QUALITY IMPROVEMENT IN DENTAL AND MEDICAL KNOWLEDGE, RESEARCH, SKILLS AND ETHICS FACING GLOBAL CHALLENGES

Edited by
Armelia Sari Widyarman, Muhammad Ihsan Rizal,
Moehammad Orliando Roeslan & Carolina Damayanti Marpaung

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Monolithic zirconia endocrown: Indirect restoration for endodontically treated teeth

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Department of Conservative Dentistry, Faculty of Dentistry, Trisakti University, Jakarta, Indonesia

ABSTRACT: Endodontically treated tooth requires precise restoration that can prevent fracture and allow them to function again. Monolithic zirconia crown is made from zirconia without veneering using CAD/CAM technology which has a strength similar to dentin. A 26-year-old patient had a complaint of a spontaneous throbbing in the right lower tooth. Tooth #47 was diagnosed with irreversible pulpitis. Root canal treatment was done by *ProTaper Gold* rotary instrument using 5,25% NaOCl and 17% EDTA as an irrigant. $Ca(OH)_2$ was placed as an intracanal medicament for 7 days. Obturation was done using *ProTaper Gold* gutta percha point. The final restoration of choice for tooth #47 is an endocrown made of monolithic zirconia as a direct restoration that can be used as an option for a single crown with intraradicular retention in post-endodontic molars. Cementation of the monolithic endocrown was performed on the next visit using resin cement. Monolithic zirconia can be an option for posterior indirect restoration after endodontic treatment.

1 INTRODUCTION

Post-endodontic teeth need coronal restorations to protect the teeth from fracture and treatment failure (Acar & Kalyoncuoğlu 2021). The teeth will experience a large loss of tissue structure, a decrease in dentin elasticity, and the influence of irrigation solution and chelating agents that can dissolve the inorganic components of the dentin structure, thereby reducing the microhardness of teeth (Bainy et al. 2021).

Restoration options of post-endodontic teeth depend on the remaining structure of healthy tissue, location of the teeth, aesthetics, endodontic/periodontal prognosis, functional activity in the occlusal region of the teeth, age of the teeth, and financial aspects of the patient (Rocca *et al.* 2013). Large decay caused by caries or fractures needs to be restored with a full-coverage crown and additional support with a cast metal core has been recommended. However, there are limitations in using intraradicular posts, such as narrow canals, instrument fractures, or calcified root canals. Over-preparation can occur after using intraradicular posts, so dentists choose other options, such as the use of endocrowns (Dogui et al. 2018).

Indications for endocrown are small intermaxillary spaces that are impossible to restore using posts and crowns, extensive loss of tooth structure, and variations in root anatomy. The advantages of endocrowns over conventional crowns include a simple operation, superior mechanical performance, lower costs due to shorter treatment times and fewer steps, and excellent aesthetics (Irmaleny et al. 2019). Endocrown restorations use all depths, extensions, and slopes of the pulp chamber walls to increase the stability and to improve macromechanical retention, without removing the filling material from within the root canal and adhesive cementation can improve microretention (Dogui et al. 2018; Rocca *et al.* 2013).

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A computer-aided design/computer-aided manufacturing (CAD/CAM) technology is used to create endocrown. Monolithic zirconia ceramics, lithium disilicate reinforced ceramics, and leucite-reinforced ceramics are the materials available for endocrine (Tzimas et al. 2016).

2 CASE REPORT

A 26-year-old male patient came to the clinic complaining of a throbbing pain in his left lower posterior tooth for the past 1 month, and he often finds food got stuck in his tooth. The tooth had never been treated and the patient wanted the tooth to be preserved. Clinical examination showed blackish-brown caries on the occlusal portion of the right lower posterior tooth (Figure 1). Vitality examination with a cold thermal test gave a positive response. On radiographic examination of tooth #47, a radiolucent appearance from the occlusal to the apex of the pulp was carious (Figure 2). The diagnosis of tooth #47 was asymptomatic irreversible pulpitis with normal apical tissue. The treatment plan that will be carried out is root canal treatment followed by monolithic zirconia endocrown restoration after taking informed consent. Root canal treatment was done by ProTaper Gold (Dentsply, Switzerland) rotary instrument using 5,25% sodium hypochlorite (NaOCl) (Onemed, Surabaya) and 17% ethylenediaminetetraacetic acid (EDTA) (Onemed, Surabaya) as an irrigant. $Ca(OH)_2$ (Ultracal, Ultradent, USA) was placed as an intracanal medicament for 7 days. Obturation was done using Protaper Gold gutta percha point (Dentsply, Switzerland).

