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Double Monolithic Protocol: The Solution to Fluorescence Limitations

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ABSTRACT

Objective: The present paper aims to demonstrate the incorporation of the double monolithic protocol (DMP) into a chairside digital workflow to reproduce the fluorescence properties of natural teeth with chairside monolithic restorations when exposed to different light sources.

Clinical Considerations: A female patient reporting dissatisfaction with her upper anterior teeth was rehabilitated using seven veneers and a three-element bridge. The DMP was applied to the bridge, which consisted of a primary lithium disilicate framework to which leucite-reinforced glass ceramic veneers were cemented. The fluorescence of the different substrates and ceramic restorations was evaluated throughout the rehabilitation process, under 365 and 405 nm light.

Conclusions: The DMP allows chairside procedures to be optimized by achieving predictable, mechanically resistant, and esthetic restorations.

Clinical Significance: The DMP is a new chairside solution for developing ceramic restorations with optimal esthetics and combined mechanical properties, eliminating the need for sintering or glazing procedures.

1 | Introduction

The incorporation of novel chairside workflows using digital technology and innovative materials enables more efficient treatments to be carried out in a reduced amount of time. In particular, the integration of intraoral scanners, CAD/CAM software, and milling machines in dental practice led to the development of digital design techniques and immediate fabrication of dental restorations [1, 2].

Chairside restorations are usually monolithic, meaning that they are made from a single material, which should provide adequate mechanical and esthetic properties in order to achieve optimum results. Although zirconia is the most commonly used material, other options have recently been integrated into this working approach. Zirconia is an oxide ceramic with excellent mechanical properties, being therefore indicated for bridges and load-bearing areas [3]. However, as the restoration should attempt to imitate natural structures for proper integration, biomimetic characteristics should also be considered and zirconia's lack of translucency restricts its use in esthetically demanding clinical cases [3]. Furthermore, this type of ceramic tends to transition from white to gray, in low-light environments [4]. On the other hand, leucite-reinforced, feldspathic, and lithium disilicate glass ceramics present higher translucency and are optically similar to the natural tooth, despite their reduced fracture resistance [3, 5].

The same factors that affect natural teeth should be considered in esthetic restorations, such as descriptive surface elements (surface texture, gloss, and luster), objective color elements (hue, chroma, and value), and subjective optical elements (translucency, opalescence, and fluorescence) [6]. Fluorescence plays a crucial role in achieving natural looking dental restorations [7], being defined as the emission of light by a substance that has previously absorbed light of higher energy. This optical property can be measured with spectrophotometers and fluorescence microscopy, and recently, the use of filters in photography has been introduced [8].

In natural teeth, fluorescence primarily arises from the presence of organic components within tissues. As the amount of organic substances is superior in the dentinal substrate in comparison to enamel, the former is three times more fluorescent [8, 9]. This enhanced fluorescence is particularly notable in dentinal tubules and at the dentino-enamel junction [9]. Consequently, this optical property can act as an indicator of tissue's organic content, allowing the differentiation among dental tissues [9]. Additionally, fluorescence proves valuable in the identification of dental caries, calculus, and different restorative materials [8].

Restorative materials are also capable of emitting fluorescence in the visible light spectrum, which contributes to their esthetic properties [8]. In some materials, fluorescence is achieved by incorporating rare earth oxides, such as europium, cerium, and terbium [10], enabling the restorations to behave properly under different light sources such as daylight, ultraviolet (UV), or even black light [11]. The main factors influencing fluorescence are the type of material, tooth structure, and type of cement [7, 12]. Therefore, in an esthetic restoration, materials must be correctly selected according to the presented clinical scenario and expected outcome.

It should be taken into account that CAD/CAM materials can be either milled in a finished or precrystallized phase, with the latter still requiring a sintering process [3]. Finished materials have the advantage of shorter working time and lower deformation. Additionally, some countries present restrictive legislation that does not allow clinicians to have sintering furnaces. Therefore, the chosen materials must be fully crystallized, only requiring polishing and surface texturing.

