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Case Report

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Integration of Direct Metal Laser Sintering in Post-Endodontic Fixed Prosthodontics: A Clinical Report

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Abstract

Failures in endodontic therapy are commonly linked to inadequate coronal sealing or suboptimal crown restorations, both of which may jeopardize the long-term prognosis of the treated tooth. In recent years, Direct Metal Laser Sintering (DMLS) metal–ceramic restorations have gained widespread acceptance because of their superior mechanical properties, fabrication precision, and dependable clinical performance.

DMLS is an advanced additive manufacturing technology that utilizes a high-powered laser to selectively fuse sequential layers of metal powder, thereby constructing the restoration in a layer-by-layer manner within an inert gaseous environment to reduce oxidation. The application of a DMLS-fabricated metal–ceramic crown for an endodontically treated first premolar offers enhanced functional stability along with satisfactory esthetic outcomes, resulting in favorable clinical performance.

This case report presents a 65-year-old male patient who reported with a noticeable swelling in the maxillary right posterior region. A previously placed restoration in the affected area had repeatedly dislodged, underscoring the necessity for a more durable and long-lasting restorative approach. Multiple-visits endodontic therapy was successfully completed, after which a DMLS metal–ceramic crown was selected as the definitive prosthetic restoration. The present case report seeks to describe the clinical protocol and assess the outcomes associated with the use of a DMLS-based porcelain-fused-to-metal (PFM) crown for restoring a first premolar following endodontic treatment.

Keywords: Additive Manufacturing, CAD/CAM Technology, Coronal Seal, Direct Metal Laser Sintering (DMLS), Endodontically Treated Tooth, Fixed Dental Prosthesis, Indirect Restoration, Intraoral Scanner, Metal–Ceramic Crown, Post-Endodontic Rehabilitation.

Introduction

The optimal strategy for restoring teeth following endodontic therapy remains an area of ongoing research and clinical discussion. The long-term prognosis of root canal–treated teeth depends not only on the quality of the endodontic procedure but also, to a considerable extent, on the adequacy of the definitive coronal restoration. Evidence indicates that insufficient coronal sealing can result in microleakage, significantly compromising treatment outcomes and reducing success rates by as much as 40% in certain cases [1].

The selection of restorative material and the design of the definitive prosthesis for endodontically treated teeth (ETT) are

determined by several factors, including the quantity and quality of the remaining tooth structure, its anatomical relationship with adjacent teeth, and its functional interaction with the opposing dentition.

Biomechanical Considerations in Endodontically Treated Teeth

Traditionally, it was believed that dentin in endodontically treated teeth differs structurally from that of vital teeth [1–3]. Earlier hypotheses proposed that endodontic procedures could increase dentin brittleness due to dehydration and diminished collagen cross-linking, thereby predisposing the tooth to fracture [1,3]. However, contemporary research has challenged these assumptions.

In a landmark investigation conducted in 1991, Huang et al. assessed the physical and mechanical properties of dentin from vital teeth and endodontically treated teeth under varying hydration conditions. Their findings demonstrated that neither endodontic therapy nor dehydration significantly affected the physical or mechanical characteristics of dentin [4]. These observations were corroborated by Sedgley and Messer, who compared dentin from endodontically treated teeth with that of their contralateral vital counterparts and concluded that ETT are not intrinsically more brittle [5].

Accordingly, the increased fracture incidence observed in ETT is more accurately attributed to structural compromise resulting from access cavity preparation and pre-existing damage, rather than inherent alterations in dentin composition [6]. Access cavity preparation increases cuspal deflection under occlusal loading, thereby elevating the risk of cusp fracture and marginal microleakage [7,8]. Furthermore, many ETT are already structurally compromised due to extensive caries, trauma, or large existing restorations.

Randow and Glantz further emphasized that the loss or reduction of protective neurosensory feedback mechanisms in non-vital and root canal–treated teeth diminish the ability to modulate occlusal forces, thereby increasing susceptibility to structural failure [9].

Therefore, restorative strategies must achieve not only an effective coronal seal but also reinforcement of the residual tooth structure to withstand functional stresses and preserve long-term integrity.

