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Improvement of Preventive Prostheses in Children with Missing Permanent Teeth

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Abstract The loss of permanent molars in the pediatric population presents significant challenges for normal masticatory development, occlusal stability, and psychological well-being. This study aimed to evaluate and improve preventive prosthetic solutions for children with congenitally missing or prematurely lost permanent molars. A prospective cohort study was conducted on 120 children (mean age 10.4 ± 2.1 years) who received either conventional removable dentures (n=60) or advanced removable dentures with reinforced clasps and biocompatible resin matrices (n=60). Clinical parameters assessed included masticatory efficiency (using standardized food comminution tests), occlusal force distribution (utilizing digital bite force analysis), denture retention and stability (measured by dislodgement resistance), and psychological adaptation scores. Radiographic evaluation included assessment of alveolar ridge resorption and treatment-related changes in bone morphology. Statistical analysis using Student's t-test and Chi-square tests revealed that improved denture design significantly enhanced masticatory efficiency (72.4 ± 8.3% vs. 58.6 ± 9.7%, $p < 0.001$) and reduced denture dislodgement frequency ($p = 0.002$). Advanced prosthetic designs incorporating flexible clasps and shock-absorbing materials demonstrated superior retention characteristics and reduced risk of iatrogenic ridge resorption. Furthermore, children treated with improved prostheses reported higher psychological acceptance (satisfaction score: 8.2 ± 1.1 vs. 6.4 ± 1.5, $p < 0.01$) and better compliance with denture wear. In conclusion, optimization of pediatric preventive prostheses through biomechanical enhancement, material selection, and design modification substantially improves clinical outcomes and child well-being. Recommendations include preferential use of flexible clasping systems, biocompatible polymeric materials, and periodic clinical reassessment protocols to accommodate the dynamic changes inherent to the growing dentition.

Keywords Preventive prostheses, Pediatric dentistry, Missing permanent molars, Masticatory efficiency, Removable dentures, Occlusal development

1. Introduction

The permanent dentition serves as the fundamental framework for lifelong oral function, esthetics, and overall quality of life. However, the loss of permanent molars during childhood—whether due to congenital absence, developmental anomalies, traumatic injury, or caries—represents a significant clinical and developmental challenge. The prevalence of hypodontia (congenital tooth agenesis) in the global pediatric population ranges from 3.5% to 10.1%, with permanent molars being among the most frequently affected teeth following third molars and lateral incisors [1]. The premature loss of permanent molars during the developmental years disrupts the delicate equilibrium of occlusal development and carries multifactorial consequences. Functionally, the absence of molar support reduces masticatory efficiency, necessitating compensatory stress redistribution to remaining dentition and potentially leading to excessive wear, temporomandibular dysfunction, and altered feeding patterns [2]. Biomechanically, the loss of posterior support compromises the vertical dimension of occlusion and destabilizes the spatial relationship of dental arches, precipitating mesial drift of posterior teeth, anterior crowding, and progressive malocclusion [3]. Orthopedically, continued alveolar ridge resorption progresses without functional stimulus from tooth roots, particularly in pediatric patients where bone metabolism is heightened [4]. Psychologically and socially, visible dental deficiencies during formative years generate significant negative impact on self-esteem, social integration, and psychological development [5]. While osseointegrated implants represent the gold standard for adult patients with missing teeth, their application in pediatric populations is contraindicated until completion of skeletal maturity due to the risk of progressive infraocclusion and compromised esthetic outcomes [6]. Consequently, preventive prostheses—including removable

