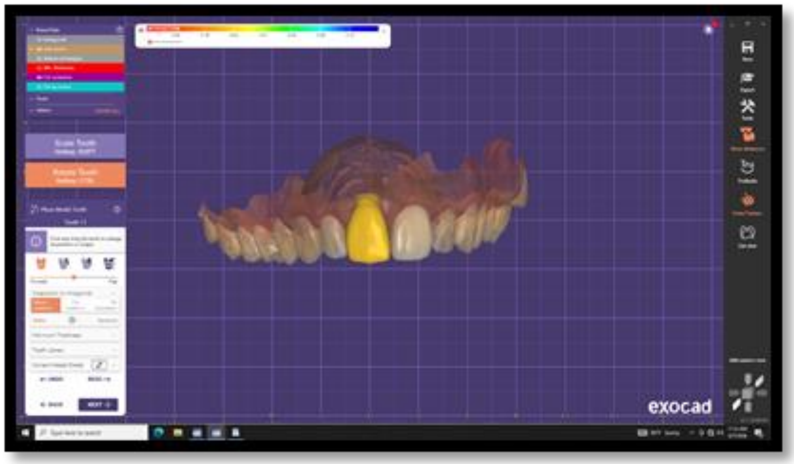

Figure 5: designing the anatomy of veneer

C-Finalising the design

In this step the technician designed all the teeth required for the veneers. The veneers are ready to be exported for the CAM. (Figure 6)

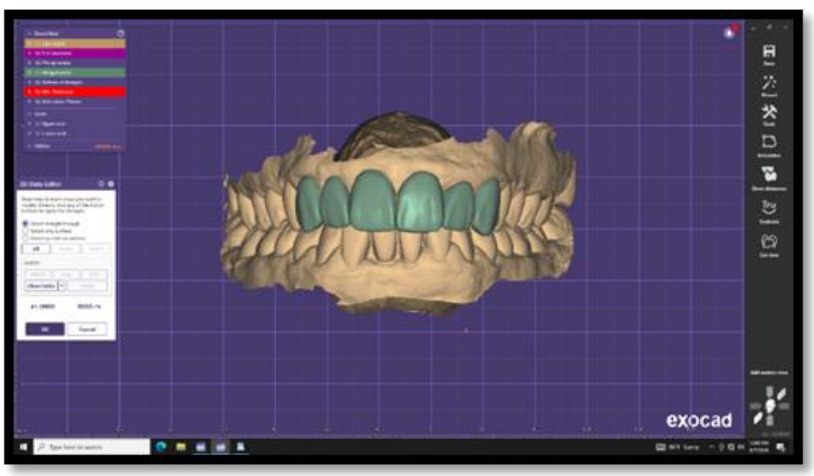

Figure 6: finishing the design on the software

3-fabrication methods of laminate veneers

Two digital methods were chosen to fabricate indirect laminate veneer and the steps of the procedure as following:

A-Milling method: in this option, the material that used in this step is Glass Ceramic bleach color (Upcera, China). (Figure 7)

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Figure 7: Glass Ceramic ingot

Aidite milling machine (AMW-400S, China) was used to mill the glass ceramic ingot as shown in (figure 8. A). Inside the milling machine there is a holder where the ingots are attached for the milling procedure (Figure 8B).

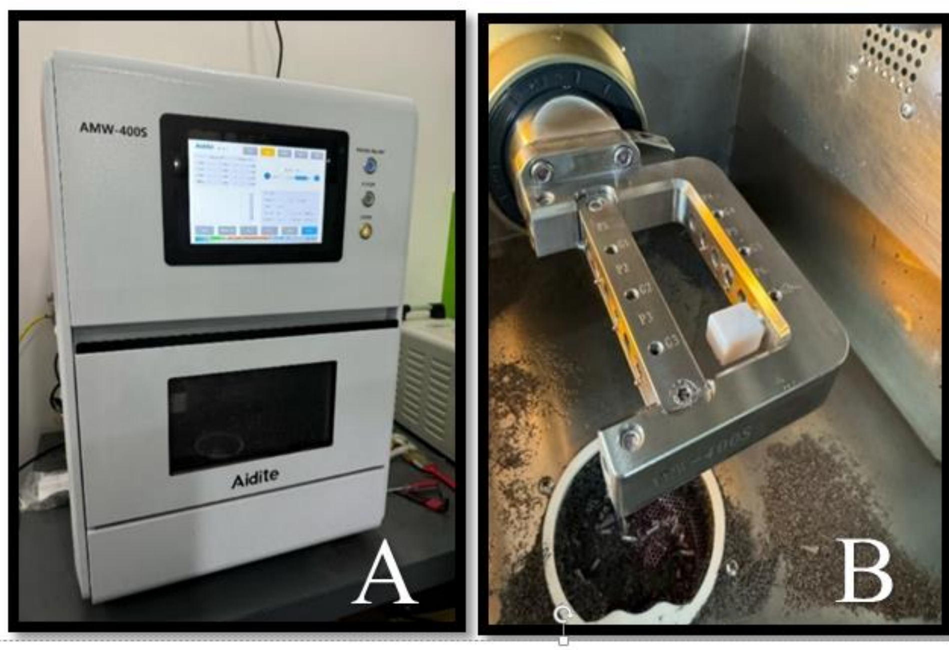

Figure 8: A: Aidite milling machine B: glass ceramic ingot mounted in the holder

Figure 9 describes the glass ceramic veneer after milling were the process of milling took approximately 20 minutes to obtain the result that has shown in the picture.