In an attempt to overcome the limitations of both glass and oxide ceramics, a novel protocol was implemented resorting to different monolithic materials with different optical properties, to achieve homogeneity in teeth rehabilitation. Thus, the aim of the present paper is to demonstrate the incorporation of the double monolithic protocol (DMP) into a chairside digital workflow to reproduce the fluorescence properties of natural teeth with chairside monolithic restorations, when exposed to different light sources.

2 | Case Description

A female patient sought clinical care reporting discontentment regarding the shape and color of her upper anterior teeth and the desire to replace the missing upper right canine. Upon comprehensive clinical examination, several treatment plans were presented to the patient for the rehabilitation of the anterior sector. The approved treatment plan comprised seven ceramic veneers and a three-unit bridge. A written informed consent was obtained from the patient prior to the initiation of treatment.

Considering that the restorative material selected for the three-unit bridge needed to provide both adequate mechanical properties and satisfactory esthetic results, the novel DMP was applied. This protocol involves cementing two monolithic chairside restorations, each possessing different esthetic and mechanical properties, using an ultra-fluorescent resin cement to achieve ideal optical results and adequate mechanical characteristics.

To select the materials for the rehabilitation, the fluorescence of different monolithic restorations was previously evaluated. Veneers milled from a leucite-reinforced glass ceramic block (IPS Empress CAD, Ivoclar Vivadent, Liechtenstein), 0.6 mm thick, were assessed in association with two different substructures made from the same leucite-reinforced glass ceramic and lithium disilicate glass ceramic (Initial LiSi, GC, Leuven, Belgium) blocks. The selected materials do not require sintering to acquire adequate physical and mechanical properties, nor do they require glazing procedures for surface finish. The different materials, manufacturers, and compositions are depicted in Table 1.

The fluorescence of each material was measured under natural light, with a 365 nm light source provided by the customized flash fluor_eyes (Emulation, Frankfurt, Germany) and a 405 nm light source emitted by the Zeiss Extaro 300 in fluorescence mode (Zeiss, Jena, Germany). The camera settings were as follows: manual mode with an aperture of f22, a shutter speed of

TABLE 1 | Type, manufacturer, and composition of the employed materials.

Material	Type[a]	Manufacturer	Composition[b]
IPS Empress CAD	Leucite-reinforced glass ceramic	Ivoclar Vivadent, Liechtenstein	1–5 nm leucite crystals embedded in glass matrix: crystal phase (35–45 vol%)
Initial LISI	Lithium disilicate glass ceramic	GC, Leuven, Belgium	Fully crystallized lithium disilicate blocks with high density micronization

[a]Classification by Blatz and Conejo [2].
[b]Data provided by the manufacturer.

1/125 s, and an ISO sensitivity of 200–400 [13]. The fluorescence of the uncemented monolithic restorations under different types of light is displayed in Figure 1.

Subsequently, the leucite veneers were luted to the CAD/CAM blocks with a super-fluorescent resin cement (G-CEM Veneer, GC, Leuven, Belgium). Depending on the material, the restorations were cemented according to the manufacturer's instructions. After the luting procedure, the fluorescence was again measured in the same conditions (Figure 2).

The similar esthetic results obtained between the leucite restoration and the combination of leucite and lithium disilicate led to the decision to use this double monolithic approach to the three-element bridge. Additionally, leucite was selected as the material of choice for the veneers cemented to natural teeth.

Regarding the preparation process, teeth from the right central incisor to the left second premolar, as well as the right second premolar, were prepared for veneers. Furthermore, the upper right lateral incisor and first premolar were prepared as abutment teeth for the three-element bridge. Preparations are displayed in Figure 3.

After impression taking, leucite-reinforced veneers and a primary lithium disilicate framework were milled (Figure 4a). The primary structure was then cemented to three leucite veneers resorting to the previously tested super-fluorescent resin cement (Figure 4b).

The restorations were adhesively cemented according to the manufacturer's instructions using the same resin cement. The fluorescence of the preparations and the different cemented restorations is presented in Figure 5. Additionally, the final result under natural light is exhibited in Figure 6.