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partial dentures, space maintainers with functional components, and advanced hybrid designs—represent the most evidence -based interim therapeutic modality for pediatric patients with missing permanent teeth [7]. Traditional removable prostheses have served pediatric patients for decades; however, conventional designs frequently suffer from inadequate retention, frequent dislodgement, reduced masticatory efficiency, and poor long-term compliance [8]. These limitations result from several factors: (1) the physiological changes inherent to the growing jaws necessitate frequent prosthetic adjustments and remakes; (2) rigid clasping systems impose excessive force on abutment teeth, inducing root resorption and periodontal damage; (3) inadequate shock absorption during mastication transmits harmful forces to remaining dentition; and (4) esthetic concerns and social stigma associated with visible removable dentures reduce patient acceptance and denture wear compliance [9]. Recent advances in pediatric prosthodontics have introduced biomechanical improvements including flexible clasping mechanisms, thermoplastic and semi-flexible resin matrices, and multilayered cushioning systems designed to mimic natural periodontal support [10]. These innovations aim to preserve the integrity of abutment teeth, enhance denture stability, improve masticatory function, and optimize psychological acceptance in pediatric patients. The current body of evidence regarding these advanced prosthetic designs remains limited, necessitating rigorous clinical evaluation to establish their superiority over conventional approaches and to develop evidence-based treatment protocols for optimal pediatric prosthetic rehabilitation [11]. The present study seeks to evaluate the clinical and biomechanical efficacy of improved preventive prosthetic designs in pediatric patients with missing permanent molars, comparing advanced removable dentures incorporating biomechanical innovations with conventional removable prostheses using standardized clinical outcome measures, radiographic assessment, and psychosocial evaluation tools.

2. Materials and Methods

A prospective cohort study was conducted over a 24-month period involving 120 children (mean age: 10.4 ± 2.1 years; range: 8-15 years) presenting with congenitally missing or prematurely lost permanent molars. Participants were recruited from the Department of Pediatric Dentistry at Tashkent State Medical University and affiliated pediatric dental clinics. Inclusion Criteria: (1) Age between 8 and 15 years; (2) Documented absence of one or more permanent molars (first or second molars); (3) Eruption or near-eruption of permanent successors (not primary dentition); (4) Absence of systemic conditions affecting bone metabolism or wound healing; (5) Parental consent and patient assent to prosthetic treatment; (6) Minimum 24-month follow-up feasibility. Exclusion Criteria: (1) Uncontrolled caries or active periodontal disease; (2) Presence of systemic conditions affecting dental development (e.g., amelogenesis imperfecta, dentinogenesis imperfecta); (3) History of facial trauma affecting occlusal relationships; (4) Previous denture wear or prosthetic treatment; (5) Developmental syndromes affecting craniofacial morphology. Participants were stratified into two treatment groups based on prosthetic design:

Group A (Conventional Dentures, n=60): Children received removable partial dentures constructed using rigid acrylic resin bases with stainless steel circumferential clasps using conventional clasp design principles [12]. Group B (Advanced Dentures, n=60): Children received removable partial dentures incorporating biomechanical innovations: (1) flexible thermoplastic clasping systems designed to distribute retentive forces over extended abutment surfaces; (2) resilient resin matrices incorporating shock-absorbing elastomeric layers; (3) enhanced retention mechanisms through improved undercut engagement; (4) ergonomic design modifications facilitating insertion and removal by pediatric patients [13]. Masticatory Efficiency Evaluation: Masticatory efficiency was quantified using the standardized food comminution test, wherein participants were instructed to masticate a standardized sample of peanuts (20 grams) for 20 complete masticatory cycles. Comminuted particles were collected and sieved through standardized mesh screens (2mm, 1mm, and 0.5mm). The percentage of particles retained on the 1mm screen was calculated as the masticatory efficiency index, with higher percentages indicating superior masticatory function [14]. Occlusal Force Distribution Analysis: Digital bite force analysis was conducted using the T-Scan III system (Tekscan, Inc., South Boston, MA), capturing real-time occlusal contact patterns and force distribution across bilateral molar regions. Maximum bite force (MBF) was recorded in Newtons, and force symmetry ratio was calculated as the percentage difference between contralateral molar regions [15]. Denture Retention and Stability Assessment: Denture retention was objectively measured using the vertical dislodgement resistance test, wherein a calibrated force gauge (Shimpo DFS-100, Shimpo Instruments, Itasca, IL) applied progressively increasing vertical load until denture dislodgement occurred. Measurements were recorded in Newtons. Clinical stability was assessed through dynamic functional tests including mastication, speech, and swallowing maneuvers, with stability scored on a four-point scale (1=unstable; 4=highly stable) [16]. Psychological Adaptation and Compliance Assessment: Psychological adaptation was evaluated using a modified version of the Denture Satisfaction Scale, a validated instrument assessing patient satisfaction with esthetics, retention, comfort, and masticatory function. Scores ranged from 0-10, with higher scores indicating greater satisfaction. Denture wear compliance was documented through parental questionnaires at baseline, 3, 6, 12, and 24 months, quantifying daily wear duration and frequency of voluntary removal [17]. Standardized digital periapical radiographs were obtained using the parallel technique at baseline and at 12-month intervals. Alveolar ridge height was measured digitally from the alveolar crest to the inferior border of the mandible using calibration software (ImageJ, National Institutes of Health). Ridge resorption was calculated as the absolute change in millimeters and presented as percentage change relative to baseline measurements [18].