Impact of Tooth Structure Loss on Biomechanics

The primary biomechanical compromise in ETT stems from the loss of structural tissue, whether due to caries, fractures, or operative interventions such as cavity preparation. Conservative access cavity designs exert minimal influence on overall tooth stiffness, typically resulting in approximately a 5% reduction in rigidity [10]. However, as additional structural elements—particularly marginal ridges—are removed, the weakening effect becomes progressively more significant.

Studies have shown that occlusal cavity preparations can reduce tooth stiffness by 14–44%, whereas mesio-occluso-distal (MOD) preparations may decrease stiffness by as much as 20–63% [11]. These substantial reductions underscore the importance of selecting restorative approaches that effectively restore structural strength and functional support.

Emergence of DMLS in Dental Restorations

Traditionally, cobalt–chromium (Co–Cr) alloys for fixed prostheses have been fabricated using conventional casting techniques. Although widely utilized, casting procedures are associated with several limitations, including increased costs, labor-intensive workflows, material wastage, and a greater likelihood of human error [12]. Over the past decade, digital innovations have revolutionized prosthodontic practice, particularly with the integration of computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies.

These digital systems enable the fabrication of a wide range of dental prostheses, including single crowns, multi-unit fixed partial dentures, removable prostheses, and implant-supported restorations [13]. Among modern CAD/CAM techniques, Direct Metal Laser Sintering (DMLS) has emerged as a promising modality for producing high-precision metal frameworks.

DMLS is an additive manufacturing process that employs a high-powered ytterbium (Yb) fiber-optic laser to selectively melt and fuse metal powder in successive layers, constructing the restoration incrementally within a controlled inert gas environment to prevent oxidation [14,15]. Each fabricated layer measures approximately 10–30 microns in thickness, permitting exceptional accuracy, fine detail reproduction, and optimal marginal adaptation. This technique facilitates the production of metal–ceramic restorations with enhanced mechanical strength, improved marginal integrity, and reduced technique sensitivity due to minimized human intervention [13,16].

The present case report aims to describe the clinical protocol and outcomes associated with the restoration of a maxillary second premolar using a DMLS-fabricated metal–ceramic crown following successful endodontic therapy. It highlights the rationale for material selection, delineates the procedural workflow, and discusses the functional and esthetic outcomes achieved through this advanced digital restorative approach.

CASE REPORT

A 65-year-old male patient reported to the Department of Prosthodontics, Crown & Bridge, and Oral Implantology with a chief complaint of pain in the maxillary right posterior region. He was referred to the Department of Conservative Dentistry and Endodontics, where root canal treatment of tooth 15 was initiated and completed over multiple visits. Approximately one month following completion of endodontic therapy, the patient returned to the Prosthodontics department for definitive prosthetic rehabilitation.

The patient's medical history was non-contributory, with no history of systemic hypertension, diabetes mellitus, cardiovascular disease, or known drug allergies. His past dental history was also unremarkable. Radiographic examination confirmed satisfactory obturation and periapical status with respect to tooth 15.

Clinical Procedure

At the initial prosthodontic visit, comprehensive oral hygiene instructions were provided, and the proposed treatment plan was explained in detail. Written informed consent was obtained prior to commencing the procedure. Endodontic therapy had already been completed in multiple sessions before prosthodontic intervention.

Tooth preparation was carried out using a deep chamfer finish line design. Approximately 1 mm of axial reduction and 2 mm of occlusal reduction were achieved to provide sufficient space for the definitive restoration. Final subgingival refinement of the margins was performed using a round-end tapered fissure diamond bur (Figures 1 & 2).

Gingival displacement was accomplished using a gingival retraction cord (Roeko Stay-Put Retraction Cord, Coltene Whaledent Pvt. Ltd., Navi Mumbai, India) along with a retraction medicament (Dux GingiGEL, Kerr, California, United States) prior to impression making.