Figure 1. Initial clinical photo.

Figure 2. Preoperative radiographic image.

Endocrown preparation was performed on tooth #47, prior to preparation, the endocrown color was determined, the color obtained was A2 vita classical, and a bite registration was also performed. After that, preparations were made for the production of endocrown on tooth #47, the occlusal portion was reduced using a 2 mm round edge wheel bur. The design of the endocrown preparation was flat and 90° to shoulder (Figure 3a, b, c). A taper fissure tip with an internal taper of 8–10° was used to prepare the pulp chamber. The preparation margins measured 2 mm in width and 4 mm in height. A polyvinyl siloxane material was used to make an impression, which was then transmitted to the lab with information on the shade and the material.

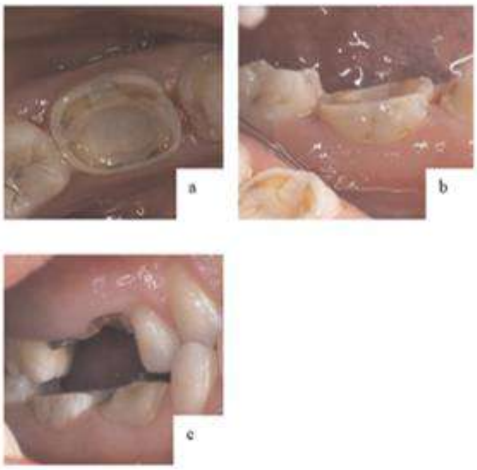

Figure 3. a. Occlusal view after endocrown preparations, b. Buccal view after endocrown preparations, c. Right occlusion view after endocrown preparations.

On the next visit, cementation was done. Isolated tooth #47 used a rubber dam *(DuraDam, Shanghai)*. The tooth was cleaned with air abrasion *(AquaCare, Velopex, UK)* Aluminum oxide (Al_2O_3) 29-micron powder (Figure 4a) and then treated with a 37% phosphoric acid gel etchant *(Ultra-Etch, Ultradent, USA)*. It is then rinsed and bonded *(OptiBond, Kerr, USA)* in a light cure for 20 seconds. The restoration was luted adhesively with self-adhesive resin cement *(Maxcem Elite Chroma, Kerr, USA)* and was applied to the intaglio surface of the restoration, then slowly inserted into tooth #47 and applied pressure. The remaining cement was cleaned using a probe and dental floss on the proximal part, then polymerized using a light cure. Occlusion and articulation were checked with articulating paper (Figure 4b, c, d, e). Radiographs were taken to view the restoration results (Figure 4f).

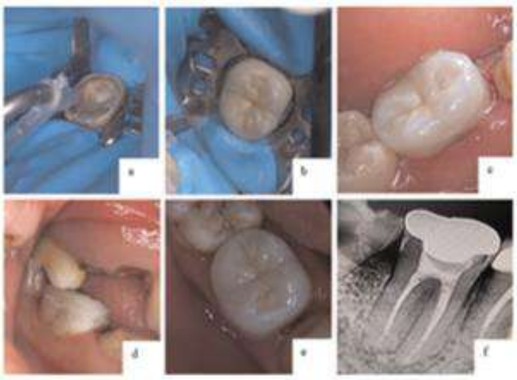

Figure 4. a. Cleaning with AquaCare, b. Endocrown cementation, c. The cementation results were seen from the lingual, d. The cementation results are visible from the bite, e. Cementation results were seen from the occlusal, f. Endocrown cementation radiography results.

3 DISCUSSION

In this case, the selected restoration was endocrown. The endocrown approach utilizes the pulp chamber and the cavity margin with no root canal involvement. As a result, less tooth structure is removed, and the walls of the pulp chamber and the adhesive cementation system achieve macro-micro mechanical retention. Stress resistance and a supragingival cervical margin are provided. This promotes periodontal health and makes taking impressions easier. High fracture resistance is seen in the endocrown's occlusal region. Its thickness is between 3 and 7 mm more than the typical crown, therefore no further macro-retentice preparation or ferrule is required (Soliman et al. 2021).