3 | Discussion

Chairside workflows have simplified the effective restoration of teeth and implants with monolithic restorations. This case report, preceded by a laboratory proof of concept, demonstrated

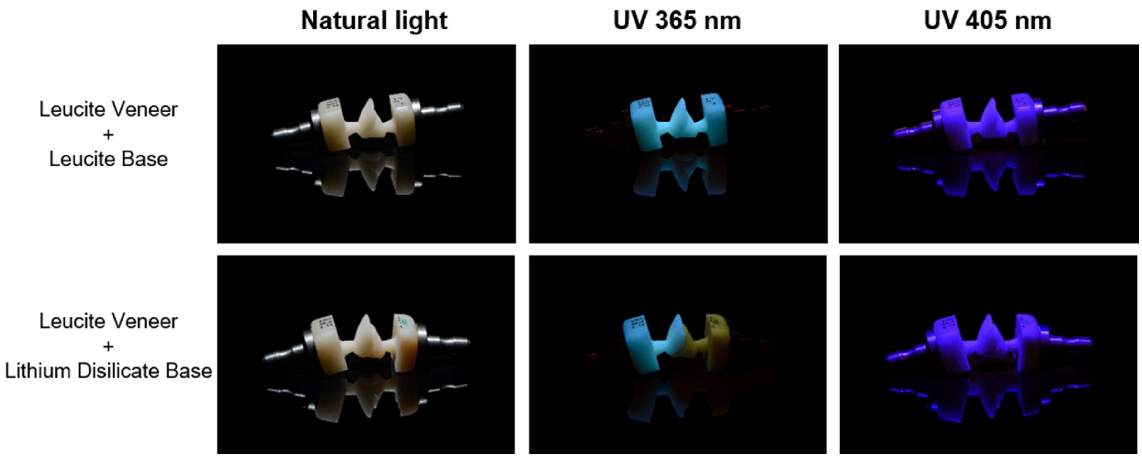

FIGURE 1 | Fluorescence of the two combinations of veneer and block, under natural light, 365 and 405 nm ultraviolet (UV) light.

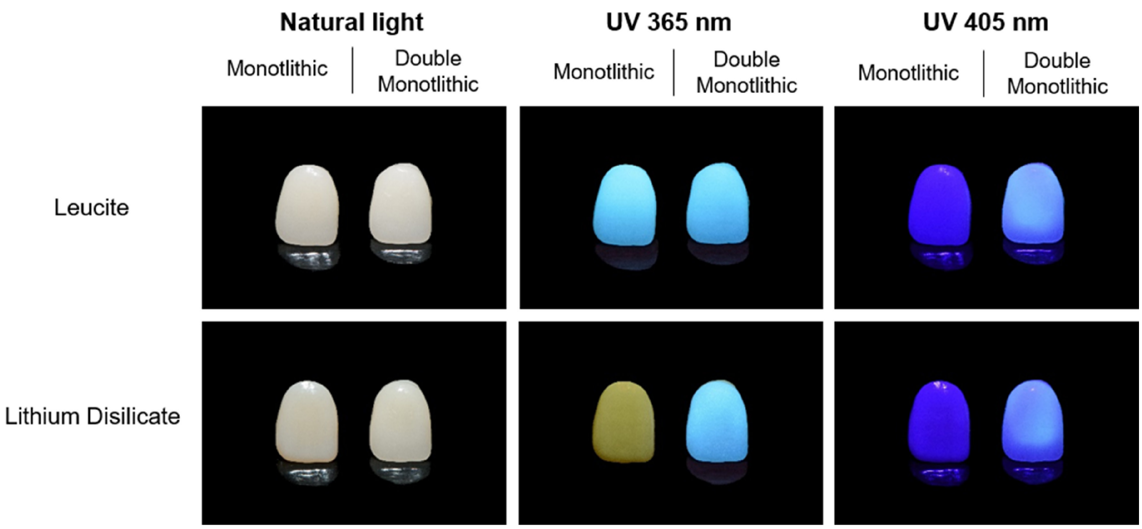

FIGURE 2 | Fluorescence of the monolithic restoration (left) and the respective double monolithic (right), obtained by luting a leucite-reinforced glass ceramic veneer to the different substrates using a super-fluorescent resin cement, under natural light, 365 and 405 nm UV light.

