DIGITAL FLUORESCENCE–GUIDED MULTIMODAL APPROACH TO EARLY DENTAL FLUOROSIS IN CHILDREN

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Abstract. Dental fluorosis is a developmental disturbance of enamel mineralization associated with excessive systemic fluoride exposure during tooth formation. Mild forms in children may present as subtle diffuse white striations or opacities and can be difficult to differentiate clinically from early carious lesions and other developmental enamel defects. Conventional visual examination remains essential, but its diagnostic accuracy may be influenced by illumination, tooth hydration, surface cleanliness, and examiner experience. Digital fluorescence technologies, particularly quantitative light-induced fluorescence (QLF), provide opportunities for more objective detection, quantitative documentation, and longitudinal monitoring of early enamel alterations.

Objective. To evaluate the role of digital fluorescence methods in the early diagnosis of dental fluorosis in children and to substantiate a multimodal approach combining standardized clinical assessment, digital imaging, fluoride-exposure analysis, prevention, and minimally invasive treatment.

Materials and Methods. A focused narrative analysis of contemporary scientific literature on pediatric dental fluorosis, fluorescence-based diagnostics, standardized clinical indices, preventive strategies, and minimally invasive treatment was performed. Particular attention was given to QLF, digital intraoral imaging, the Thylstrup–Fejerskov Index, fluoride-exposure assessment, remineralizing approaches, microabrasion, bleaching, and resin infiltration.

Results and Discussion. Early dental fluorosis remains diagnostically challenging because mild fluorotic opacities may resemble initial enamel demineralization. Fluorosis is typically characterized by diffuse and relatively symmetrical changes affecting corresponding teeth, whereas early caries more commonly develops in plaque-retentive areas and has a different distribution. Standardized visual scoring therefore remains the first diagnostic step.

Digital fluorescence can supplement clinical examination by recording changes in enamel fluorescence intensity, lesion area, and optical properties. QLF and related technologies allow quantitative comparison over time and may improve documentation of subtle enamel changes. However, fluorescence parameters should not be interpreted independently, as enamel hydration, surface conditions, imaging settings, and lesion structure can influence optical measurements. Therefore, digital fluorescence should be regarded as an adjunct rather than a replacement for standardized visual examination. A multimodal diagnostic model may include standardized visual examination, digital photography, fluorescence imaging, analysis of lesion symmetry and distribution, assessment of caries activity, and detailed evaluation of fluoride exposure during enamel development. Particular attention should be given to drinking-water sources, use and swallowing of fluoride-containing toothpaste, fluoride supplements, and other environmental or dietary sources.

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Prevention should aim to avoid excessive fluoride ingestion during tooth development while preserving the established caries-preventive benefits of appropriate topical fluoride use. Parent education, supervision of toothbrushing, reduction of toothpaste swallowing in young children, assessment of drinking-water fluoride concentration, and avoidance of unnecessary systemic fluoride supplementation are particularly important in high-risk populations.

Management of already erupted fluorotic enamel should follow minimally invasive principles. In very mild cases without substantial esthetic concern, observation, preventive counseling, and periodic digital documentation may be sufficient. In mild-to-moderate fluorosis with esthetic impairment, conservative options may include enamel microabrasion, bleaching in appropriately selected patients, and resin infiltration. Resin infiltration is particularly promising because penetration of low-viscosity resin into porous enamel can reduce the optical contrast between fluorotic areas and surrounding healthy enamel without substantial removal of tooth structure. The integration of digital fluorescence with minimally invasive treatment may also improve follow-up. Standardized pre- and post-treatment fluorescence imaging can support objective comparison, although treatment success should additionally be assessed by clinical appearance, surface integrity, standardized photography, and patient- or parent-reported esthetic satisfaction.

Conclusion. Digital fluorescence methods represent a promising adjunct for the early detection and monitoring of dental fluorosis in children. Their greatest value lies in integration with standardized visual examination, digital documentation, fluoride-exposure assessment, and differential diagnosis of other enamel lesions. A multimodal approach enables more individualized prevention and may reduce unnecessary invasive treatment. For erupted mild-to-moderate fluorotic lesions, minimally invasive techniques, particularly resin infiltration and carefully selected combination protocols, may provide favorable esthetic outcomes while preserving enamel structure. Future prospective studies should establish standardized fluorescence protocols and determine their diagnostic and monitoring value across different degrees of pediatric dental fluorosis.

Keywords: dental fluorosis, children, digital fluorescence, QLF, enamel, early diagnosis, resin infiltration, microabrasion, prevention, minimally invasive dentistry.

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