Preparation was done by reducing the occlusal of 2 mm using a round edge wheel with a flat tip bur for the space of ceramic restoration. A flat margin was made to make the most favorable stress distribution patterns (Guo *et al.* 2021). An additional sharp slope of 8–10° in the pulp chamber was prepared to achieve stabilization and retention of the restoration (Yaqoob et al. 2019). Before cementation, teeth were cleaned using air abrasion (Al_2O_3) to strengthen the micromechanical bond between the zirconia and the resin-based luting agent (Buyukerkmen et al. 2022). To increase the retention and improve interfacial filling during the zirconia cementation, resin-based cement was used in this case (Campos et al. 2017).

CAD-CAM technology was used in this case to create monolithic zirconia endocrowns. CAD-CAM has many advantages, such as fast and accurate production, its ability to constantly run on repetitive tasks by its machine, and its suitability for producing a mass/flow production line (Abdulla et al. 2020). The benefits of monolithic zirconia restorations include high flexural strength, reduced wear on antagonists, satisfactory esthetics, more conservative tooth preparation, no chance of chipping, less time spent in the research facility, and fewer dental visits. The main drawback is the inability to achieve satisfactory transparency. Regardless, recent modifications to structure, composition, and fabrication techniques have led to monolithic zirconia ceramics with translucency but a significantly diminished level of strength. Patients with poor occlusion, parafunctional habits, a history of fracture, and situations where there is limited space for restorative material are all suggested indications for the adoption of monolithic restorations (Kontonasaki et al. 2019).

Zirconia does not contain amorphous silica and has an acid-resistant polycrystalline structure. Conventional porcelain surface treatments like silane priming or hydrofluoric acid etching are not the best choices for enhancing the bonding between the tooth and zirconia restoration. Because the micromechanical bond between zirconia and resin-based luting agents is insufficient, doctors combine primers with them to form a chemical bond that will improve the bond. For the optimal cementation of zirconia restorations, new single-step self-adhesive resin-based luting agents and new universal adhesives that contain 10-methacryloyloxydecyl dihydrogen phosphate (MDP) are required. It is recommended to use as many primers as possible that use functional monomer adhesive systems, such as 10-MDP and other phosphate monomer adhesive systems, in order to strengthen the binding between the zirconia and the resin-based luting agent. The ceramic surface's hydroxyl group and the methacrylate group of the resin-based luting agent form cross-links that make the surface wettable and produce siloxane connections with both of these groups (Buyukerkmen et al. 2022).

Due to its superior mechanical qualities connected to change toughness, which is the highest ever observed for dental ceramics and improved distinctive appearance compared to metal ceramics, zirconia, also known as zirconium dioxide (ZrO2), may be an incredibly enticing ceramic substance. Since it has excellent chemical characteristics, dimensional stability, high mechanical strength, toughness, and Young's modulus (210 GPa) similar to stainless-steel alloys, it is frequently utilized to create prosthetic devices (193 GPa) (Kayahan 2016).

Zirconia has a physical characteristic known as "transformation reinforcement" that allows for its high initial strength and fracture toughness. Zirconia has three crystalline stages: monoclinic (m), tetragonal (t), and cubic. It is a polymorphism material (c). Zirconia is monoclinic at ambient temperature and transitions to a tetragonal stage around 1170°C, followed by a cubic structure at 2370°C. Tetragonal zirconia that is metastable cools to monoclinic zirconia that is stable. The transition from a tetragonal to a monoclinic structure (tm) is associated with an expansive volume extension (3–5%) that causes a compressive stress counter to the initiation of a crack and increases the resistance to crack propagation. The flexural strength of zirconia specimens studied *in vitro* ranges from 900 to 1200 MPa, while fracture toughness is between 9 and 10 MPa/m2. It is an insoluble, bioinert metal oxide that also exhibits good radiopacity and little propensity for corrosion (Kayahan 2016).

4 CONCLUSION

Endocrown is an effective approach for restoring root canal-treated molars with extensive loss of tooth structure. A posterior indirect restoration made of monolithic zirconia with CAD/ CAM technology may be a possibility.

