

Advanced Applications of Polyetheretherketone (PEEK) in Pediatric Dental Care: A Contemporary Review

Dr. Tenzin Dorji

Department of Dental
Sciences, Thimphu, Bhutan

Dr. Pema Choden

Department Department of
Oral Medicine, Paro, Bhutan

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ABSTRACT

Polyetheretherketone (PEEK) has emerged as one of the most promising high-performance polymers in modern dentistry owing to its exceptional mechanical properties, biocompatibility, chemical stability, and esthetic potential. While its application in prosthodontics, implantology, and restorative dentistry has been extensively explored, its utilization in pediatric dental care remains comparatively underrepresented despite substantial clinical potential. The increasing demand for child-friendly, metal-free, lightweight, and biologically compatible dental materials has stimulated interest in PEEK-based solutions for pediatric patients. This review critically examines the contemporary applications of PEEK in pediatric dentistry by synthesizing evidence from existing literature regarding its physicochemical characteristics, biological performance, restorative capabilities, and future prospects. The review analyzes the material's structural properties, surface modification strategies, biomechanical behavior, and clinical adaptability in pediatric oral environments. Furthermore, it evaluates current evidence concerning crowns, space maintainers, prosthetic devices, orthodontic components, and implant-related applications. Comparative assessment with conventional dental materials demonstrates that PEEK offers several advantages including reduced plaque accumulation, favorable stress distribution, excellent wear resistance, and improved patient comfort. Nevertheless, limitations associated with bonding performance, esthetic customization, and long-term clinical validation remain important considerations. The findings indicate that PEEK represents a transformative biomaterial capable of addressing several challenges in pediatric dental rehabilitation while supporting minimally invasive and patient-centered treatment approaches. Continued research and clinical evaluation are required to establish standardized protocols and expand its application across pediatric dental specialties.

Keywords: Polyetheretherketone, PEEK, Pediatric Dentistry, Biomaterials, Dental Restorations, Space Maintainers, Biocompatibility, Digital Dentistry, CAD/CAM, Pediatric Oral Rehabilitation.

1. INTRODUCTION

1.1 Background

Advancements in dental biomaterials have significantly transformed clinical dentistry by enabling the development of restorations and appliances that exhibit superior mechanical performance, enhanced esthetics, and improved biological compatibility. Among contemporary biomaterials, polyetheretherketone (PEEK) has attracted considerable attention due to its unique combination of physicochemical properties that make it suitable for various medical and dental applications. Initially developed for aerospace and industrial applications because of its high thermal stability and mechanical strength, PEEK subsequently gained recognition in orthopedic and spinal implant systems owing to its excellent biocompatibility and

resistance to degradation (Kurtz & Devine, 2007; Shekar et al., 2009).

The transition of PEEK into dentistry represents an important development in restorative and prosthetic sciences. Unlike conventional metallic frameworks, PEEK possesses an elastic modulus closer to that of human bone, allowing favorable stress distribution and reducing biomechanical complications associated with rigid restorative materials (Skirbutis et al., 2017). Furthermore, the material demonstrates excellent resistance to wear, corrosion, and chemical degradation, making it particularly suitable for long-term intraoral applications (Akay & Ersöz, 2020).

Pediatric dentistry presents unique challenges that differ substantially from adult dental care. Children often require restorative materials that are lightweight, non-toxic, esthetically acceptable, durable, and comfortable. Traditional

materials such as stainless steel crowns, acrylic appliances, and metallic space maintainers may fulfill functional requirements but frequently encounter limitations related to esthetics, allergic reactions, weight, and patient acceptance. Consequently, there is growing interest in alternative biomaterials capable of addressing these concerns while maintaining clinical effectiveness.

PEEK has emerged as a potential solution to many of these challenges. Recent studies have suggested that its favorable biomechanical properties, low plaque affinity, and high biocompatibility may support diverse pediatric applications including crowns, space maintainers, removable appliances, and prosthetic reconstructions (Mushtaq et al., 2021). Additionally, developments in CAD/CAM technology have facilitated the precise fabrication of customized PEEK-based restorations, enhancing their clinical applicability in pediatric populations.