FIGURE 3 | Teeth preparation (cross-polarized photography).

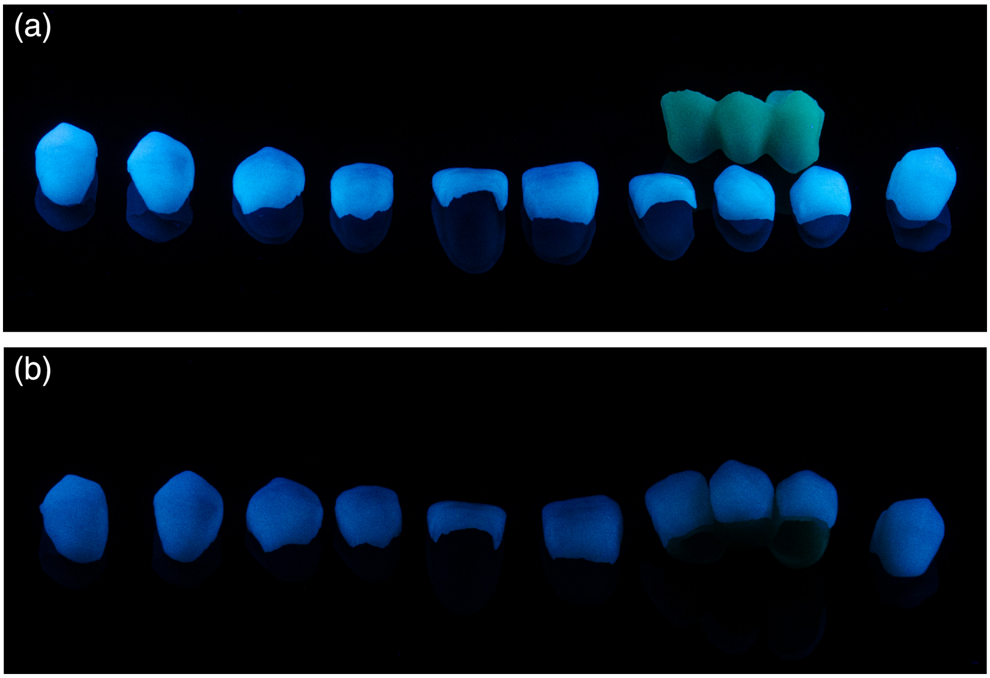

FIGURE 4 | Fluorescence of the ceramic restorations captured using the fluorescence macro flash fluor_eyes (365 nm). (a) Leucite-reinforced glass ceramic veneers and the primary structure of lithium disilicate glass ceramic. (b) Bridge with cemented veneers.

the clinical application of the DMP, highlighting the optimal fluorescence achieved under both 365 and 405 nm light, as well as the potential replicability of this protocol.

Fluorescence involves the emission of light at various wavelengths, with values exceeding 400 nm allowing a clear distinction between natural teeth and ceramics [8]. It is noteworthy that the most materials have incorporated additives for 365 nm wavelengths but not for longer wavelengths. Therefore, the response to 405 nm wavelength light, within the visible spectrum, must be taken into account to ensure a satisfactory esthetic restorative result.

Monolithic restorations exhibit different optical behavior depending on the material used [3]. Leucite-reinforced glass ceramic restorations are the most esthetic, and consequently, the preferred option for anterior sector rehabilitation [3]. Due to their high translucency and fluorescence similar to that of enamel, the final optical outcome is largely dependent on the substrate to which they are luted. Nevertheless, this material is characterized by an intrinsic low fracture resistance, which can only be compensated for by employing adhesive cementation techniques to a substrate [3]. In the absence of an adequate substrate, such as in the case of a pontic, the intrinsic low mechanical properties of this ceramic may predispose it to restorative failure due to fracture.

On the other hand, lithium disilicate has a flexural strength of approximately 400 MPa, which is twice as high as that documented for leucite-reinforced ceramics [14]. Zirconia possesses even superior mechanical properties, despite the fact that this type of ceramic lacks fluorescence [15]. Although this disadvantage can be overcome by using additives, the process requires sintering in a furnace, which is not easily incorporated into chairside workflows [16].