Digital impressions of both the maxillary and mandibular arches were obtained using an intraoral scanner (Medit i600, Medit Corp., Seoul, South Korea), ensuring accurate and high-resolution capture of the prepared tooth and surrounding anatomical structures (Figures 3 & 4). A digital interocclusal record (bite scan) was subsequently recorded to establish precise occlusal relationships (Figure 5).

The acquired digital data were utilized to fabricate 3D-printed master casts of both arches, thereby eliminating the requirement for conventional stone model pouring (Figures 6 & 7).

An indirect provisional crown was fabricated using Protemp™ 4 Temporisation Material (3M ESPE, Karnataka, India). At the subsequent appointment, a metal framework try-in was performed to evaluate marginal fit and internal adaptation. Shade selection was conducted using a VITA shade guide (shades 2M2 and 2M3), following which the restoration was returned to the laboratory for ceramic veneering and completion of the definitive crown (Figures 8 & 9).

A bisque trial appointment was scheduled to assess marginal integrity, occlusion, articulation, proximal contacts, and soft tissue harmony. After necessary occlusal refinements, the restoration was sent back to the laboratory for final glazing.

Definitive cementation was performed using a glass ionomer luting cement (GC Fuji Gold Label Type 1 Luting Cement, GC Corporation, Tokyo, Japan).

Post-cementation evaluation included both subjective and objective assessment of treatment outcomes. The patient reported no discomfort or functional limitations. Clinical examination revealed absence of tenderness on percussion, satisfactory marginal adaptation, no evidence of food impaction, and no signs of periodontal inflammation. The surrounding gingival tissues appeared healthy and well adapted to the definitive restoration (Figures 10 & 11).

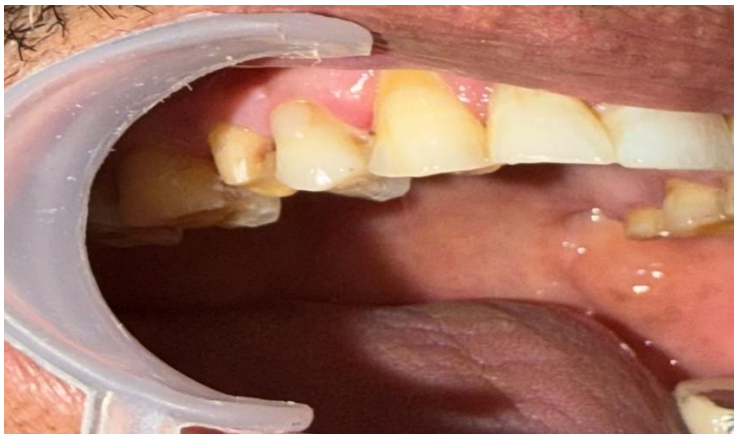

Figure 1 – Tooth preparation (lateral view)

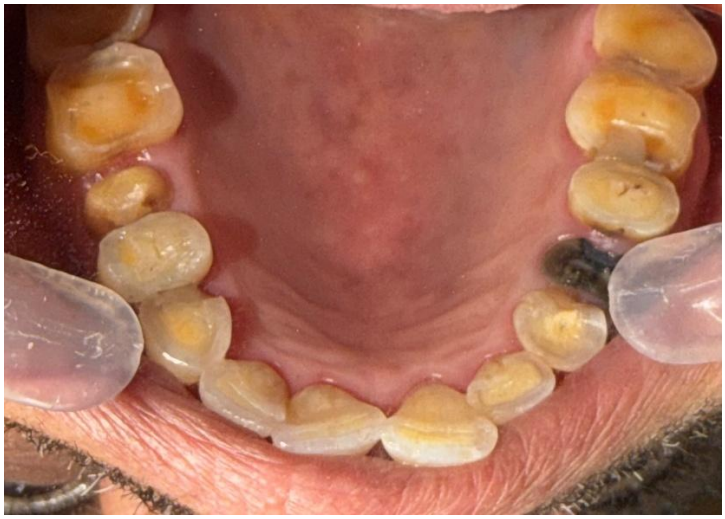

Figure 2 – Tooth preparation (occlusal view)