Data were analyzed using IBM SPSS Statistics Version 26.0 (IBM Corp., Armonk, NY). Descriptive statistics were calculated for all continuous variables, expressed as mean ± standard deviation. Comparative analysis between groups was conducted using independent samples Student's t-test for normally distributed continuous variables (verified through Shapiro-Wilk testing). Categorical variables were analyzed using Chi-square tests. Repeated measures ANOVA was employed to assess changes over time within each group. Pearson's correlation coefficients were calculated to determine relationships between variables. A confidence interval of 95% ($\alpha = 0.05$) was established for all analyses, with $p < 0.05$ considered statistically significant.

3. Results

No significant differences were observed between Group A and Group B regarding age, gender distribution, or distribution of missing teeth ($p > 0.05$). Mean age was 10.4 ± 2.1 years across both groups. Fifty-two percent of participants were female, and 48% were male. Missing first molars comprised 65% of cases, while missing second molars represented 35% of cases, distributed equally between maxillary and mandibular arches ($p = 0.62$). Group B (advanced dentures) demonstrated significantly superior masticatory efficiency compared to Group A (conventional dentures) at all time intervals. At baseline, mean masticatory efficiency was 72.4 ± 8.3% for Group B versus 58.6 ± 9.7% for Group A ($t = 8.92$, $p < 0.001$). This significant difference was maintained at 12-month (Group B: 71.8 ± 8.9% vs. Group A: 59.2 ± 10.1%, $p < 0.001$) and 24-month follow-up (Group B: 70.5 ± 9.2% vs. Group A: 58.1 ± 10.8%, $p < 0.001$), demonstrating sustained superiority of advanced prosthetic design [19]. Digital bite force analysis revealed that Group B achieved significantly more symmetrical force distribution, with mean bilateral asymmetry ratio of 8.3 ± 2.1% compared to Group A's 14.6 ± 3.2% ($t = 11.24$, $p < 0.001$). Maximum bite force values were similar between groups at baseline (Group B: 285 ± 52 N vs. Group A: 278 ± 48 N, $p = 0.41$), indicating that superior force distribution in Group B was attributable to prosthetic design rather than inherent force-generating capacity [20]. Vertical dislodgement resistance testing revealed substantial differences between groups. Group B dentures required mean vertical force of 18.6 ± 3.4 N to dislodge, whereas Group A dentures required only 11.2 ± 2.8 N ($t = 12.87$, $p < 0.001$). Frequency of accidental denture dislodgement during normal functional activities (eating, speaking, swallowing) was significantly lower in Group B: 0.3 ± 0.2 episodes per week versus 1.8 ± 0.6 episodes per week in Group A ($\chi^2 = 28.41$, $p = 0.002$). Clinical stability scores during dynamic functional evaluation were higher for Group B (mean: 3.7 ± 0.4) compared to Group A (mean: 2.6 ± 0.6, $t = 9.56$, $p < 0.001$) [21]. Progressive alveolar ridge resorption was observed in both groups, but magnitude of resorption differed significantly. At 12 months, Group A demonstrated mean ridge resorption of 1.8 ± 0.5 mm, whereas Group B demonstrated 0.8 ± 0.3 mm ($t = 9.34$, $p < 0.001$). At 24 months, resorption had progressed to 3.2 ± 0.7 mm in Group A versus 1.4 ± 0.4 mm in Group B ($t = 13.82$, $p < 0.001$). These findings suggest that superior force distribution and shock absorption in advanced denture design significantly reduces harmful loading on alveolar ridge tissues [22]. Mean satisfaction scores on the Denture Satisfaction Scale were significantly higher for Group B (8.2 ± 1.1) compared to Group A (6.4 ± 1.5) at baseline ($t = 7.34$, $p < 0.01$). Subscale analysis revealed that Group B participants reported significantly higher satisfaction with denture esthetics ($p < 0.05$), retention ($p < 0.01$), and masticatory comfort ($p < 0.01$), with no significant difference in perceived denture comfort ($p = 0.18$). Denture wear compliance differed substantially between groups. At baseline, both groups showed similar wear compliance; however, at 6-month follow-up, Group B maintained mean daily wear duration of 14.8 ± 2.1 hours compared to Group A's 9.6 ± 3.2 hours ($t = 9.27$, $p < 0.001$). This differential was maintained at 12-month (Group B: 14.6 ± 2.3 hours vs. Group A: 8.9 ± 3.5 hours, $p < 0.001$) and 24-month follow-up (Group B: 14.2 ± 2.6 hours vs. Group A: 8.1 ± 3.8 hours, $p < 0.001$) [23]. Clinical examination of abutment teeth revealed no significant differences in plaque accumulation or gingival inflammation between groups. However, mobility of abutment teeth was significantly greater in Group A at 24-month follow-up: 35% of Group A abutment teeth exhibited grade 1 or higher mobility, compared to only 8% in Group B ($\chi^2 = 18.46$, $p < 0.001$). This finding suggests that rigid clasping systems in conventional dentures induce cumulative trauma to abutment tooth periodontium [24].

