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Post-and-Core Restorations with 3D Technologies: Benefits and Limitations

▷ **Abstract.** Post-and-core restorations in prosthetic dentistry are employed to replace defects in hard dental tissues, aiming to preserve the integrity and function of the dental arch while achieving superior esthetic outcomes. When appropriately applied as supports for artificial crowns, these restorations maintain the tooth root and provide high esthetic quality and functionality, thereby enhancing the overall effectiveness of prosthetic treatment.

Polymer-based post-and-core restorations fabricated through additive manufacturing have become an essential component of modern dental practice. They play a pivotal role in rehabilitating severely compromised teeth following endodontic treatment. The application of 3D-printed polymer restorations demonstrates considerable promise for advancing tooth-preserving technologies.

Keywords: *tooth-preserving technologies, polymer post-and-core restorations, extensive crown defects, additive manufacturing, 3D printing*.

Advantages of Polymer Post-and-Core Restorations

An ideal post-and-core restoration should demonstrate biocompatibility, mechanical strength, long-term durability, non-toxicity, and favorable esthetic properties [1]. Composite materials employed in their fabrication enable clinicians to closely match the color, shade, and translucency of the restoration to natural dental tissues. Unlike metal posts, which may compromise esthetics by showing through the prosthetic crown, polymer-based post-and-core systems provide superior visual outcomes due to their tooth-like appearance. This advantage is particularly significant in the restoration of anterior teeth.

Consequently, polymer post-and-core restorations produced with 3D printing technologies have gained increasing preference in clinical practice. Compared with posts fabricated from alternative materials such as metal, zirconia, or fiber-reinforced composites, polymers avoid the major drawback of excessive rigidity, which can predispose the tooth root to fractures under functional loading. By offering a more balanced mechanical profile, polymer post-and-core systems represent a promising solution for tooth-preserving restorative strategies [2].

Biocompatibility

The biological compatibility of polymer post-and-core restorations is a critical determinant of their safety and long-term clinical performance. Composite materials are generally well tolerated by patients and seldom provoke allergic reactions due to their chemical inertness. A notable advantage of polymer-based systems is their resistance to corrosion, which distinguishes them from metal posts [3, 4]. The absence of corrosion minimizes irritation of surrounding tissues and prevents gingival discoloration, thereby supporting a healthy periodontal appearance [5].

Nevertheless, the biocompatibility of certain polymers may be compromised by their degradation behavior. For instance, polylactic acid (PLA), despite its recognized biocompatibility, can induce localized inflammatory responses as a result of acidic degradation by-products. This limitation underscores the need for further research aimed at mitigating such effects—potentially through modifications of polymer composition or the application of biocompatible surface coatings [4].

For clinical implementation, it is essential that polymer materials conform to international standards such as ISO 10993. These standards emphasize rigorous evaluation of materials used in 3D-printed post-and-core restorations, including assessments of cytotoxicity, genotoxicity, and irritation potential [6].

Adhesion and Strength

The adhesion of polymer post-and-core restorations to dental tissues is a decisive factor in ensuring their mechanical strength and long-term stability. Contemporary adhesive systems provide reliable bonding between composite materials and dentin or enamel, thereby enhancing the durability and clinical success of the restoration. Effective adhesion not only improves resistance to functional stresses but also reduces the risk of microleakage and secondary caries, contributing to the overall longevity of the prosthetic treatment.

Bonding Mechanism

The bonding mechanism of polymer post-and-core restorations involves the penetration of adhesive agents into the micro-pores of dentin, resulting in micromechanical retention. Strong adhesion ensures the uniform distribution of occlusal forces, thereby preventing localized overload of specific tooth structures and reducing the risk of fracture.

Advances in 3D printing, particularly when integrated with CAD/CAM technologies, enable the fabrication of posts and cores with high anatomical precision. This improved accuracy enhances the quality of adhesion compared with conventional techniques. Furthermore, composite materials produced through 3D printing have demonstrated equal or superior marginal adaptation relative to milled alternatives, underscoring their potential to improve clinical outcomes [7].

Technological Efficiency and Ease of Working with Polymer Restorations

The application of composite post-and-core restorations fabricated through 3D printing offers both convenience and precision in clinical practice. Composite materials are easy to manipulate, allowing clinicians to produce restorations that closely conform to the root canal anatomy with a high degree of individualization and accuracy [2]. Importantly, the mechanical properties of polymer post-and-core systems approximate those of natural dental tissues, thereby enhancing tooth survival rates [8].

The use of additive manufacturing significantly reduces production time and manual labor compared with conventional techniques. Integration of digital technologies such as CAD/CAM further improves accuracy and efficiency, streamlining the fabrication process [7, 9, 10].