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Figure 9: Glass ceramic veneer after milling

B-3D printed method: in this option XFAB 3500 DP 3D printer (Italy) was allocated to print out the laminate veneers (Figure 10). Regarding the material that used in this method for printing is Nano-composite resin which filled in a special container as illustrated in Figure No 11. The 3D printed veneers took 45 minutes to be built up and stayed attached to the platform as indicated in figure 12.

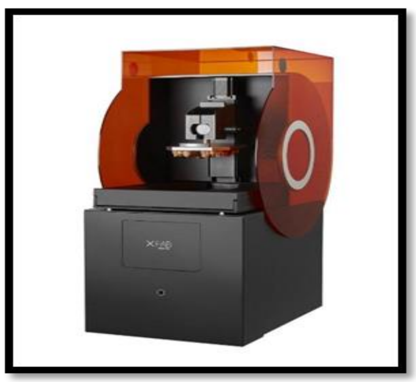

Figure 10: 3D Printer XFAB 3500

Figure 11: Nano Composite Resin

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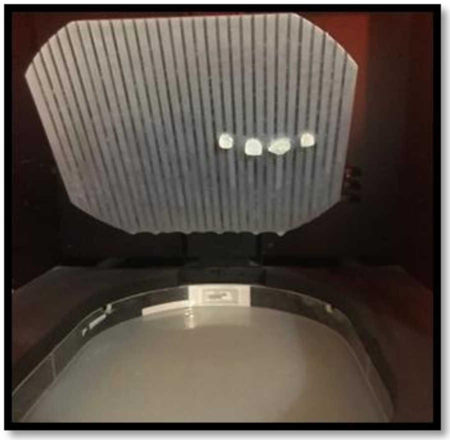

Figure 12: 3D printed veneers after printing

There are two different processes for glazing the veneers and each material needs its own process. In the milling laminate veneer the application was to apply the glaze and then put it in the furnace at temperature of 800 °C for 15 minutes (Figure 13 A&B). On the other hand the glazing of the veneer of the 3d printed will be glazed and put in the light cure device for 2 minutes for each veneer (Figure 14 A&B)..

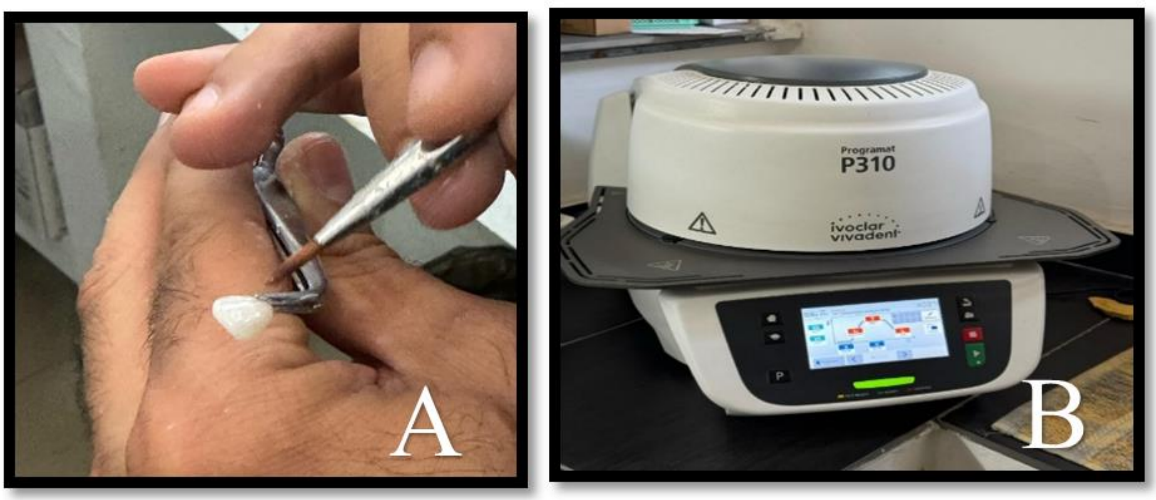

Figure 13: A: applying a layer of glaze. B: milled veneers in the furnace for glaze firing

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Figure 14: A: Glazing 3D printed veneer (B): putting the glazed veneer in the light cure device

RESULTS

Glazing is the final step applied for all veneers that have been fabricated by the milled and 3D printed methods. Figure 15 shows the ready milled glass ceramic veneers fitted on a 3D mode, whereas figure 16 demonstrates the final result of 3D printed nanocomposite resin veneers.