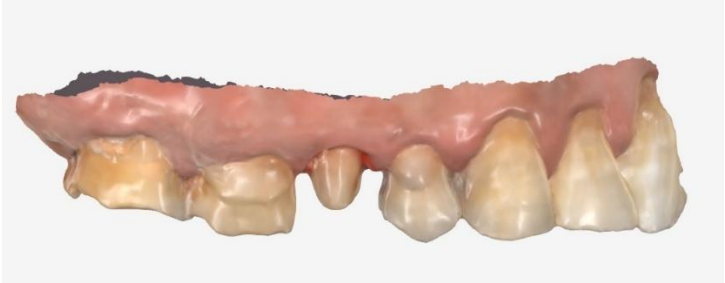

Figure 3 – Maxillary digital impression

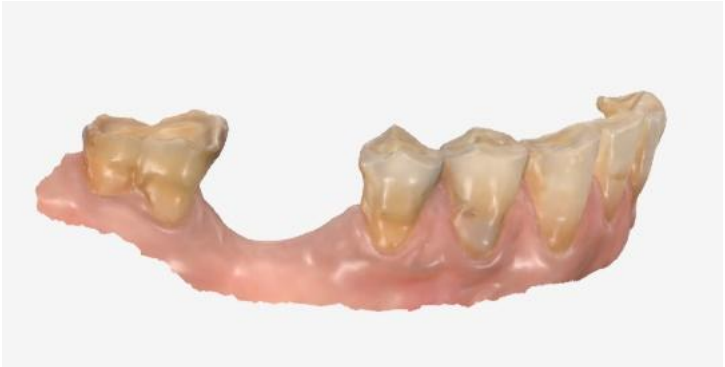

Figure 4 – Mandibular digital impression

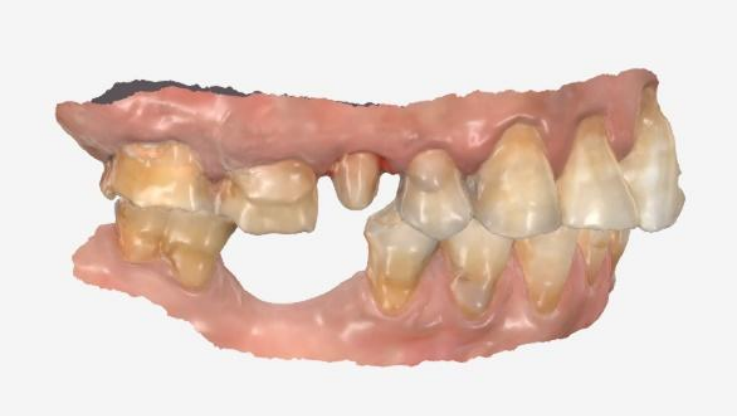

Figure 5 – Bite scan