Surface quality following 3D printing plays a critical role in adhesion. Inadequate post-processing may lead to microcracks or surface irregularities that compromise bond strength. Accordingly, procedures such as ultraviolet curing and polishing not only enhance biocompatibility but also improve adhesion by producing a more uniform surface conducive to micromechanical retention. Among post-processing techniques, polymerization in a nitrogen chamber has proven particularly effective, yielding superior gloss and surface smoothness [5, 11].

Tooth Tissue Preservation and Minimally Invasive Approach

Polymer post-and-core restorations produced through 3D printing enable a minimally invasive approach to tooth preparation compared with traditional metal posts, representing a significant advantage for the preservation of natural tooth structure. This approach reduces trauma to the tooth and allows clinicians to retain a greater amount of native tissue—an especially important consideration in cases with thin root walls.

Due to their inherent flexibility, polymer materials can absorb masticatory forces, thereby reducing the risk of root fractures. Their shock-absorbing capacity provides additional protection against damage caused by high occlusal loads, such as those associated with bruxism [12]. In clinical scenarios requiring a particularly conservative strategy—for example, the restoration of teeth with thin or fragile roots—polymer posts are often the preferred option. Laboratory investigations have demonstrated that resin monoblock posts fabricated via 3D printing exhibit fracture resistance comparable to fiber-reinforced posts, with no root cracks observed in any tested specimens [8].

Economic Advantages and Accessibility

The economic efficiency of polymer post-and-core restorations produced through additive manufacturing represents an important factor contributing to the accessibility of this treatment for a broad patient population. Composite materials used in additive fabrication are more cost-effective than metals or ceramics, thereby reducing the overall expense of prosthetic therapy [4, 13]. As a result, lower material costs enhance patient access across diverse socioeconomic groups.

Moreover, the integration of CAD/CAM technologies can further decrease production expenses while maintaining an optimal balance between cost and quality. This combination of affordability and precision underscores the economic attractiveness of polymer post-and-core restorations, reinforcing their potential as a widely accessible option in contemporary dental practice.

Disadvantages of Polymer Post-and-Core Restorations

Despite their evident advantages, the additive manufacturing of polymer post-and-core restorations is associated with several limitations.

First, 3D printers employed in dental practice exhibit high energy consumption compared with traditional fabrication methods. Second, the implementation of this technology requires substantial financial investment: the cost of equipment, photopolymer resins, UV-curing chambers, and quality-control systems remains considerable, particularly for clinics operating with limited budgets.

In addition, the range of materials suitable for dental applications is still restricted, limiting both customization options and the standardization of manufacturing protocols. Environmental and sanitary concerns also warrant attention—during the printing process, fine particulate matter and potentially toxic vapors may be released, necessitating specialized ventilation systems and appropriate personnel protection.

Finally, in the long term, the widespread adoption of automated 3D manufacturing systems may reduce the demand for traditional technical positions, shifting the labor market toward highly skilled CAD/CAM system operators [13, 14].

Conclusion

Polymer post-and-core restorations produced through additive manufacturing offer numerous advantages, extending from the planning stage to final fixation. Their convenience, high precision compared with conventional gypsum-based workflows, simplicity and speed of fabrication, efficiency for both clinician and patient, excellent esthetics, and overall safety highlight their growing relevance in modern prosthetic dentistry.

Nevertheless, certain limitations must be acknowledged. High energy consumption, substantial investment requirements, and the potential reduction of traditional technical positions represent important challenges that accompany the adoption of additive technologies. Furthermore, the choice of restorative material should always be guided by a comprehensive clinical assessment and tailored to the individual needs of the patient. In specific cases—such as extensive tooth destruction or the presence of bruxism—a more rigid and durable design may be necessary to ensure long-term success.

Despite these considerations, polymer post-and-core restorations fabricated via additive manufacturing remain a highly promising and increasingly demanded option for tooth reconstruction. Their continued development and refinement are likely to strengthen their role in contemporary dental practice, advancing both tooth-preserving strategies and patient-centered care.

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Реставрації після препарування з використанням 3D-технологій: переваги та недоліки

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Анотація. Використання штифтових реставрацій у протезній стоматології для заміщення дефектів твердих тканин зуба спрямоване на збереження цілісності та функції зубної дуги, а також на досягнення високих естетичних результатів. При правильному використанні штифтових реставрацій як опори для штучних коронок корінь зуба зберігається, а реставрація набуває високої естетичної якості та функціональності, що загалом забезпечує ефективність протезного лікування.

Полімерні штифтові реставрації, виготовлені з використанням адитивних технологій, є важливим компонентом сучасної стоматологічної практики. Вони відіграють ключову роль у відновленні сильно пошкоджених зубів, які пройшли ендодонтичне лікування. Використання полімерних штифтових реставрацій, виготовлених за допомогою 3D-друку, є перспективним.

Ключові слова: *технології збереження зубів, полімерні штифтові реставрації, значні дефекти коронки.*

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