4. Discussion

The present study demonstrates that advanced preventive prosthetic designs incorporating biomechanical enhancements substantially improve clinical outcomes in pediatric patients with missing permanent molars. The significant differences in masticatory efficiency between groups (72.4 ± 8.3% vs. 58.6 ± 9.7%, $p < 0.001$) indicate that improved denture design not only restores masticatory function but achieves levels approximating those with intact natural dentition, particularly relevant during the critical period of pediatric development when adequate nutritional intake is essential [25]. The superior force distribution characteristics of Group B dentures, evidenced by significantly lower bilateral asymmetry ratios (8.3 ± 2.1% vs. 14.6 ± 3.2%, $p < 0.001$), reflect the biomechanical advantages of flexible clasping systems and resilient resin matrices. These design features distribute occlusal forces more physiologically across broader abutment surfaces and cushioning structures, mimicking the natural periodontal support provided by tooth roots and supporting ligaments. This mechanism is consistent with contemporary understanding of force distribution in biological systems and explains the reduced rate of abutment tooth mobility observed in Group B [26].

Radiographic findings demonstrating reduced ridge resorption in Group B (1.4 ± 0.4 mm at 24 months vs. 3.2 ± 0.7 mm in Group A, $p < 0.001$) carry profound implications for long-term prosthetic stability and treatment outcomes. Ridge resorption represents an irreversible process that progressively compromises denture retention and necessitates periodic prosthetic remakes. The approximately 56% reduction in resorption rate in Group B suggests that advanced prosthetic designs preserve alveolar ridge morphology, potentially extending the functional lifespan of individual prostheses and reducing overall treatment burden [27]. The significantly higher psychological acceptance and improved compliance observed in Group B (satisfaction score: 8.2 ± 1.1 vs. 6.4 ± 1.5, $p < 0.01$) reflect the multidimensional benefits of improved prosthetic design. Enhanced retention and stability reduce the psychosocial stress associated with denture dislodgement during social interactions, a particular concern during adolescence when peer social acceptance is paramount. Superior masticatory efficiency enables normal dietary choices rather than restricting children to soft foods, further enhancing quality of life [28]. The sustained differences in wear compliance over 24 months (Group B: 14.2 ± 2.6 hours/day vs. Group A: 8.1 ± 3.8 hours/day, $p < 0.001$) indicate that improved initial design success translates into durable compliance patterns, critical for achieving therapeutic objectives. Adequate denture wear is fundamental to preserving alveolar ridge morphology, maintaining occlusal relationships, and achieving optimal masticatory function. The approximately 75% reduction in accidental dislodgement episodes in Group B (0.3 vs. 1.8 episodes/week, $p = 0.002$) substantially reduces the embarrassment and social disruption experienced by children when dentures become dislodged during school, sports, or social activities [29]. The clinical observation that abutment tooth mobility was significantly lower in Group B (8% vs. 35%, $p < 0.001$) represents a critical finding supporting the hypothesis that rigid clasping systems induce cumulative traumatic stress to periodontal tissues. This finding aligns with biomechanical principles demonstrating that force distribution over extended surface areas and through flexible transmission mechanisms reduces stress concentration on individual load-bearing points. The preservation of abutment tooth health is essential, as these teeth represent crucial remaining elements of the natural dentition and their loss would necessitate more extensive and complex prosthetic rehabilitation [30].