1.2 Problem Statement

Despite increasing recognition of PEEK within dentistry, its applications in pediatric dental care remain relatively underexplored compared with prosthodontics and implantology. Most existing studies focus on adult restorative procedures, leaving significant gaps regarding pediatric-specific indications, clinical outcomes, long-term durability, and treatment protocols. Furthermore, questions remain concerning surface modifications, bonding mechanisms, and esthetic optimization necessary for successful pediatric implementation.

The lack of comprehensive synthesis of available evidence limits understanding of how PEEK can be integrated into contemporary pediatric practice. Consequently, clinicians may be hesitant to adopt PEEK-based interventions despite their potential benefits.

1.3 Research Relevance

The increasing prevalence of childhood dental diseases, developmental anomalies, traumatic injuries, and early tooth loss necessitates innovative restorative approaches that improve clinical outcomes and patient experiences. Pediatric dentistry increasingly emphasizes minimally invasive treatment, biological compatibility, and patient-centered care. Within this context, PEEK offers several attributes aligned with modern clinical objectives.

Its mechanical resilience, lightweight nature, and compatibility with digital manufacturing technologies position PEEK as a promising material capable of enhancing pediatric restorative and rehabilitative procedures. Moreover, growing interest in metal-free dentistry has further increased the relevance of PEEK as a substitute for traditional metallic devices (Akay & Ersöz, 2020).

1.4 Objectives

This review aims to:

1. Examine the physicochemical and biological properties of PEEK relevant to pediatric dentistry.
2. Analyze current applications of PEEK in pediatric dental care.
3. Evaluate evidence concerning clinical performance and therapeutic outcomes.
4. Identify advantages and limitations associated with PEEK-based pediatric treatments.
5. Explore future directions and research opportunities for PEEK in pediatric dentistry.

1.5 Scope and Significance

The scope of this review encompasses material science, biological interactions, restorative applications, prosthetic utilization, and technological advancements related to PEEK in pediatric dentistry. The review synthesizes available evidence to establish a comprehensive understanding of how PEEK may contribute to improved pediatric oral healthcare.

The significance of this work lies in its integration of biomaterial science with pediatric clinical requirements, thereby providing a foundation for future research and evidence-based adoption of PEEK in pediatric practice.

2. LITERATURE REVIEW

2.1 Evolution of PEEK as a Biomedical Material

The biomedical adoption of PEEK originated from orthopedic and spinal surgery applications where conventional metallic implants frequently generated stress shielding and imaging artifacts. Research conducted by Wenz et al. (1990) demonstrated the favorable in vitro biocompatibility of polyetheretherketone composites, establishing an early scientific basis for medical utilization.

Subsequent investigations expanded understanding of the material's biological performance. Rivard et al. (2002) reported successful in vivo biocompatibility outcomes in rabbit spinal implant systems, while Katzer et al. (2002) demonstrated the absence of significant cytotoxic and mutagenic effects. These findings collectively contributed to the acceptance of PEEK as a safe implantable biomaterial.

Kurtz and Devine (2007) further documented the successful integration of PEEK in trauma, orthopedic, and spinal applications. Their work highlighted the material's resistance to degradation, favorable mechanical properties, and compatibility with biological tissues. These characteristics

subsequently stimulated interest in dental applications.

2.2 Physicochemical Characteristics Relevant to Dentistry

The success of any dental biomaterial depends largely upon its mechanical and physicochemical properties. PEEK exhibits exceptional thermal stability, chemical resistance, and structural integrity. Originally developed for demanding aerospace applications, its high-performance characteristics remain evident in biomedical settings (Shekar et al., 2009).

One of the most significant advantages of PEEK is its elastic modulus, which approximates that of cortical bone more closely than conventional metallic materials. This property enables improved stress distribution during mastication and minimizes biomechanical overload at restoration interfaces (Skirbutis et al., 2017).

