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RESTORATION OF ANTERIOR TEETH WITH COMPOSITE MATERIALS AND METHODS FOR THEIR EVALUATION

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Abstract: Restoration of anterior teeth represents one of the most demanding tasks in restorative dentistry, requiring not only the recreation of function but also high-level aesthetics and biomimetic integration. Composite materials have undergone remarkable development, enabling clinicians to reproduce the optical and mechanical properties of natural teeth. Despite advances in materials and techniques, clinical success depends on accurate evaluation and long-term monitoring of restorations. This review aims to summarize current evidence on composite restoration of anterior teeth, focusing on material characteristics, clinical application, and standardized evaluation methods such as the FDI and USPHS criteria. Furthermore, patient-centered assessment and future trends in digital evaluation are discussed.
Keywords: anterior teeth, composite resin, esthetic restoration, clinical evaluation, FDI criteria, USPHS, patient satisfaction, restorative dentistry.

Introduction

The restoration of anterior teeth is a central aspect of modern restorative dentistry, as it combines aesthetic demands with the necessity to maintain oral function and tissue health. Loss of tooth structure due to caries, trauma, erosion, or previous restorations can significantly affect facial appearance, phonetics, and self-esteem. The increasing patient demand for minimally invasive and highly aesthetic treatments has driven the evolution of composite materials and bonding technologies (Tuncer et al., 2022).

Composite resins have become the material of choice for anterior restorations because of their ability to replicate the natural translucency and color of enamel and dentin. Improvements in filler technology, polymer matrices, and light-curing systems have increased their durability and color stability (Krejci & Ardu, 2020). Alongside material advancements, clinical techniques and evaluation protocols have been refined to ensure predictable outcomes. The assessment of restoration quality, both immediate and long-term, remains a key component of evidence-based restorative dentistry.

This review provides a comprehensive overview of composite restoration of anterior teeth and the clinical methods used for their evaluation, highlighting both material considerations and objective assessment criteria.

1. Principles of Aesthetic Restoration of Anterior Teeth

Aesthetic restoration aims to restore harmony between teeth, gingiva, and lips. The principles guiding anterior restorations include color matching, surface texture, morphology, and symmetry (Dietschi, 2021). Proper diagnosis and treatment planning require shade analysis under natural light, photographic documentation, and the use of diagnostic wax-ups or digital mock-ups.

The biomimetic approach emphasizes the recreation of enamel and dentin layers using composite resins of different translucencies and opacities (Frankenberger & Ilie, 2018). Layering techniques, including the use of dentin shades in deeper layers and enamel shades superficially, allow for lifelike results. The clinician must also consider optical phenomena such as fluorescence, opalescence, and light diffusion.

2. Composite Materials: Properties and Developments

Composite resins are composed of a resin matrix (commonly Bis-GMA, UDMA, or TEGDMA), inorganic fillers, and a coupling agent. Over time, filler technology has evolved from macrofill to

microhybrid and nanohybrid formulations, improving polishability and mechanical resistance (Ilie & Hickel, 2020). Nanofilled composites exhibit superior gloss retention and reduced wear, making them ideal for anterior restorations.

Recent innovations include bulk-fill composites, which allow for greater depth of cure and simplified placement, although their optical control remains inferior for anterior use (Van Ende et al., 2019). Additionally, bioactive composites capable of ion release and remineralization are being developed to enhance longevity and tissue compatibility.

The physical properties of composites such as polymerization shrinkage, modulus of elasticity, and thermal expansion play crucial roles in clinical performance. Modern resin systems incorporate stress-relieving monomers and optimized photoinitiators to minimize shrinkage stress and discoloration (Mitra et al., 2021).

3. Clinical Techniques for Direct Composite Restorations

Clinical success relies heavily on technique sensitivity. Proper isolation, usually achieved through rubber dam placement, prevents contamination and ensures optimal bonding (Deliperi, 2018). The cavity design should follow a minimally invasive principle, preserving as much enamel as possible to enhance adhesion.

The etch-and-rinse and self-etch adhesive systems are the two major bonding protocols. While the etch-and-rinse system provides superior enamel bonding, self-etch adhesives reduce postoperative sensitivity and simplify application (Van Meerbeek et al., 2020).