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Monolithic Zirconia Endocrown

by Widya Endocrown 3 Oktober

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Monolithic Zirconia Endocrown: Indirect Restoration for Endodontically Treated

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Background: Endodontically treated tooth requires precise restoration that can prevent fracture and to allow them to function again. Monolithic zirconia crown is crown which is made from zirconia without veneering and made with CAD/CAM technology which has a strength similar to dentin. **Case report:** A 26-year-old patient had a complaint of a spontaneous throbbing in the right lower tooth. Tooth #47 was diagnosed with irreversible pulpitis. **Case Management:** Access cavity was performed with a rubber dam. Crown-down preparation and serial of 5.25% sodium chloride irrigation were followed by root canal disinfection. The obturation using warm vertical compaction technique. Considering the remains of hard tissue, The final restoration of choice for tooth #47 is an endocrown made of monolithic zirconia as a direct restoration that can be used as an option for a single crown with intraradicular retention in post-endodontic molars. Cementation of the monolithic endocrown was performed on the next visit using resin cement. **Conclusion:** Monolithic zirconia can be an option for posterior indirect restoration after endodontic treatment.

Keywords: CAD/CAM fabrication, Endocrowns, Endodontic Treatment, Indirect Restoration, Monolithic Zirconia.

BACKGROUND

Post endodontic teeth need coronal restorations to protect the teeth from fracture and treatment failure.[1] The teeth will experience a large loss of tissue structure, a decrease in dentin elasticity, the influence of irrigation solution and chelating agents that can dissolve the inorganic components of the dentin structure, thereby reducing micro hardness of teeth.[2]

Restoration options of post endodontics teeth depend on the remain structure of healthy tissue, location of the teeth, aesthetics, endodontic/ periodontal prognosis, functional activity in the occlusal region of the teeth, age of the teeth, and financial aspects of the patient.[4] Large decay cause by caries or fracture needs to be restored with a full- coverage crown and additional support with a cast metal core has been recommended. However, there are limitations to the use of intraradicular posts, such as narrow canals, instrument fractures, or calcified root canals. Over-preparation can occur after using intraradicular posts, so dentists choose other options, such as the use of endocrowns.[5]

Indications for endocrown are small intermaxillary spaces that imposible to restored using posts and crowns, extensive loss of tooth structure, and variations in root anatomy. The advantages of endocrowns over conventional crowns include a simple operation, superior mechanical performance, lower costs due to shorter treatment times and fewer steps, and excellent aesthetics.[3] Endocrown restorations use all depths, extension, and slope of the pulp chamber walls to increase the stability and to improve macromechanical retention, without removing the filling material from within the root canal and adhesive cementation can improve microretention.[4,5]

Endocrown is made using a computer-aided design/ computer-aided manufacturing (CAD/ CAM) system. The materials options used for endocrown are monolithic zirconia ceramics, lithium disilicate reinforced ceramics, and leucite reinforced.[6]

CASE REPORT

A 26-year-old male patient came to the clinic complaining of a throbbing pain in his left lower posterior tooth in the past 1 month ago, and he often got stuck in food. The tooth had never been treated and the patient wanted the tooth to be preserved. Clinical examination showed blackish brown caries on the occlusal portion of the right lower posterior tooth (Figure 1). On vitality examination with cold thermal test gave a positive response. On radiographic examination of tooth #47, a radiolucent appearance from the occlusal to the apex of the pulp was carious (Figure 2). The diagnosis of tooth #47 was asymptomatic irreversible pulpitis with normal apical tissue. The treatment plan that will be carried out is root canal treatment followed by monolithic zirconia endocrown restoration after taking informed consent. Root canal treatment was done by ProTaper Gold (Dentsply, Switzerland) rotary instrument using 5,25% sodium hypochlorite (NaOCl) (Onemed, Surabaya) and 17% ethylenediaminetetraacetic acid (EDTA) (Onemed, Surabaya) as an irigant. $Ca(OH)_2$ (Ultracal, Ultradent, USA) was placed as an intracanal medicament for 7 days. Obturation was done using Protaper Gold gutta percha point (Dentsply, Switzerland)

Endocrown ~~preparation~~ was performed on tooth #47, prior to preparation, the endocrown color was determined, the color obtained was A2 vita classical and a bite registration was also performed. After that, preparations were made for the produce of endocrown on tooth #47, the occlusal portion was reduced using a 2 mm round edge wheel bur. The design of the endocrown preparation was flat and 90° shoulder (Fig. 3a, b, c). A taper fissure tip with an internal taper of 8 to 10° was used to prepare the pulp chamber. The preparation margins measured 2 mm in width and 4 mm in height. A polyvinyl siloxane material was used to make an impression, which was then transmitted to the lab with information on the shade and the material