Akay and Ersöz (2020) emphasized that PEEK possesses low density, high fatigue resistance, and excellent wear characteristics. These properties are particularly valuable in pediatric patients where lightweight restorations and appliances may enhance comfort and compliance. The authors further identified PEEK as a versatile material suitable for numerous dental applications, reinforcing its growing significance within contemporary dentistry.

The fracture resistance of restorative materials remains another critical consideration. Although ceramic materials exhibit superior esthetics, they may be susceptible to brittle fracture under excessive stress. Quinn et al. (2003) demonstrated how microstructural factors influence fracture toughness in dental ceramics, indirectly supporting exploration of alternative materials such as PEEK that possess greater flexibility and impact resistance.

2.3 Biocompatibility and Biological Performance

Biocompatibility represents a fundamental requirement for materials intended for pediatric use. The oral environment exposes restorations to saliva, microorganisms, mechanical forces, and fluctuating temperatures. Consequently, long-term biological stability is essential.

Multiple investigations have confirmed favorable biological interactions associated with PEEK. Wenz et al. (1990), Rivard et al. (2002), and Katzer et al. (2002) collectively demonstrated excellent cellular compatibility and minimal adverse tissue responses.

Further evidence emerged from D'Ercole et al. (2020), who investigated bacterial adhesion on PEEK and titanium surfaces. Their findings indicated favorable microbial behavior associated with PEEK, suggesting

potential advantages for maintaining oral hygiene. This characteristic is particularly important in pediatric patients, who frequently exhibit challenges related to plaque control and oral hygiene maintenance.

Moreover, research involving nano-hydroxyapatite-coated PEEK implants demonstrated enhanced biological integration and bone interaction (Barkarmo et al., 2013). Similar outcomes were reported by Wu et al. (2012), who developed bioactive nano-TiO₂/PEEK composites exhibiting improved biological performance. These studies suggest that surface modifications may significantly expand future pediatric applications of PEEK.

2.4 PEEK in Contemporary Dental Practice

The integration of PEEK into dentistry has accelerated substantially during the past decade. Tekin et al. (2018) identified multiple dental applications including removable prostheses, implant components, fixed restorations, and orthodontic devices. Their analysis highlighted the material's versatility and compatibility with evolving digital workflows.

Similarly, Skirbutis et al. (2017) described PEEK as an emerging alternative to metallic frameworks due to its favorable mechanical behavior and patient comfort. These findings were further supported by Akay and Ersöz (2020), who emphasized its growing role across restorative and prosthetic disciplines.

2.5 Digital Manufacturing and CAD/CAM Integration

The incorporation of computer-aided design and computer-aided manufacturing (CAD/CAM) technologies has substantially expanded the clinical applicability of PEEK. Digital workflows facilitate the fabrication of highly accurate restorations, appliances, and prosthetic frameworks while reducing laboratory variability. For pediatric patients, digital production offers important advantages including reduced chairside time, improved precision, and enhanced patient comfort.

Vulović et al. (2022) evaluated the surface characteristics of commercially available CAD/CAM restorative materials and highlighted the importance of surface quality in determining long-term restorative success. The compatibility of PEEK with digital milling systems enables production of customized pediatric restorations exhibiting excellent fit and predictable mechanical behavior.

Furthermore, additive manufacturing techniques have expanded opportunities for producing complex PEEK structures. Tan et al. (2003) demonstrated the feasibility of selective laser sintering for fabricating PEEK-hydroxyapatite scaffolds, indicating the potential for advanced regenerative and reconstructive applications. Such developments suggest future opportunities for customized pediatric prostheses and craniofacial rehabilitation devices.

2.6 Surface Modification and Adhesion Challenges

Despite numerous advantages, one frequently cited limitation of PEEK is its relatively inert surface chemistry. The material's low surface energy can compromise adhesion to composite resins and veneering materials, potentially affecting restorative durability.

Zhou et al. (2014) investigated the influence of various surface treatments on bond strength and reported significant improvements following appropriate surface modification procedures. Their findings emphasize the importance of mechanical and chemical conditioning protocols to optimize clinical performance.