Incremental layering is a fundamental strategy to control polymerization stress and achieve natural stratification. Each increment (≤2 mm) should be adequately light-cured with appropriate intensity and exposure time. Finishing and polishing sequences using multi-step abrasive systems improve surface gloss and reduce plaque accumulation.

Indirect composite restorations fabricated via CAD/CAM or laboratory techniques also offer high aesthetics and repairability but require additional steps and cost (Alshali et al., 2021).

4. Evaluation Methods for Anterior Composite Restorations

Evaluation of composite restorations is essential for determining their clinical success, longevity, and need for replacement. Several standardized methods have been developed to objectively assess their performance.

4.1. The USPHS (Ryge) Criteria

The United States Public Health Service (USPHS) criteria, introduced by Ryge and Snyder (1973), remain one of the most widely used systems. Restorations are rated according to parameters such as marginal adaptation, anatomic form, color match, surface roughness, and secondary caries. Each criterion is graded from Alfa (ideal) to Charlie (failure). Although simple and reproducible, the USPHS system has limitations in sensitivity, especially for aesthetic evaluation (Heintze et al., 2018).

4.2. The FDI World Dental Federation Criteria

To address USPHS limitations, the FDI criteria were developed (Hickel et al., 2010). This system differentiates between *esthetic*, *functional*, and *biological* properties, allowing for a more comprehensive evaluation. Scores range from 1 (excellent) to 5 (poor), with specific descriptors for color match, translucency, marginal staining, and texture. The FDI system is now recommended for clinical trials and quality assurance.

4.3. Esthetic and Functional Parameters

Beyond standardized scales, esthetic evaluation includes color stability, gloss retention, and surface texture. Clinical photography and digital shade analysis support objectivity. Parameters such as ΔE values from spectrophotometric measurements help quantify color changes over time (Perez et al., 2022). Functional assessment includes anatomical integrity, marginal adaptation, and resistance to wear and fracture.

4.4. Patient-Centered Evaluation

Subjective assessment by patients has gained importance as part of outcome evaluation. Patient satisfaction surveys and visual analogue scales (VAS) are used to measure aesthetic acceptance, comfort, and function (Perea et al., 2021). These evaluations contribute to a holistic understanding of restorative success.

5. Longevity and Failure Factors

Longevity of anterior composite restorations depends on multiple factors including operator skill, material properties, and patient-specific variables. Long-term studies report survival rates between 80–95% over 5–10 years (Opdam et al., 2021). Common reasons for failure include marginal discoloration, secondary caries, and fracture of restoration or tooth substrate.

Moisture contamination during bonding, incorrect polymerization, and inadequate finishing can significantly reduce longevity. Surface roughness increases plaque accumulation, leading to gingival inflammation and staining. The use of nanocomposites and improved adhesive systems has reduced failure rates, but technique sensitivity remains a key determinant.

6. Future Perspectives and Digital Integration

Recent advances in digital dentistry have introduced new methods for restoration planning and evaluation. Intraoral scanners and 3D imaging systems allow for precise documentation of shape and surface wear over time (Schlenz et al., 2020). Digital shade matching and AI-based image analysis are emerging tools for objective assessment of color and texture.

CAD/CAM-fabricated composite restorations combine the advantages of controlled polymerization and precision milling, though challenges remain in bonding and repair. The integration of bioactive and smart materials capable of responding to pH changes or releasing fluoride represents a promising direction (Garoushi et al., 2023).

Future evaluation methods may combine clinical indices (FDI, USPHS) with quantitative digital data, enabling comprehensive longitudinal analysis.

Conclusion

Composite restoration of anterior teeth remains a cornerstone of aesthetic dentistry, combining art and science to reproduce natural beauty and function. Continuous developments in resin technology, adhesive systems, and optical properties have significantly improved outcomes. Reliable evaluation using standardized clinical criteria like FDI and USPHS, supported by patient feedback ensures evidence-based quality control and long-term success. The integration of digital tools will further refine objective assessment and enhance the predictability of restorative procedures.

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