On the next visit cementation was done. Isolated tooth #47 using a rubber dam (DuraDam, Shanghai). The tooth was cleaned with air abrasion (AquaCare, Velopex, UK) Aluminum Oxide (Al_2O_3) 29-micron powder (Figure 4a) and then treated with a 37% phosphoric acid gel etchant (Ultra-Etch, Ultradent, USA) then rinsed and bonded (OptiBond, Kerr, USA) in light cure for 20 seconds. The restoration was luted adhesively with self-adhesive resin cement (Maxcem Elite Chroma, Kerr, USA) was applied to the intaglio surface of the restoration, then slowly inserted into tooth #47 and applied pressure. The remaining cement was cleaned using a probe and dental floss on the proximal part, then polymerized using light cure. Check for occlusion and articulation with articulating paper. (figure 4b, c, d, e). Taking radiographs to view the restoration results (Figure. 4f)

DISCUSSION

In this case, the selected restoration was endocrown with monolithic zirconia material. Preparation was did by reducing the occlusal 2mm using a round edge wheel bur with a flat tip and 90° shoulder to stable and retent the restoration due to the stress distribution so the stress level on the enamel was higher than the dentin to the flat margin model.[7] With a sharp slope of 8-10° in the pulp chamber for space of ceramic restoration.[8] Before cementation, the teeth were cleaned using air abrasion (Al_2O_3) to strengthen the micromechanical bond between the zirconia and the resin-based luting agent.[9] To increased the retention and improve interfacial filling during the zirconia cementation , the resin based cement was use in this case.[10]

The endocrown approach utilizes the pulp chamber and the cavity margin with no root canal involvement. As a result, less tooth structure is removed, and the walls of the pulp chamber and the adhesive cementation system achieve macro-micro mechanical retention. Endocrowns are created by simultaneously preparing parallel occlusal surfaces. Stress resistance and a supragingival cervical margin are provided. This promotes periodontal health and makes taking impressions easier. High fracture resistance is seen in the endocrown's occlusal region. its thickness is between 3-7mm more than the typical crown, therefore no further macro-retentice preparation or ferrule is required.[11]

Monolithic endocrowns are produced by using various systems, including CAD-CAM technology. Tetragonal zirconia polycrystalline (Y-TZP) ceramics with yttria stabilization offer good aesthetics and biocompatibility, flexural strength, and strong fracture resistance. Zirconia, on the other hand, has an acid-resistant polycrystalline structure and does not contain amorphous silica, thus conventional porcelain surface treatments like silane priming or hydrofluoric acid etching are not the best choices for enhancing the binding between the tooth and zirconia restoration. The micromechanical bond between zirconia and resin-based luting agent is insufficient, thus physicians build a chemical bond by combining primers with resin-based luting agent to strengthen the bond. For the optimal cementation of zirconia restorations, new single-step self-adhesive resin-based luting agents and new universal adhesives that contain 10-methacryloyloxydecyl dihydrogen phosphate (MDP) are required. Because of the presence of metal oxides in zirconia ceramics, it is encouraged to maximized primers with functional monomer adhesive systems, such as 10-MDP and other phosphate monomer adhesive systems, for strengthen the binding between the zirconia and the resin-based luting agent. The cross-links between the methacrylate group of the resin-based luting agent and the hydroxyl group of the ceramic surface makes the surface wettable that produced siloxane linkages with both of these groups.[9]

The benefits of monolithic zirconia restorations include high flexural strength, reduced wear on antagonists, satisfactory esthetics, more conservative tooth preparation, no chance of chipping, less time spent in the research facility, and fewer dental visits. The main drawback is the inability to achieve satisfactory transparency. Regardless, recent modifications to structure, composition, and fabrication techniques have led to monolithic zirconia ceramics with translucency but a significantly diminished level of strength. Patients with poor occlusion, parafunctional habits, a history of fracture, and situations where there is limited space for restorative material are all suggested indications for the adoption of monolithic restorations.[12]

Due to its superior mechanical qualities connected to change toughness, which is the highest ever observed for dental ceramics and improved distinctive appearance compared to metal ceramics, zirconia, also known as zirconium dioxide (ZrO2), may be an incredibly enticing ceramic substance. Since it has excellent chemical characteristics, dimensional stability, high mechanical strength, toughness, and a Young's modulus (210 GPa) similar to stainless-steel alloys, it is frequently utilized to create prosthetic devices (193 GPa).[13]

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CONCLUSION

An effective approach for restoring root canal treated molars with extensive loss of tooth structure is endocrown. A posterior indirect restoration made of monolithic zirconia with CAD/ CAM technology may be a possibility.