Surface engineering has become a major focus of contemporary PEEK research. Bioactive coatings, plasma treatments, and nanoparticle incorporation have been explored to enhance biological integration and restorative bonding. Barkarmo et al. (2013) demonstrated improved biological behavior following nano-hydroxyapatite coating, while Wu et al. (2012) reported enhanced bioactivity using nano-TiO₂ reinforcement.

For pediatric dentistry, these developments are particularly relevant because long-term retention and durability of restorations depend heavily on predictable bonding performance. Continued advances in surface modification may overcome one of the principal barriers limiting widespread adoption.

2.7 PEEK in Pediatric Dentistry

Specific literature concerning pediatric applications remains comparatively limited; however, available evidence indicates substantial clinical promise. Mushtaq et al. (2021) described PEEK as a futuristic material capable of addressing several limitations associated with traditional pediatric restorative materials. The authors highlighted advantages including superior biocompatibility, reduced weight, esthetic acceptability, and enhanced patient comfort.

Children requiring long-term space maintenance, prosthetic rehabilitation following trauma, or management of developmental anomalies may particularly benefit from PEEK-based appliances. Unlike metallic devices, PEEK offers improved esthetics and reduced risk of metal sensitivity. Furthermore, its favorable mechanical properties support functional performance while minimizing excessive force transmission to developing oral structures.

The increasing emphasis on minimally invasive dentistry further strengthens the relevance of PEEK. Modern pediatric treatment strategies prioritize preservation of healthy tissues while ensuring long-term function and patient acceptance. The material's versatility aligns

closely with these objectives.

2.8 Identification of Research Gaps

Although existing studies establish a strong scientific foundation for PEEK utilization, several significant gaps remain.

First, most investigations focus on prosthodontic and implantological applications involving adult populations. Pediatric-specific clinical studies remain limited, restricting evidence-based treatment recommendations.

Second, long-term clinical outcomes involving pediatric restorations and appliances have not been comprehensively evaluated. Data regarding durability, wear behavior, maintenance requirements, and patient satisfaction remain insufficient.

Third, standardized protocols for bonding, surface treatment, and esthetic enhancement require further refinement. Although studies demonstrate improvements through surface modification, consensus regarding optimal clinical procedures has not yet emerged.

Finally, economic evaluations comparing PEEK with conventional pediatric materials remain scarce. Understanding cost-effectiveness will be essential for broader clinical adoption.

Collectively, these gaps justify continued investigation into PEEK-based pediatric dental applications and support the need for comprehensive contemporary reviews.

3. Methodology

3.1 Research Design

This study employed a narrative-review methodology designed to critically evaluate and synthesize existing scientific evidence regarding the advanced applications of polyetheretherketone in pediatric dentistry. The review approach was selected because the available literature encompasses material science, biomedical engineering, prosthodontics, restorative dentistry, implantology, and pediatric clinical practice.

The objective was not merely to summarize published studies but to develop an integrated conceptual framework explaining how the physical, biological, and clinical characteristics of PEEK contribute to its emerging role in pediatric dental care.

3.2 Theoretical Framework

The theoretical basis of this review is founded upon three interconnected dimensions:

Material Science Dimension

This dimension evaluates the intrinsic properties of PEEK, including:

- Mechanical strength
- Elastic modulus
- Wear resistance
- Thermal stability
- Chemical resistance
- Surface characteristics

These factors determine the suitability of PEEK for long-term intraoral use and influence restorative performance.

Biological Dimension

The biological framework examines:

- Cytocompatibility
- Tissue integration
- Biofilm formation
- Bacterial adhesion
- Host response

These variables determine the safety and biological acceptance of PEEK in pediatric patients.

Clinical Dimension

The clinical dimension investigates:

- Restorative applications
- Prosthetic rehabilitation
- Space maintenance
- Orthodontic utility
- Digital fabrication compatibility

The interaction among these dimensions provides a comprehensive understanding of the material's role in pediatric dentistry.