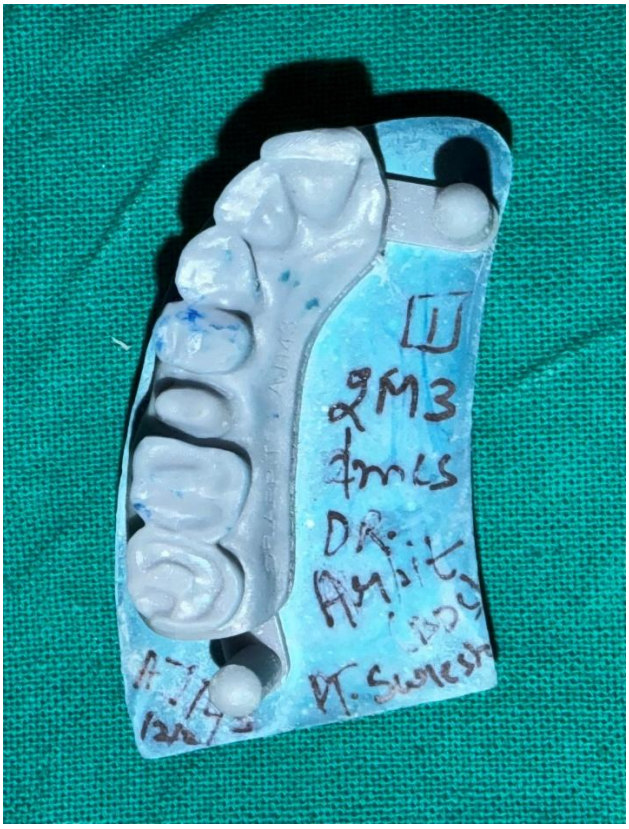

Figure 6 – Maxillary digital cast

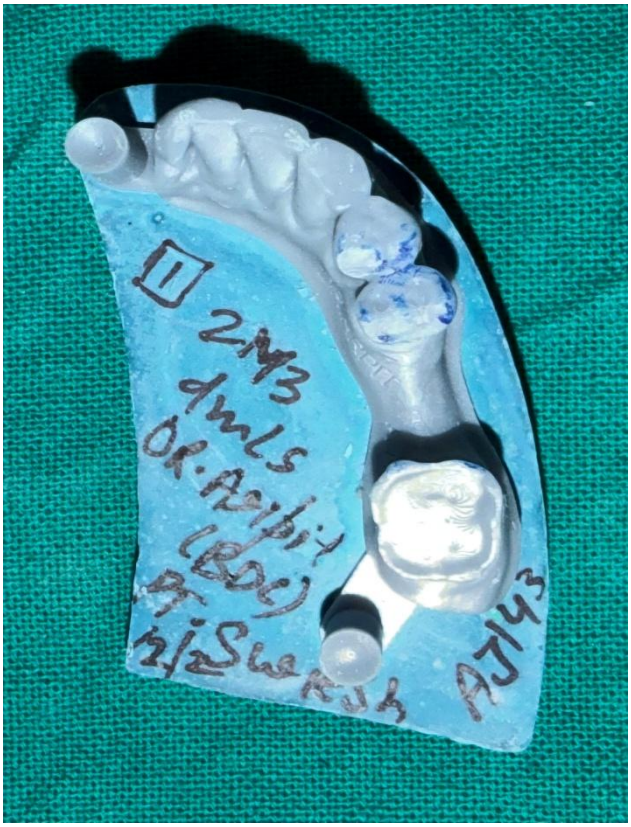

Figure 7 – Mandibular digital cast

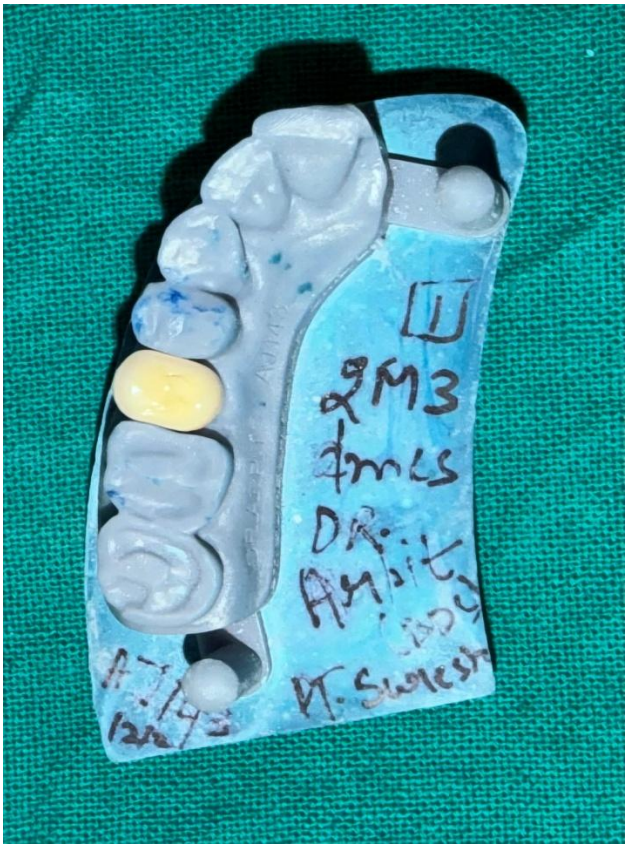

Figure 8 – Final DMLS metal-ceramic (PFM) crown (Occlusal view)

