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Conventional compared to CAD/CAM ceramic inlay

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ABSTRACT

Objectives. This study aimed at comparing the methodologies for achieving an occlusal-mesial ceramic inlay using both the conventional and digital methods in terms of workflow protocol, aesthetic and functional results, working time, but also costs and equipment needed.
Material and methods. A 22-year-old patient presented with a direct mesio-occlusal composite restoration with a secondary marginal decay in tooth 3.6 that was subsequently restored by a ceramic inlay manufactured using both traditional and digital methods.
Outcomes. The dental technician's talent, experience, and vision guided the technical process of creating the conventional inlay. The technical process of producing the digital inlay involved fewer laboratory stages, but also contamination risks than conventional ones, removing potential human errors associated with each stage and allowing possible changes to be made more quickly and efficiently. The conventional method took more time to complete all of the laboratory steps than the digital method.
Conclusions. When compared to the digital method, the traditional method allowed the dental technician to achieve a high level of individualization of the prosthetic restoration. Digital techniques are a method of the future that is rapidly growing and improving. Digital techniques for obtaining an inlay involved high-performance equipment, which is pricey to purchase and maintain.

Keywords: ceramic inlay, conventional technique, digital workflow

INTRODUCTION

The need for all-ceramic restorations has risen steadily, owing to the patient's desire for optimal aesthetics, advancements in the materials' mechanical and aesthetic characteristics, and the expectation for minimally invasive tooth preparation [1].

Due to the emergence of adhesive techniques and restorative materials that have properties similar to natural teeth, in prosthodontics less invasive treatment alternatives have become available [2]. Inlays and onlays can be used safely in terms of fracture resistance because both have values that exceed the physiologic requirements [3].

The medium-term performance of lithium disilicate ceramic (pressed or milled) restorations (inlays or onlays, veneers, single crowns, or fixed partial dentures) is suitable with ceramic fracture being the most common cause of failure [4]. Inlays manufactured using the conventional impression technique showed marginal discrepancy when compared to inlays designed using an intraoral scanner, followed by subtractive milling [5].

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For several intraoral scanning systems, accuracy values for both preparation margin and preparation surface of single-unit preparations were comparable to conventional impressions [6]. Pressed inlays manufactured from the conventional impression and milled wax patterns were more accurate in terms of fit than milled inlays produced from the conventional impression and subtractive manufacturing [7].

As a long-term luting material for leucite-reinforced glass-ceramic and lithium disilicate inlays, self-adhesive resin-cement may be used [8] .

This study aimed at comparing the methodology of achieving an occlusal-mesial inlay ceramic restoration using both the conventional method and the digital method in terms of protocol, aesthetic and functional results, work time, but also equipment needed and its costs.

MATERIAL AND METHODS

A 22-year-old patient presented with a direct mesio-occlusal composite resin restoration with a secondary decay in tooth 3.6 (Figure 1). The aim was at restoring the tooth using an indirect mesio-occlusal ceramic inlay restoration. The tooth color was determined together with the dental technician using the Vita Classic shade key (*Ivoclar Vivadent*). The dental technician developed a color map (A2 based) to accurately reproduce the color characteristics of the adjacent teeth.

FIGURE 1. Initial situation: composite resin restoration with a secondary marginal decay in tooth 3.6.

After medical history, general and intraoral clinical examination and a set of standardized photographs, the inlay was performed using both methods: the conventional and the digital one.

The first step was to remove the filling and to prepare the cavity for the indirect restoration. The principles for the adhesive inlay implied divergent axial walls, rounded angles, cusps widths of at least 1.5 mm and occlusal width of 2 mm.

CONVENTIONAL WORKFLOW

For the classical technique, the impression of the working lower arch was made with a polyether in double consistency in sandwich technique (Impregum Monophase, Impregum Soft Light Body, *3M*) (Figure 2.a) and of the antagonistic maxillary arch was made with irreversible hydrocolloid (Cavex Cream Alginate, *Cavex*) (Figure 2.b).

a b

FIGURE 2. Conventional impressions of a. working arch; b. antagonist arch.