3.3 Data Sources

The review exclusively utilized the references provided for this study. These references were selected because they collectively represent the major scientific domains influencing contemporary PEEK research.

The included studies encompassed:

1. Fundamental biomaterial investigations.
2. Biocompatibility assessments.
3. Surface modification research.
4. Prosthodontic applications.
5. Implantology studies.
6. CAD/CAM material evaluations.
7. Pediatric dentistry-specific investigations.

Restricting analysis to the provided literature ensured consistency and maintained methodological transparency.

3.4 Analytical Framework

To facilitate systematic evaluation, the literature was categorized into five major analytical themes.

Theme 1: Material Properties

Studies examining the physicochemical characteristics of PEEK were analyzed to determine how these properties influence clinical performance.

Important parameters included:

- Elastic modulus
- Fracture resistance
- Wear resistance
- Fatigue behavior
- Structural stability

The findings of Shekar et al. (2009), Skirbutis et al. (2017), and Akay and Ersöz (2020) were particularly relevant within this category.

Theme 2: Biological Compatibility

Studies evaluating cytotoxicity, mutagenicity, tissue response, and microbial interactions were examined to assess safety profiles.

Research conducted by Wenz et al. (1990), Katzer et al. (2002), Rivard et al. (2002), and D'Ercole et al. (2020) formed the primary basis for this analysis.

Theme 3: Surface Engineering

This category evaluated modifications designed to improve:

- Bond strength
- Osseointegration
- Bioactivity
- Surface roughness

Studies by Zhou et al. (2014), Barkarmo et al. (2013), and Wu et al. (2012) provided critical evidence regarding enhancement strategies.

Theme 4: Dental Applications

This theme focused on clinical applications within dentistry.

Particular attention was given to:

- Fixed restorations
- Removable prostheses
- Implant components
- Orthodontic appliances
- Pediatric dental devices

The investigations of Tekin et al. (2018), Skirbutis et al. (2017), and Mushtaq et al. (2021) significantly contributed to this area.

Theme 5: Digital Dentistry

Digital workflows increasingly influence contemporary clinical practice.

This category evaluated:

- CAD/CAM fabrication
- Digital customization
- Additive manufacturing
- Precision production

Studies by Vulović et al. (2022) and Tan et al. (2003) supported analysis of digital integration.

3.5 Conceptual Model of PEEK Utilization in Pediatric Dentistry

Based on synthesized evidence, a conceptual model was developed describing the progression from material properties to clinical outcomes.

Stage 1: Material Characteristics

PEEK possesses:

- High mechanical strength
- Favorable elasticity
- Chemical stability
- Low density

These characteristics establish the foundation for clinical use.

Stage 2: Biological Performance

The material demonstrates:

- Excellent biocompatibility
- Minimal cytotoxicity
- Reduced inflammatory potential
- Favorable microbial interactions

These properties support safe intraoral application.

Stage 3: Clinical Adaptation

Through CAD/CAM technologies and surface modifications, PEEK can be adapted for diverse pediatric indications.

Examples include:

- Crowns
- Space maintainers
- Removable appliances
- Prosthetic frameworks

Stage 4: Clinical Outcomes

Expected outcomes include:

- Improved patient comfort
- Enhanced esthetics
- Reduced appliance weight
- Favorable biomechanical behavior
- Increased treatment acceptance

3.6 Application Areas Evaluated

The methodology specifically examined five major pediatric application domains.

Pediatric Crowns

PEEK crowns were evaluated for:

- Durability
- Esthetics
- Marginal integrity
- Wear resistance

Space Maintainers

Analysis focused on:

- Structural stability
- Patient comfort
- Oral hygiene maintenance

Removable Prostheses

Factors assessed included:

- Weight reduction
- Retention
- Functional performance

Orthodontic Components

Evaluation included:

- Mechanical flexibility
- Biocompatibility
- Esthetic acceptability

Implant-Related Pediatric Applications

Although uncommon in pediatric patients, implant-related applications were examined from a future-oriented perspective due to emerging technological developments.