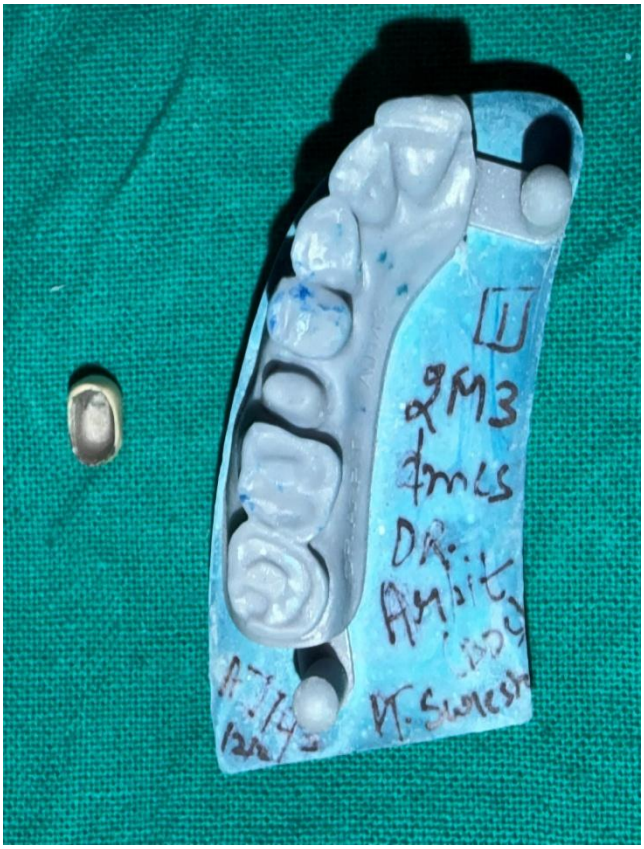

Figure 9 – Final DMLS metal-ceramic (PFM) crown – an overview

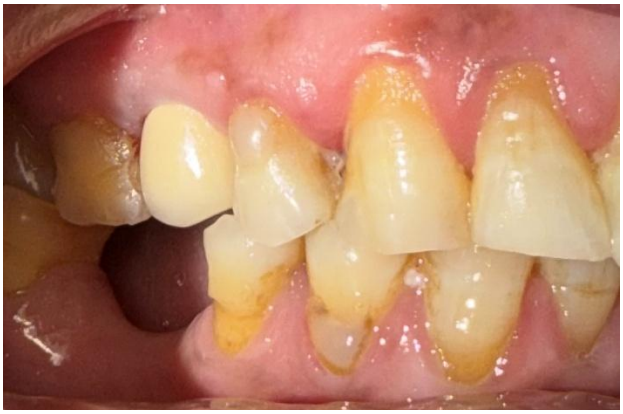

Figure 10 – Final DMLS PFM crown in situ (Lateral view)

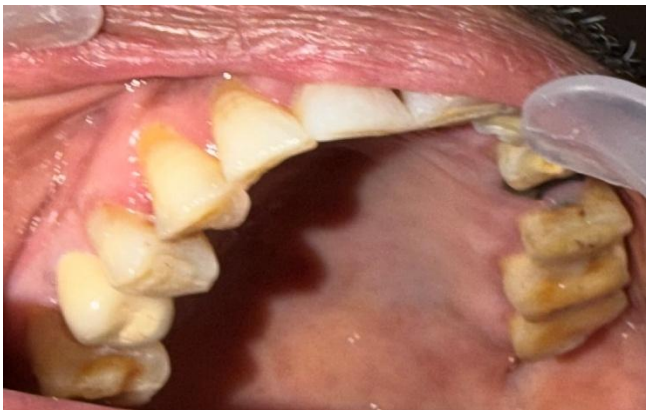

Figure 11 - Final DMLS PFM crown in situ (Occlusal view)

DISCUSSION

The concept of "success" in endodontic therapy is multifactorial and may be interpreted from different clinical perspectives. From a dental standpoint, treatment success is generally defined as the completion of root canal therapy resulting in an asymptomatic tooth that has fully regained functional efficiency. Achieving such an outcome requires precise diagnosis, meticulous biomechanical preparation, thorough disinfection, and a properly executed restorative phase. Both apical and coronal seals play a pivotal role in ensuring complete rehabilitation and long-term stability.