No occlusal registration was needed due to the stability of the occlusion before and after the tooth preparation. Photos of the contact points marked with 200 microns articulating paper (Bausch Arti-Check, *Bausch*) were taken in order to be send to dental laboratory. The impressions were disinfected using 1% Sodium hypochlorite. A facial bow registration (Artex, *Amann Girrbach*) and a computerised axiography were taken (Cadiax Compact 2, *Gamma Dental*).

In the lab, the impressions were poured using a class IV extra hard plaster (*Garreco Dental*) and the Artex facebow was used for mounting the models in a mounting semi-adjustable Artex articulator (Figure 3), and the intermaxillary relations were checked by using the same articulating paper and compare the results with the intraoral photos. The working model was prepared with mobile dies. The articulator condylar parameters (sagittal inclination and Bennett Angle) were set on the semi-adjustable working Artex articulator according to the axiography results (Figure 4).

In the conventional technique the following steps were performed in order to produce the inlay: delimitation of the margins with a pencil on the mobile die, wax-up using the wax additive technique in order to achieve proximal and occlusal adaptation using wax and modeling tools (*Bredent*) (Figure 5.a, b).

After checking the wax prototype, the pressing of a lithium-dilsilicate ingot LT A2 (eMax press LT A2, *Ivoclar Vivadent)* took place: preheating, mould, liq-

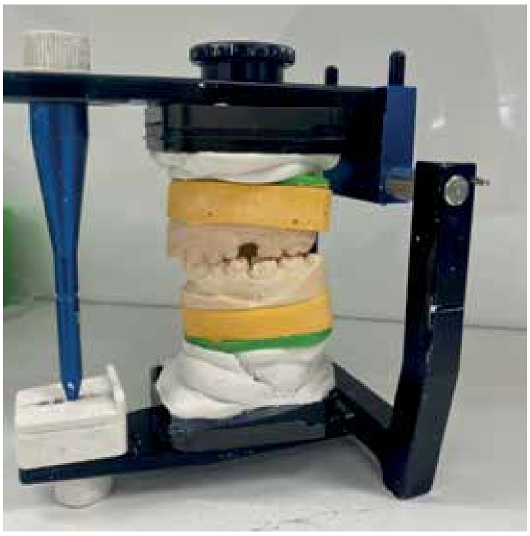


FIGURE 3. Mounted casts in the Artex articulator used for mounting

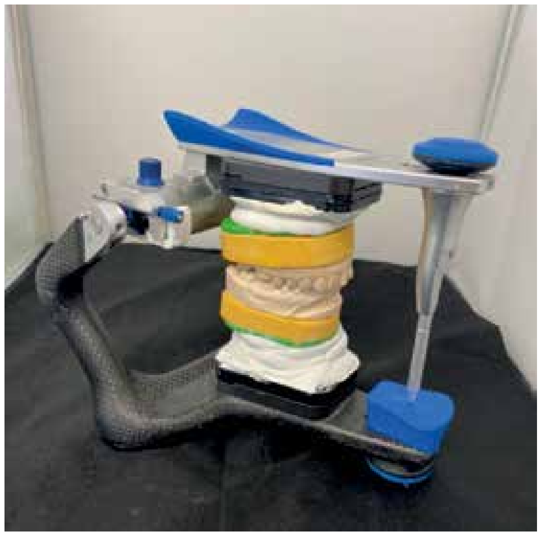


FIGURE 4. Mounted casts in the Artex articulator used for performing the wax-up.