3.7 Methodological Limitations

Several limitations should be acknowledged.

The available literature contains relatively few pediatric-specific investigations, necessitating partial extrapolation from broader dental and biomedical research.

Additionally, many studies are laboratory-based rather than clinical trials, limiting direct translation into routine practice.

Variability in surface treatment protocols, manufacturing methods, and outcome measures further complicates comparison among studies.

Nevertheless, the collective evidence provides a robust foundation for evaluating the current and future role of PEEK in pediatric dental care.

4. Results

The comprehensive analysis of the selected literature demonstrates that polyetheretherketone (PEEK) possesses a unique combination of mechanical, biological, and clinical properties that support its increasing relevance in pediatric dental care. The findings indicate that PEEK is not merely an alternative restorative material but a multifunctional biomaterial capable of addressing several limitations associated with conventional pediatric dental materials.

A major finding concerns the material's biomechanical compatibility. Unlike traditional metallic restorations and appliances, PEEK exhibits an elastic modulus closer to cortical bone, enabling more favorable stress distribution during functional loading (Skirbutis et al., 2017; Kurtz & Devine, 2007). This characteristic is particularly important in pediatric patients because developing craniofacial structures are more susceptible to adverse biomechanical forces. The literature consistently suggests that PEEK-based restorations may reduce stress concentration and improve long-term functional adaptation.

The evidence further demonstrates strong biological compatibility. Studies evaluating cytotoxicity, mutagenicity, and tissue responses revealed minimal adverse biological effects, supporting the safety of PEEK for intraoral applications (Katzner et al., 2002; Rivard et al., 2002; Wenz et al., 1990). Such findings are especially relevant in pediatric dentistry, where material safety is a critical consideration due to prolonged exposure during developmental years.

Another significant finding relates to microbial interactions. D'Ercole et al. (2020) reported favorable bacterial adhesion characteristics on PEEK surfaces compared with conventional implant materials. Reduced microbial colonization may contribute to improved oral hygiene maintenance and lower risk of inflammatory complications in pediatric patients who frequently experience challenges in plaque control.

Surface modification studies identified both opportunities and limitations. While untreated PEEK exhibits relatively low surface energy, various treatment approaches significantly improved bond strength and biological performance (Zhou et al., 2014; Barkarmo et al., 2013; Wu et al., 2012). These findings suggest that surface engineering can substantially enhance clinical outcomes and expand the range of pediatric applications.

The review also identified growing integration between PEEK

and digital dentistry. CAD/CAM manufacturing enables precise fabrication of customized restorations, space maintainers, and prosthetic devices with consistent quality and reduced production variability (Vulović et al., 2022). Digital workflows appear particularly advantageous in pediatric settings because they facilitate efficient treatment delivery and individualized appliance design.

Regarding pediatric-specific applications, the available evidence indicates potential utility in crowns, removable prostheses, space maintainers, and orthodontic devices (Mushtaq et al., 2021). The material's lightweight nature, esthetic neutrality, and patient comfort may improve treatment acceptance among children. However, despite encouraging laboratory and clinical observations, long-term pediatric clinical studies remain limited.

Overall, the findings support the conclusion that PEEK represents a promising biomaterial with substantial potential to enhance contemporary pediatric dental care through improved biological compatibility, biomechanical performance, and digital adaptability.

5. Discussion

The findings of this review highlight the growing significance of PEEK as an innovative biomaterial capable of transforming pediatric dental treatment approaches. The evidence suggests that the material's success derives from the interaction of its mechanical, biological, and technological advantages rather than any single property alone.

From a theoretical perspective, the favorable elastic modulus of PEEK represents one of its most important characteristics. Traditional metallic materials possess significantly greater rigidity than biological tissues, often producing stress concentration and biomechanical mismatch. In contrast, PEEK demonstrates mechanical behavior more closely resembling natural bone, thereby promoting more physiologic force transmission (Kurtz & Devine, 2007; Skirbutis et al., 2017). This advantage may be particularly beneficial in pediatric patients whose oral structures remain actively developing.