According to Nurulaqmar-Iwani [17], defective or inadequate restorations constitute a significant cause of endodontic failure. Loss of integrity at either the coronal or apical seal permits microbial penetration and diffusion of toxins from the oral cavity, leading to reinfection of the root canal system and subsequent periapical pathology. Thus, the quality and durability of the definitive coronal restoration are fundamental determinants of endodontic success.

When planning post-endodontic rehabilitation, multiple factors must be evaluated, including the quantity of remaining tooth structure, magnitude of occlusal forces, and functional and esthetic demands. The chosen restoration should reinforce the residual tooth structure, particularly in cases involving cuspal loss or significant occlusal surface destruction. In the present case, the patient's dental history revealed repeated debonding and failure of previous restorations, thereby necessitating a more durable and long-term restorative approach.

The longevity of a restoration depends on several interrelated variables, such as the materials used, the restorative technique, operator skill, patient-specific oral conditions, and local biomechanical factors. Evidence in the literature supports the use of indirect full-coverage crown restorations, which demonstrate a survival rate of approximately 75–80% over a 10-year period. Furthermore, Direct Metal Laser Sintering (DMLS) metal–ceramic restorations have reported a success rate of nearly 88% beyond five years of clinical service [18–20].

In the present case, a metal–ceramic crown was selected for the posterior tooth due to its well-documented durability, mechanical stability, and cost-effectiveness. A cobalt–chromium (Co–Cr) framework was fabricated using the rapid manufacturing technique of DMLS. Laser sintering, a core component of DMLS, falls under the broader category of additive manufacturing or rapid prototyping technologies [21]. This technology is widely applied in engineering, aerospace, and defense industries and has increasingly gained recognition in the healthcare sector. Its incorporation into restorative dentistry has expanded significantly owing to its precision, operational efficiency, and minimal material wastage.

Compared with conventional casting techniques, DMLS provides multiple advantages. It enables the fabrication of highly precise and mechanically robust fixed prostheses with superior marginal adaptation [22,23]. Moreover, by eliminating several intermediate laboratory steps—such as wax pattern fabrication and traditional casting—the process reduces technique sensitivity and minimizes the risk of human error, thereby enhancing overall reproducibility.

Although both titanium and cobalt–chromium alloys in powdered form can be processed using DMLS technology, Co–Cr remains the preferred material because of its favorable mechanical characteristics and ease of fabrication. In comparison with all-ceramic systems, Co–Cr-based metal–ceramic restorations offer a cost-effective solution without compromising structural strength, especially in posterior regions subjected to substantial occlusal forces. Accordingly, in this clinical case, a Co–Cr-based DMLS-fabricated metal–ceramic fixed prosthesis was selected as the definitive restorative modality for the posterior dentition.

For definitive luting, Glass Ionomer Cement (GIC) was employed. GIC was chosen due to its clinical advantages, including simplified cementation procedures, reduced chairside errors, lower risk of contamination, and decreased operative time. Additionally, its intrinsic properties—such as chemical adhesion to tooth structure and fluoride release—enhance its clinical applicability, particularly in endodontically treated teeth where durable sealing and prevention of secondary caries are critical considerations.

CONCLUSION

In conclusion, the use of a DMLS-fabricated metal–ceramic crown for the restoration of a second premolar following endodontic therapy demonstrates reliable functional performance along with satisfactory esthetic results. Such restorations ensure effective coronal sealing and precise marginal adaptation, thereby contributing significantly to the overall success and longevity of treatment.

At follow-up appointments, the patient remained asymptomatic, with no tenderness on percussion or palpation, no signs of food impaction, and no detectable marginal discrepancies. The peri-restorative gingival tissues were healthy and well maintained. In the present case, the combination of laser sintering technology and CNC machining enabled the attainment of optimal functional stability and esthetic integration. Regular recall visits were scheduled and conducted to monitor and ensure the long-term success and durability of the restoration.

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