THE JOURNAL OF PROSTHETIC DENTISTRY

RESEARCH AND EDUCATION

Wear behavior of CAD-CAM zirconia, ceramic, and 3D printed nano-hybrid resin crowns for the restoration of primary and permanent molars: An in vitro study

Behrang Ghabchi, DDS, MS, PhD,[a] Fırat Mavi, BE, MSc,[b] Erhan Çömlekoğlu, DDS, MS, PhD,[c] Ibrahim Etem Saklakoğlu, BTEd, MSc, PhD,[d] and Ilhan Uzel, DDS, MS, PhD[e]

ABSTRACT

Statement of problem. Early childhood caries is one the world's most common problems in infants and treatment of posterior teeth with esthetic crowns in a low rate of wear on opposite dentition is a challenge for pediatric dentists.

Purpose. The purpose of this in vitro study was to evaluate the wear behavior of the tooth colored crown materials and the opposing teeth in using different esthetic crown materials in the mixed dentition period.

Material and methods. The following tooth type and crown materials were considered in the experiment. Primary molars consist of first and second molars that were close to exfoliation or needed to be extracted because of orthodontic treatment and were caries free and with no restorations. Permanent teeth consisted of third molars that were caries free and with no restorations. Three different types of crown materials were used: nano-hybrid resin (VarseoSmile Crown ^{plus}; Bego GmbH), tetragonal zirconia polycrystalline stabilized with 3 mol% yttria (G-CERAM; Atlas Enta), and lithium disilicate glass-ceramic (IPS e.max CAD; Ivoclar AG). The wear test was performed in an artificial saliva environment (pH=6.7), based on the pin-on-plate technique, for a 2-mm stroke, under a compressive force of 30-N, at a frequency of 2-Hz and with 10 000, 20 000, and 30 000 cycles. A multi-way ANOVA statistical method was used (α=.05).

Results. Wear of the opposing teeth by the glass-ceramic was greater than by the nano-hybrid resin or zirconia materials (P<.05). All 3 crown materials wore primary teeth more than permanent teeth (P<.05). Compared with nano-hybrid resin, zirconia led to more wear of the opposing tooth (P<.05). The wear behavior of the nano-hybrid resin was more predictable compared with the other 2 materials.

Conclusions. Zirconia and lithium disilicate-based glass-ceramic materials caused more wear on both primary and permanent teeth compared with nano-hybrid materials, yet exhibited less wear themselves when opposed by primary or permanent teeth. (J Prosthet Dent 2025;134:177.e1-e8)

Early childhood caries (ECC) is a prevalent dental issue in infants and children, often leading to pain, infection, eating difficulties, and heightened risks for both primary and permanent teeth, potentially impacting the eruption of permanent teeth.[1,2] Symptoms can range from demineralization to loss of tooth structure or complete crown destruction, characterized by a dynamic and active decay process with periods of destruction and repair.[1] The World Health Organization has ranked early childhood caries as a worldwide problem, with a prevalence ranging from 60% to 90%.[3] Overall, posterior dentition loss had a selective effect on cognitive outcomes, suggesting that the posterior dentition is of greater importance than the anterior dentition.

Depending on the progression of ECC, different treatment methods have been applied, ranging from conservative techniques to crown restorations.[4] Primary teeth with extensive crown damage have been successfully treated with stainless steel crowns (SSCs) for many

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

[a]PhD candidate, Department of Pedodontics, School of Dentistry, Ege University, Izmir, Turkey.
[b]PhD candidate, Department of Mechanical Engineering, Faculty of Engineering, Ege University, Izmir, Turkey.
[c]Professor, Department of Prosthodontics, School of Dentistry, Ege University, Izmir, Turkey.
[d]Professor, Department of Mechanical Engineering, Faculty of Engineering, Ege University, Izmir, Turkey.
[e]Associate Professor, Department of Pedodontics, School of Dentistry, Ege University, Izmir, Turkey.