The biological evidence further strengthens the rationale for pediatric utilization. The collective findings of Wenz et al. (1990), Katzer et al. (2002), and Rivard et al. (2002) consistently demonstrate favorable tissue compatibility and biological safety. Such outcomes are essential in pediatric dentistry because long-term exposure to restorative materials occurs during critical developmental periods. The absence of significant cytotoxic or mutagenic effects enhances confidence in the material's suitability for young patients.

An important observation emerging from the literature is

the growing role of surface engineering. Although PEEK's inert nature contributes to its chemical stability, the same property may compromise adhesive performance. Studies investigating surface modification strategies demonstrate that bioactive coatings and mechanical treatments can significantly improve bonding and biological integration (Zhou et al., 2014; Barkarmo et al., 2013). Consequently, future clinical success may depend not only on the base material itself but also on optimization of surface characteristics.

The findings additionally emphasize the importance of digital dentistry in facilitating PEEK adoption. CAD/CAM systems enable precise fabrication of customized restorations that satisfy both functional and esthetic requirements. For pediatric patients, reduced chairside adjustments and improved appliance fit may contribute to better treatment experiences and greater compliance. The integration of digital manufacturing therefore represents a critical factor supporting future expansion of PEEK applications.

Despite these advantages, several limitations must be acknowledged. First, pediatric-specific evidence remains relatively scarce. Most available studies originate from prosthodontics, implantology, and orthopedic research. Consequently, direct extrapolation to pediatric dentistry should be approached cautiously. Second, esthetic limitations remain relevant because the intrinsic color of PEEK may not fully replicate natural dental tissues without veneering procedures. Third, specialized manufacturing requirements and material costs may restrict accessibility in certain clinical settings.

The review also identifies a need for standardized clinical protocols. Variability in bonding techniques, surface treatments, and fabrication methods complicates comparison among studies and may affect clinical outcomes. Future research should therefore focus on establishing evidence-based guidelines for pediatric applications.

Overall, the literature supports the view that PEEK is positioned to become an increasingly important component of pediatric dental rehabilitation. Its ability to combine biological safety, mechanical performance, and digital compatibility aligns closely with contemporary principles of minimally invasive and patient-centered care.

6. Conclusion

Polyetheretherketone has emerged as one of the most promising biomaterials in contemporary dentistry and demonstrates substantial potential for pediatric dental applications. The evidence reviewed in this study indicates that PEEK possesses a unique combination of favorable biomechanical properties, excellent biocompatibility, chemical stability, and compatibility with modern digital manufacturing technologies. These characteristics distinguish it from many conventional pediatric restorative materials and support its

growing clinical relevance.

The review demonstrates that PEEK can contribute to multiple areas of pediatric dental care, including crowns, space maintainers, prosthetic devices, orthodontic components, and future implant-related applications. Its lightweight nature, resistance to degradation, favorable stress-distribution characteristics, and biological safety provide important advantages for young patients. The material's compatibility with CAD/CAM systems further enhances its clinical utility by enabling customized, precise, and efficient treatment solutions.

The literature also highlights the importance of surface modification technologies in overcoming limitations related to bonding and bioactivity. Emerging approaches involving nano-hydroxyapatite coatings, titanium dioxide reinforcement, and surface conditioning techniques have shown encouraging results and may significantly expand future clinical applications.

Nevertheless, important challenges remain. Long-term pediatric clinical studies are limited, standardized treatment protocols have not been fully established, and additional research is required to optimize esthetic outcomes and cost-effectiveness. Future investigations should prioritize prospective clinical trials, comparative outcome analyses, and development of pediatric-specific guidelines.

In conclusion, PEEK represents a contemporary and highly promising biomaterial that aligns with evolving goals of pediatric dentistry, including minimally invasive treatment, biological compatibility, functional efficiency, and enhanced patient comfort. Continued scientific and clinical advancement is likely to further establish its role as a valuable component of next-generation pediatric oral healthcare.

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