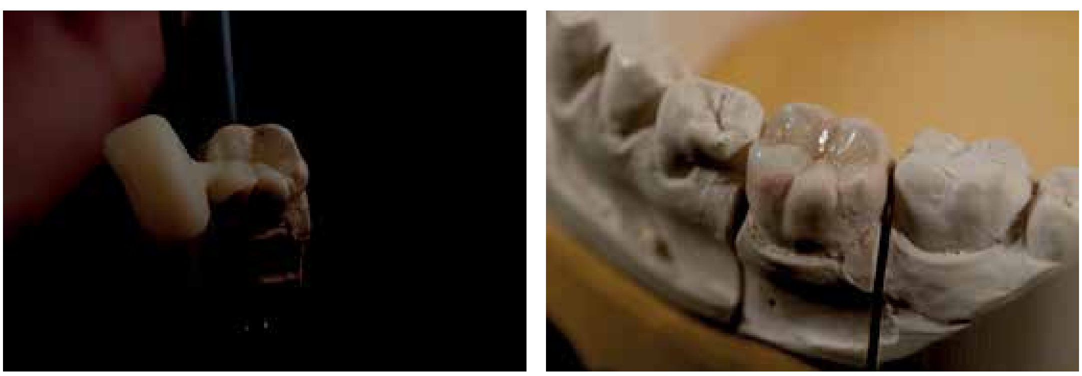
a b

FIGURE 5. The wax design of inlay: a. morfology, b. occlusal check

uifying and pressing the ceramic ingot. Pressing was done at approximately 700°C for 19 minutes. After the ceramic had been pressed and the pattern had cooled, the inlay was unpacked using a sandblaster and alumina at a pressure of 2 atmospheres (*Renfert*). Mechanical polishing was performed using diamond burs, discs, and polypants (*NTI*) (Figure 6.a). After the final control, paint and glaze were applied (IPS Ivocolor Glazing Paste, *Ivoclar Vivadent*) (Figure 6.b).

DIGITAL WORKFLOW

For the digital technique, an intra-oral scanner was used to create the digital impression (Trios 3, *3Shape*). The scans implied the lower and upper



a b

FIGURE 6. Final aspect using conventional technique: a. marginal fit on mobile die; b. final restoration after glazing

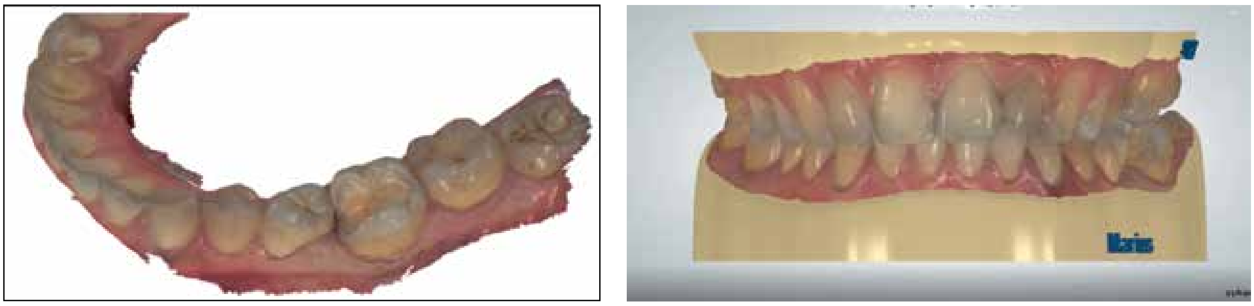


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FIGURE 7. a. Digital impression of the working arch; b. Occlusion scan

arch and the occlusion scan (Figure 7. a.b). The digital occlusion contact points were compared with the intraoral contact points determined with the articulating paper (Bausch Arti-Check@200µ, *Bausch*) and they were set on the computer at the same width. The .STL file was exported via email to the technical laboratory.

The software used was 3Shape Dental System (3Shape) and the steps were the following: importing the scans, mounting the models in the virtual articulator, setting an arbitrary occlusal plane, setting the condylar parameters of the virtual articulator according to the axiography performed previously (Figure 8).