Clinical Implications

Nano-hybrid resin materials can be used as interim restoration materials to minimize wear on the opposing dentition during the mixed dentition period, but zirconia or lithium disilicate-based glass-ceramic materials can be used as definitive restoration materials for minimal wear on the opposing dentition during the mixed dentition period.

years.[4–6] SSCs, however, do not meet the esthetic expectations of children and their parents.[7] Advances in technology and materials in pediatric dentistry have led to the development of more esthetically pleasing alternatives, including composite strip crowns, prefabricated zirconia crowns, and computer assisted design and computer assisted manufacturing (CAD-CAM) produced resin and glass-ceramic crowns.[7]

Because of the structural differences between primary and permanent teeth[8,9] the amount of wear that can occur in both tissues when using restorative materials during the mixed dentition period will differ.[10] Therefore, understanding the wear and abrasion patterns of different restorative materials is crucial.[11] Especially in children during the mixed dentition period, where oral hygiene may not be adequately maintained, definitive restorations are often needed.[12] However, the wear and abrasion caused by these restorations can also impact the occlusion.[12]

Mastication refers to a rhythmic, automatic movement in which food is mixed with saliva and crushed.[13] A general finding from previous studies is that caries, whether involving the anterior or posterior teeth, affect children's ability to masticate food.[13] Although the occlusal force has been measured differently in previous studies,[13] the mastication force has been reported to be always lower than the occlusal force.[14] Based on this information and considering the proportion between them, the mastication force of children in this study was determined to be 30 N.

The use of food, toothpaste, or easily abraded restorative materials can alter the wear rate of opposing teeth.[15] In adhesive wear, parts of one body stick to another, causing wear to the substrate. Lambrecht et al[16] reported that wear of the opposing enamel under normal function is up to 41 µm per year. The ideal restorative material should have a wear rate similar to that of natural enamel to prevent damage. In the present study, 3 different restoratives materials were manufactured using CAD-CAM technology. A wear test was then conducted with natural teeth using these specimens. Finally, the wear amounts of the restoration specimens and the natural teeth were determined and interpreted volumetrically. The null hypothesis was that definitive esthetic restorative materials with different chemical contents would have no effect on the wear of primary and permanent teeth.

Table 1. Materials and substrates used

Factors	Levels		
Tooth Type	**Primary**	**Permanent**	
Restoration Material	Zirconia	Ceramic	Nano-Hybrid Resin
Mastication cycles	10 000	20 000	30 000

MATERIAL AND METHODS

The wear mechanism of opposing teeth in the mixed dentition was evaluated concerning different restoration materials. A review of the literature revealed variations in the annual mastication cycle values that were used as a reference.[17–19] To address this, a factorial experimental design was applied, taking into account the type of tooth, restorative material, and mastication cycle values (Table 1).

Three restorative materials were tested: yttria-stabilized zirconia (G-CERAM; Atlas Enta), nano-hybrid resin (VarseoSmile Crown^{plus}; Bego GmbH), and lithium disilicate-based glass-ceramic (IPS e.max CAD; Ivoclar AG). A power analysis with a software program (G*Power 3.1.9.7; Softonic) yielded 81.78% with a sample size of N=18. Cylindrical specimens with Ø2-mm spherical ends were produced from each material. The zirconia specimens were processed using a dental milling machine (Ceramill Motion 2; Amann Girrbach AG) and sintered at 1500 °C for 2 hours. The glass-ceramic blocks were milled (M10; CAMcube Inc) and crystallized in a porcelain furnace (Programat P310; Ivoclar AG) according to the manufacturer instructions. The resin specimens were printed (Varseo XS; Bego GmbH) with a 50-µm layer thickness, followed by an isopropyl alcohol bath and light polymerization (Otoflash; Bego GmbH) for 2×1500 seconds. Caries and restoration free primary molars nearing exfoliation and impacted third molars were obtained from the Faculty of Dentistry, Ege University. Ethical approval had been obtained from Ege University Medical Research Ethics Board Presidency (ethical approval No:23–9.1T/52). Each restoration material was divided into primary and permanent tooth groups, forming 6 groups. The teeth were placed in cylindrical polyethylene terephthalate glycol (PETG) molds made using the MEX method and embedded in epoxy resin (Crystal Resin; Rich).[20] The ground surfaces were polished with silicon carbide papers of 800 to 1200 grit (Metaserv 250 Grinder Polisher;

Figure 1. Specimen after linear wear test.

Buehler) at a speed of 350 rpm and under running water, creating a 4×4-mm enamel test area. Surface roughness was measured with a profilometer (SJ-301; Mitutoyo).