5. Conclusions

This comprehensive clinical investigation demonstrates that optimization of pediatric preventive prostheses through systematic biomechanical enhancement, advanced material selection, and innovative design modification significantly improves clinical outcomes across multiple dimensions. Children treated with advanced removable dentures incorporating flexible clasping systems, resilient resin matrices, and optimized load-distribution architectures achieved substantially superior masticatory efficiency, more symmetrical occlusal force distribution, enhanced denture retention and stability, reduced alveolar ridge resorption, and markedly improved psychological acceptance compared to those receiving conventional dentures. The sustained superiority of advanced prosthetic designs across all measured outcomes—maintained throughout the 24-month observation period—indicates that these improvements are not merely transient phenomena but represent enduring functional and biological advantages. The reduced rate of ridge resorption in Group B suggests that advanced designs may extend the functional lifespan of individual prostheses and reduce the frequency of prosthetic remakes otherwise necessitated by progressive ridge atrophy. From a clinical perspective, the findings establish compelling evidence supporting preferential use of advanced prosthetic designs incorporating flexible clasping mechanisms and shock-absorbing materials in pediatric patients with missing permanent molars. The significantly improved psychological adaptation and denture wear compliance observed in children treated with advanced designs underscore the critical importance of optimizing esthetic and functional characteristics, particularly during formative years when self-esteem and psychosocial development are substantially influenced by dental appearance and function. The preservation of abutment tooth health achieved through advanced prosthetic design—evidenced by markedly lower rates of abutment tooth mobility—has profound implications for long-term dental health and future restorative needs. By protecting the remaining natural dentition, advanced prosthetic rehabilitation strategies not only optimize current function but invest in superior long-term oral health outcomes. Recommendations for clinical practice include: (1) prioritization of advanced removable denture designs incorporating flexible clasping systems and resilient resin matrices as the prosthetic modality of choice for pediatric patients with missing permanent molars; (2) implementation of systematic protocols for periodic clinical reassessment and prosthetic adjustment to accommodate the dynamic changes inherent to the growing dentition; (3) patient and parental education emphasizing the importance of adequate denture wear compliance for achievement of optimal functional and developmental outcomes; and (4) consideration of advanced prosthetic designs not as premium options but as evidence-based standard care for pediatric prosthetic rehabilitation. Future investigations should incorporate longer follow-up periods extending into late adolescence and early adulthood to assess whether the biological and functional advantages of advanced designs are sustained following skeletal maturation and to evaluate the transition to definitive prosthetic or implant-based rehabilitation. Additionally, comparative cost-effectiveness analyses incorporating direct treatment costs and indirect costs associated with reduced denture wear compliance, more frequent prosthetic remakes, and potential abutment tooth loss in conventional denture groups would provide valuable economic evidence supporting the adoption of advanced prosthetic technologies. In conclusion, while preventive prostheses represent a temporary therapeutic modality pending more definitive rehabilitation through implant dentistry at skeletal maturity, optimization of design and material characteristics ensures that this important interim treatment phase achieves maximal functional benefit, preserves oral tissues, and supports the psychological well-being of children with missing permanent teeth.

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