Afterwards, the steps were as follows in the CAD stage: segmentation of model, delimitation of the margins, choosing the axis of insertion and the tooth shape from the library, marginal and occlusal fit (Figure 9.a.b, Figure 10).

In the CAM stage the virtual inlay was placed in the virtual ingot and then the milling was performed. A crystallized lithium disilicate ceramic block (A2 LT 14, *GC Europe A.G.)* was milled using a 5-axis milling unit (*Imes-Icore CORiTEC 150i).* Meanwhile a model was made using a 3D printer (Asiga MAX 4K, *Asiga*). In the end the inlay was cut from the ingot and fitted on the printed models (Figure 11.a). Afterwards, stain and glaze were applied (IPS Ivocolor Glazing Paste, *Ivoclar Vivadent*) (Figure 11.b).

The laboratory stages were completed and the results were compared in the dental laboratory (Figure 12,13), the inlays were both clinically tried-in.

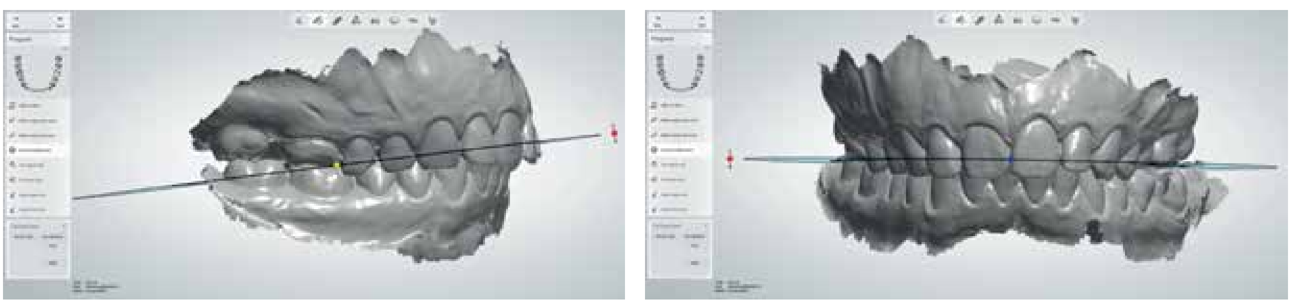

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FIGURE 8. Arbitrary occlusal alignment in the digital workflow using the computer-aided design (CAD).