Artificial saliva (500 mL, pH=6.7) was prepared based on Levallois et al.[21] Mastication cycles (10 000, 20 000, 30 000) were applied using a custom device from the Mechanical Engineering Department. Wear tests were performed using the pin-on-plate technique,[22] with a 2-mm stroke distance, 2-Hz frequency, and 30-N load in artificial saliva (Artificial Saliva; Sigma-Aldrich) as seen in Figure 1. The weights of the tooth and restoration specimens were measured using a high precision analytic balance (XB 220A; Precisa). The specimens were examined with a stereomicroscope (SZ61; Olympus) and scanned with an intraoral scanner (iTero Element 5D; Align Technology, Inc) as seen in Figure 2A. Scan data were processed, and crater volumes were calculated with a software program (Geomagic Design X; 3D Systems, Inc) as seen in Figure 2B. Statistical evaluation was performed with a software program (Python 3; Python Software Foundation), with ANOVA testing the effect of restoration materials on volume loss in opposing teeth (α=.05).

RESULTS

Binary model graphs were created to analyze the relationship between tooth type, restoration material, and the number of cycles of volume loss due to wear. The average data for each independent variable was used. Statistical values are presented in Tables 2 and 3.

After the wear testing of the permanent teeth, opposing tissue's volumetric material loss, on the Glass-Ceramic group showed losses of 0.210 mm^3, 0.345 mm^3, and 0.500 mm^3 at 10 000, 20 000, and 30 000 cycles, respectively. The Zirconia group exhibited 0.363 mm^3, 0.743 mm^3, and 1.400 mm^3 at the same cycle counts. The Resin group losses were significantly lower, with 0.004 mm^3, 0.005 mm^3, and 0.009 mm^3 (P<.05). Overall, wear volume increased with more cycles, but the Resin group showed much less wear than the other materials as seen in Figure 3A.

After the wear testing on the permanent teeth, the Glass-Ceramic restorations showed volume losses of 0.107 mm^3, 0.143 mm^3, and 0.194 mm^3 at 10 000, 20 000, and 30 000 cycles. The Zirconia displayed minimal losses 0.002 mm^3, 0.001 mm^3, 0.004 mm^3, indicating greater wear resistance. The Resin showed a different pattern, with losses decreasing at higher cycles 0.073 mm^3, 0.085 mm^3, and 0.186 mm^3, as seen in Figure 3B.

After the wear testing of the primary teeth, opposing tissue's volumetric material loss, on the Glass-Ceramic group showed losses of 0.606 mm^3, 2.195 mm^3, and 2.272 mm^3 across 10 000, 20 000, and 30 000 cycles. The Zirconia losses were 0.736 mm^3, 0.875 mm^3, and 0.792 mm^3, while the Resin losses were significantly lower at 0.005 mm^3, 0.024 mm^3, and 0.031 mm^3 (P<.05), as shown in Figure 4A.

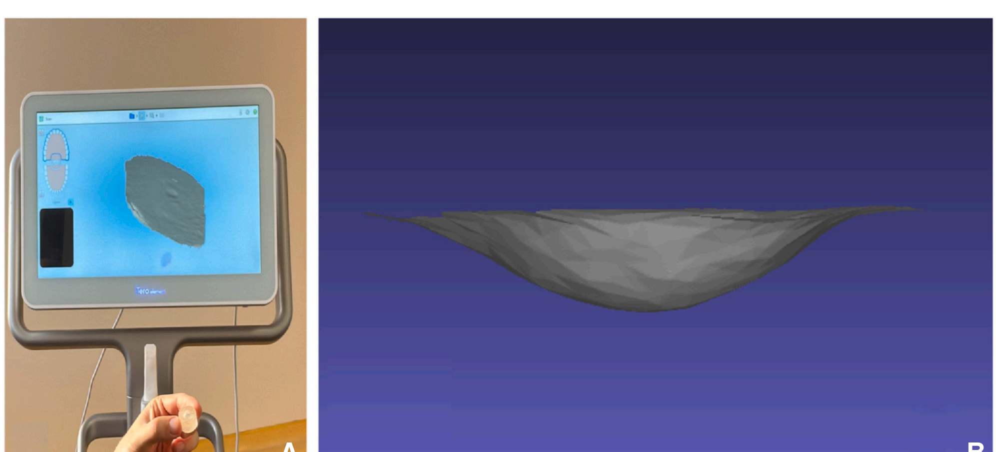

Figure 2. A, Three-dimensional intraoral scanning machine. B, Output of scanned specimen on Geomagic Design X program.