The DMP was developed to achieve optimal fluorescence results while avoiding the need for sintering or glazing steps, making it a valuable protocol for chairside workflows. This approach allows for the use of highly esthetic restorations with adequate mechanical characteristics in high-load-bearing areas by adhesively luting two different types of ceramics.

According to some authors [7], the fluorescence of ceramic restorations is influenced by the type of ceramic and resin cement employed. Throughout this clinical case, the same luting agent was used, a light-cure resin cement [17] indicated for adhesive luting of ceramic and composite veneers, inlays, and onlays with a thickness less than 2 mm and sufficient translucency to allow a proper light-curing process.

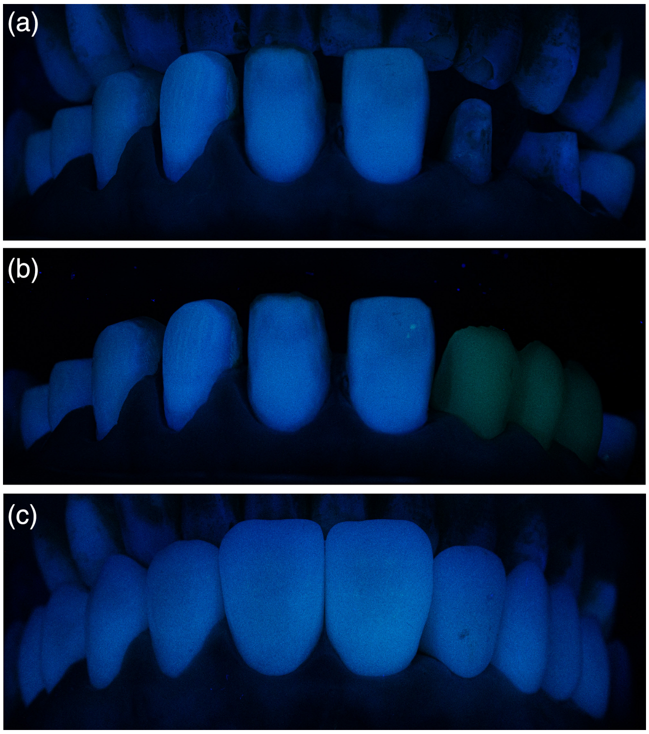

FIGURE 5 | Fluorescence of the restorations and the different substrates (365 nm). (a) Original substrate. (b) Lithium disilicate bridge primary substrate. (c) Final restorations.

Regarding the type of ceramic, the material selection process demonstrated that there is no differences in fluorescence between the restorations under natural light. On the other hand, under 365 nm UV light, the lithium disilicate monolithic restoration exhibited poor fluorescence compared with the others, which showed no observable differences among themselves. Under 405 nm, the DMP produced the most satisfactory results. Therefore, a similar optical result can be achieved regardless of the substrate, with the differences found between materials being overcome through the application of this novel protocol.

Accordingly, a similar fluorescence esthetic result was obtained for the restorations of the present clinical case, regardless of whether veneers were cemented on natural teeth (ideal substrate) or on the primary structure of lithium disilicate glass ceramic (the least favorable substrate).

The presented case report evidenced the incorporation of the DMP into a chairside digital workflow, allowing clinicians to mill different restorations and closely match the optical properties of natural teeth, regardless of the available substrate. The need to cement leucite-reinforced glass ceramic veneers to different ceramic substrates, including lithium disilicate or zirconia, can be identified as a limitation, since achieving satisfactory bond strength values remains a challenge. Further in vitro and in vivo studies are needed to demonstrate additional results on this protocol.

4 | Conclusion

This clinical case demonstrated the successful incorporation of a new chairside digital workflow into restorative dentistry. Considering the limitations of the presented case, following can be concluded:

- The DMP achieved predictable restorations with optimal esthetics and combined mechanical properties, without the need for sintering and glazing procedures.
- A consistent optical result can be achieved with leucite-reinforced ceramic, irrespective of the substrate, under 365 and 405 nm wavelengths.

FIGURE 6 | Final result of cemented veneers and bridge, under natural light.

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Disclosure

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The authors have nothing to report.

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