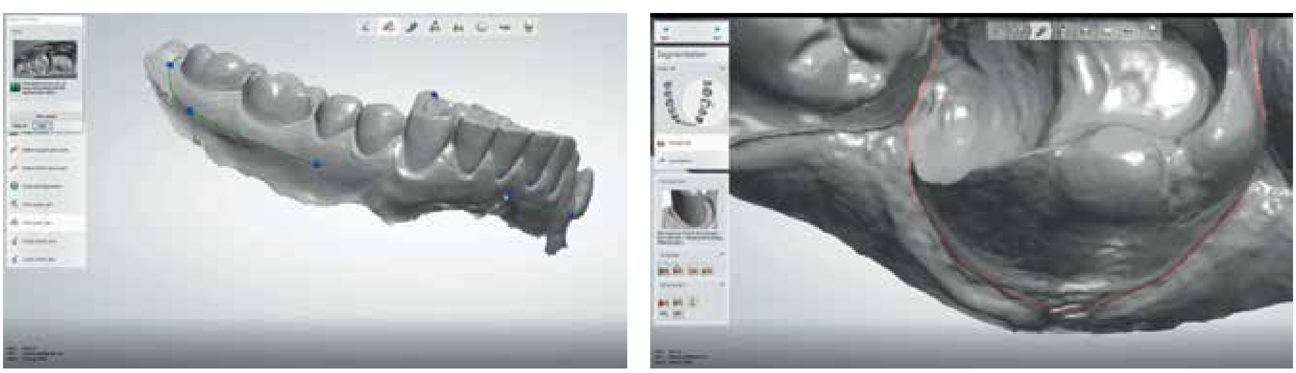

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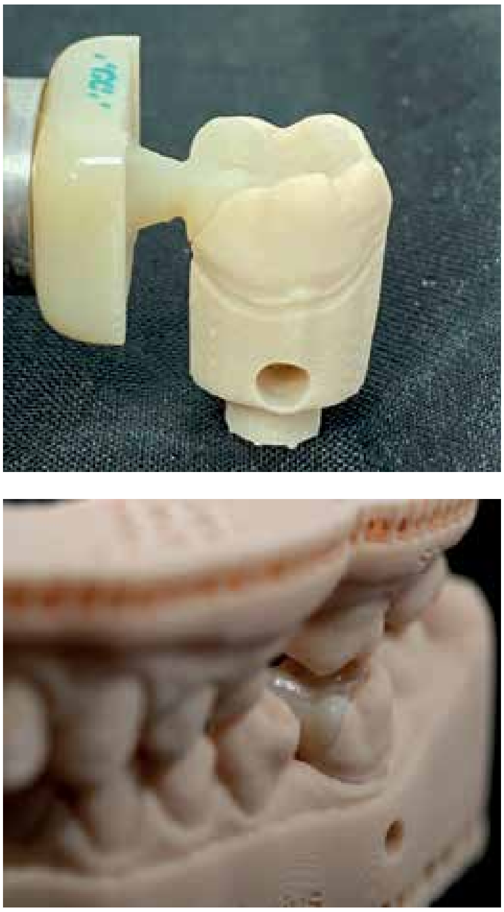
FIGURE 9. a. Segmentation of the working model; b. Delimitation of margins.

FIGURE 10. Final design



a

b

FIGURE 11. Digital workflow: a. fitting of restoration on printed model; b. glazed restoration

a

b

FIGURE 13. Final aspect. a. conventional technique, b. digital technique

For the intraoral try-in, the following factors were considered: complete inlay insertion, cervical, proximal and occlusal marginal fit, and final aesthetics (Figure 14.a.b).

The cementation of the conventional inlay was performed in the same session using a dual resin (RelyX A2 Dental Cement, *3M*). A dental dam placed on teeth 3.5-3.6 provided complete isolation. The tooth surface was treated with a 6th generation adhesive system (Single Bond, *3M*) and the inlay's internal surface was treated with 5% hydrofluoric

a b

FIGURE 12. Fitting on the abutment: a. conventional technique, b. digital technique


a b

FIGURE 14. The try-in procedure: a. digital technique, b. conventional technique

FIGURE 15. The final aspect of conventional inlay after cementation

acid (Ips Ceramic Etching Gel, 3M) and silane (Silano Silane Coupling Agent, *Angelus* (Figure 15).

OUTCOMES

The analysis of the conventional technique showed that aesthetics has been improved (micro- and macrotexture, shape and color). The time spent for the clinical stage (except for the documentation and clinical preparation, which were the same for both techniques) took around 30 minutes for the impressions, additionally the time needed for the impressions to be sent to the lab (which varies according to the laboratory location). Two hours were spent in the dental laboratory casting and mounting the models in the semi-adjustable articulator (including the setting times of the plaster). The following steps took place: investing (30 minutes), preheating (45 minutes), pressing the ceramics (30 minutes), cooling and disinvesting (30 minutes), mechanical processing and finishing (30 minutes), painting and glazing (30 minutes), reaching a total time spent in the lab of 3 hours and a half. The technical process of creating a traditional inlay was guided by the dental technician's talent, experience, and vision.

An analysis of the digital technology for creating an inlay showed that the aesthetics have been improved. The type of scanning may have an effect on the marginal fit which, from a periodontal perspective, have a major effect on gingival health [9]. The morphology was correct and corresponded to the natural one. The functional criteria were strictly followed.