Figure 15: the result of milled veneers on model

Figure 16: the result of 3D printed veneers on model

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The volunteer has an A 2 Vita shade color (Figure 17) and when the fabricated veneers are tried in the mouth of the volunteer, the result of both types of veneers are presented in figures 18 and 19. A comparison between the two fabrication methods was made in terms of fabrication time and material consumption. In addition to taking the notes for the technical processing of the manufacturing methods, physical appearance and retention on the models and the patient of the two veneer groups were observed.

Figure 17: color shade of the patient’s natural teeth

Figure 18: milled veneers after being adapted to the patient’s teeth

Figure 19: 3D printed veneers after being adapted to the patient’s teeth

DISCUSSION

Composite laminate veneers are one of the least intrusive treatment options available for rejuvenating and restoring a patient’s smile; they can be glued to the tooth structure and replicate the optical features of natural teeth esthetically However, marginal discoloration, microleakage, wear, and marginal fractures are all prevalent problems with composite restorations, and this circumstance results in a gradual deterioration of the esthetic result[10] Many factors affect the choice of method such as product quality, materials used, cost and speed of completion. That is why this research has been conducted to dive in the laboratory methods of fabricating dental veneers using the digital approach. In today’s

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dentistry, a patient's esthetic look is essential [11] The adoption of conservative restoration solutions to restore the esthetic look of the dentition has increased as adhesive techniques have improved [12]Following recent advancements in adhesive and restorative dentistry, direct resin veneers have become one of the most prevalent treatment alternatives for clinical applications[13] These restorations are directly put with an adhesive agent and a composite resin material on minimally prepared or even unprepared tooth surfaces in a single dental clinic visit[14]. Direct laminate veneers have the advantage of allowing the operator to control and evaluate the restorative process from shade selection to final morphology [15].

After the research we conducted, we did not find any previous research talking about how indirect veneers have been fabricated using CAD-CAM technology. Through our experience in the laboratory, which we concluded, we noticed some points when the digital fabrication of in direct veneer via milling machine and 3D printer are used. Same procedures are followed in terms of designing dental veneers with the help of Exo-CAD software. So, no special design is required for manufacturing dental veneers by deferent technology methods. The lithium disilicate material is solid (ingot) and needs to be milled with the help of CNC machine. While, 3D printed veneers are obtained via a three-dimensional printer. The material is a nano-composite material which is in a liquid status. In terms of preparation time, it has been noticed that the 3D printing machine is faster and needs less time to fabricate veneers if compared to milling technique. It took about 20 minutes to fabricate one milled veneer, whereas approximately 45 minutes to print out six 3D printed veneers. It also takes less time in the glazing process (120 seconds) using light cure, it hardens with light compared to the milling method, which takes 15 minutes a temperature of 800C in the glazing process in the Evo-Clar Evo dent oven by heat.

Nano composite in indirect composites have gained great popularity in dental restoration due to their multiple applications in dental restoration and cosmetic enhancements. These materials have undergone significant developments, which have improved their physical and aesthetic properties. Thus, indirect veneers are widely used to repair damaged or decayed teeth and improve the overall appearance of the teeth. They have many properties - improved aesthetic appearance - durability - better marginal adaptation - time efficiency.

Lithium disilicate in indirect Lithium disilicate ($Li_2Si_2O_5$) is a chemical compound that is a glass ceramic [16]. It has many properties: Aesthetics is the most important properties that give lithium disilicate an advantage over traditional materials such as metal and porcelain. Although metal is the gentlest material on the opposing tooth and arguably the most durable, all-metal crowns have declined in popularity in recent decades as demand for natural-looking restorations has grown. While metal-ceramic crowns have helped address this problem, the fabrication of these and other multilayered crowns such as porcelain is a much longer process than that of pressable lithium disilicate natural crowns. [17] Digital fabrication of in-direct veneers is a method that provides veneers with better

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results if compared to direct dental composite veneers. More options are available now to fabricate dental veneers when digital approach is chosen.

CONCLUSION

In this research, the methods of designing and manufacturing indirect laminate veneers using CAD-CAM technology have been explained. The following conclusions can be drawn:

- Digital approach has made the availability of making dental veneers possible with using different materials and methods.
- Physical appearance with a precise adaptation on the teeth seems to be promising when the veneers are made using digital techniques.
- Lithium disilicate appear to have better aesthetics over nanocomposite 3D printed veneers

Acknowledgments

The authors thank Dr. Yousef O Zendah for providing the assistance to conduct the lab work at Zendah Lab, Tripoli- Libya.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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