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FIGURE

Figure 1. Initial clinical photo

Figure 2. Pre-Operative radiographic Image

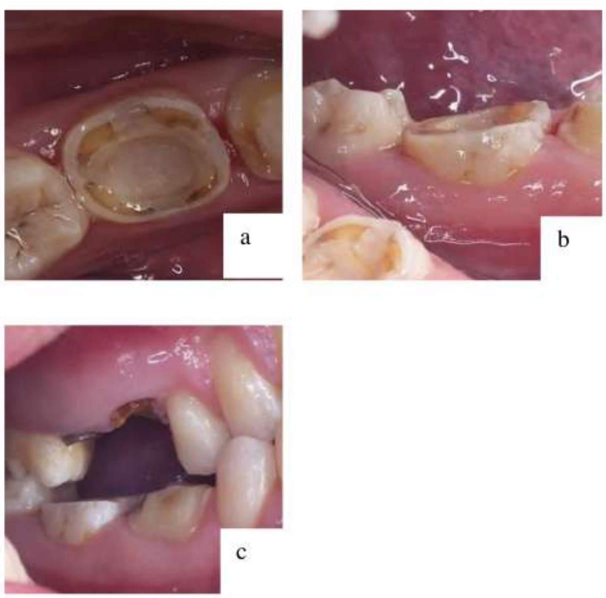

Figure 3a. Endocrown preparations appear occlusal; b. The endocrown preparation was buccal; c. The endocrown preparation looks bite

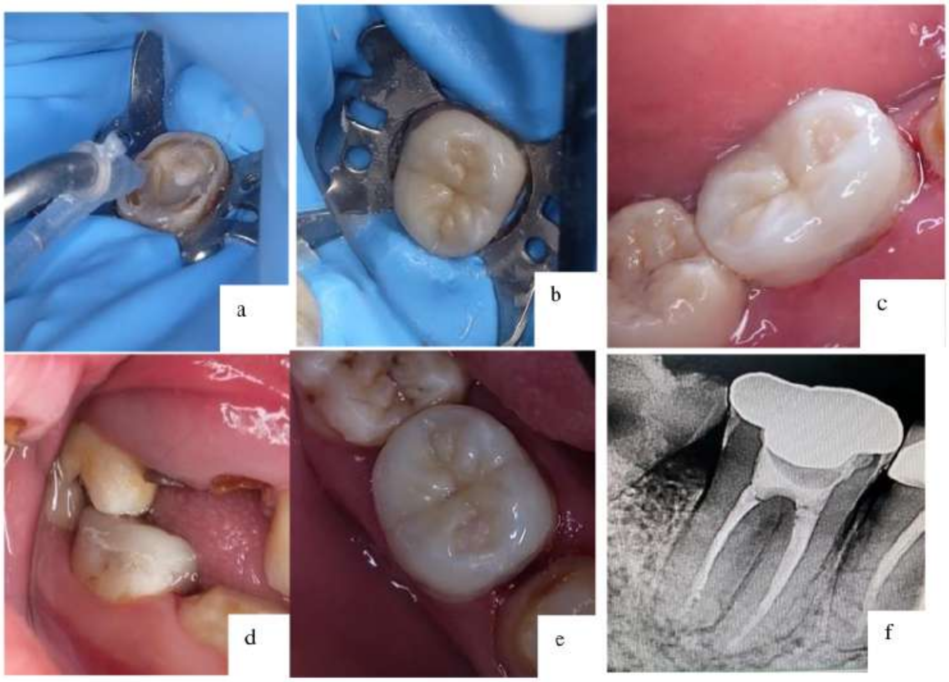

Figure 4a. cleaning with AquaCare; b. Endocrown cementation; c. The cementation results were seen from the lingual; d. The cementation results are visible from the bite; e. Cementation results were seen from the occlusal; f. Endocrown cementation radiography results

Monolithic Zirconia Endocrown

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