The time required for intraoral scanning and sending the STL files via internet took 30 minutes, so there was no additional time for disinfection and transportation of the impressions. Creating the design in 3Shape took an hour, milling the ingot took about 20 minutes, print the digital model and post-process took around one hour and a half and paining and glazing took 30 minutes. Time spent in total took two hours due to the fact that milling and printing were done simultaneously.

Technical difficulties were encountered in selecting the dental library that was used for the digital inlay, and in obtaining the natural shape and morphology of the restoration. The technical process of creating a digital inlay involved fewer laboratory stages and less time, consequently eliminating potential human errors associated with each stage and allowing possible changes to be made more quickly and efficiently.

The significant change in fixed prosthodontics from conventional to less invasive strategies was considerable and has been highlighted in this study. In static and dynamic occlusion analysis, the semi-adjustable articulator outperformed the virtual articulator caused by the lack of virtual facial bow [10]. Researchers compared the clinical performance and marginal adaptation of inlay restorations made of a new lithium disilicate strengthened material to conventional lithium-disilicate glass-ceramic and new-generation polymer-based CAD/CAM resin composite materials and have demonstrated that lithium disilicate-strengthened ceramics is a reliable material for posterior inlay restorations [11].

Occlusion was correct in both restorations which is critical to consider because certain subjects have occlusal dysfunctions without exhibiting dysfunctional symptoms [12].

Inlays produced from conventional wax and resin patterns have higher marginal disparities than inlays produced from digital and full digital patterns [13]. There were no significant differences in the distribution of contact points between analog and digital technology [14]. The marginal and internal fit accuracy of lithium disilicate glass-ceramic inlays obtained from digital scans and subtractive milling of wax patterns was superior to that of traditional impression/fabrication or additive 3D manufacturing [15].

For individual restorations, CAD/CAM solutions provide a simplified processing technique that results in an accurate, precise, and cost-effective workflow [16], which was also emphasized in our study.

Due to their reduced failure rate, indirect restorations have become an interesting solution in rehabilitation including both class I and class II lesions [17]. Glass-ceramic and feldspathic porcelain success rates of inlays, onlays, and overlays were reported as being over 90% in 10 years, with fracture being the most common failure rate [18]. We implemented all protocol guidelines in our study, so the survival rate expectancy of the ceramic inlay is high, independent of the working procedure, conventional or digital.

Comparing the results in terms of insertion, occlusal and marginal fit and color, conventional and digital inlays were similar. For digital inlay, the small marginal discrepancy in the centro-vestibular cusp was caused by milling machine burr and it had been observed first on the printed model. The burr was changed and another ingot was milled in 30 minutes perfectly adapted on printed model. Because conventional inlay had no marginal discrepancies from the beginning, it was chosen for final cementation.

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CONCLUSIONS

Digital techniques are used more often in a daily practice that are constantly evolving and improving.

The conventional method allows the dental technician to achieve better morphology in terms of macro- and micro-texture and better individualization of the restoration. The analog process involves more clinical and technical steps which implies more time needed and implies potential human errors with minimum possibilities of correction at some stages.

Even if dental equipment for conventional process implies more machines, they are less expensive than the tools needed for digital process.

Comparing the conventional and digital workflow in order to obtain ceramic restorations in terms of time consuming, clinical and laboratory steps with the potential errors involved and ease in manufacturing, the digital workflow is less time consuming and involves less clinical and technical procedures with less possible human errors.

Additionally, if errors occur at any stage, the corrections can be made easily. The possible contamination is eliminated for the digital method, meanwhile, for the conventional method there still exists the possibility of contamination during impression taking and pouring the dental models.

Digital workflow is less dependent to the craftsmanship of a skilled dental technician and also the variety of industrial shaded ingots is higher. However, it is recommended to take into consideration the financial costs and multiple dedicated software needed for the digital workflow.

The necessity of a constant update and the learning curve when choosing a digital approach are mandatory.

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