Table 2. ANOVA for wear volume of restoration material

Source	Sum of Squares	df	Mean Square	F-value	*P*
Model	0.073	11	0.007	17.500	.001
A-Tooth Type	0.008	1	0.008	20.330	.004
B-Restoration Material	0.042	2	0.021	55.730	<.001
C-Cycle	0.010	2	0.005	12.660	.007
AB	0.004	2	0.002	5.330	.047
BC	0.009	4	0.002	6.190	.025
Residual	0.002	6	0.0004		
Cor Total	0.075	17			

Table 3. ANOVA for wear volume of tooth

Source	Sum of Squares	df	Mean Square	F-value	*P*
Model	6.960	7	0.994	6.520	.004
A-Tooth Type	0.870	1	0.870	5.710	.038
B-Restoration Material	3.410	2	1.710	11.200	.003
C-Cycle	0.849	2	0.425	2.790	.109
AB	1.820	2	0.912	5.980	.020
Residual	1.520	10	0.152		
Cor Total	8.480	17			

After the wear testing on primary teeth, restoration material loss of the Glass-Ceramic group decreased slightly with more cycles 0.088 mm^3, 0.098 mm^3, 0.084 mm^3. The Zirconia losses remained minimal and stable 0.002 mm^3, 0.004 mm^3, 0.003 mm^3. The Resin wear increased with cycles, showing 0.007 mm^3, 0.007 mm^3, and 0.128 mm^3 as seen in Figure 4B. The model of wear volume of restoration material was P=.001 and for wear volume of tooth P=.004.

DISCUSSION

The null hypothesis that definitive esthetic restorative materials with different chemical compositions had no effect on the wear of primary and permanent teeth was rejected. This in vitro study investigated the wear properties of primary and permanent enamel opposing 3 types of esthetic restorative materials, yttria-stabilized zirconia, nano-hybrid resin, and lithium disilicate ceramic produced by CAD-CAM, and evaluated through tribological wear tests and 3D digital methods. Zirconia crowns have become popular because of their esthetics and biocompatibility, while SSC remained a reliable choice for ease of placement and durability.[5,23]

Zirconia crowns offered excellent esthetic properties similar to natural teeth in terms of color and light transmittance.[24] In permanent teeth, milled zirconia has been reported to be biocompatible, with a low risk of allergic reactions and inflammation in the surrounding tissues because, unlike prefabricated crowns in primary teeth, they are not adapted to the crowns, but laboratory fabricated. Achieving a perfect fit with zirconia crowns in primary teeth has been reported to be difficult, compromising the long-term success of the crown.[25] The primary concern associated with zirconia crowns is their high rigidity, which may lead to substantial wear on the opposing dentition.[5] However, zirconia was highly wear-resistant and provided long-term restoration for primary teeth by maintaining shape and function over time,[26] also found in the present study. When looking at the study's data, when the number of cycles increased (in the sense of increasing the number of mastication cycles), there was almost no wear of the restorative material. However, when taking into account the healthy tooth tissue in the opposite arch, zirconia could cause increased wear in the opposite teeth associated with the hardness, and this could lead to occlusal problems over time, which has been reported in both primary and permanent teeth.[27,28] This situation was also seen in the present study; the amount of wear on the healthy tooth in the opposite arch was directly proportional to the number of cycles. When the zirconia crown needs to be removed or replaced, the process could be quite challenging. Zirconia is a very hard material, making it difficult to cut or remove without damaging the underlying tooth structure, making future dental treatment difficult and increase the risk of tooth damage.[29]

Lithium disilicate ceramic can be produced chair-side in dental offices, eliminating the need for external laboratories.[18] This material is versatile, suitable for various restorations such as inlays, onlays, veneers, crowns, and fixed partial dentures, and can be processed using both pressing and milling techniques, offering clinical flexibility.[7] CAD-CAM based milling technology provides high precision and conformity, minimizing the need for adjustments and improving the overall quality of the restoration. However, successful chair side fabrication requires high technical skills and experience with CAD-CAM based milling systems, which may not be available in all pediatric dentistry practices and clinics.[30]

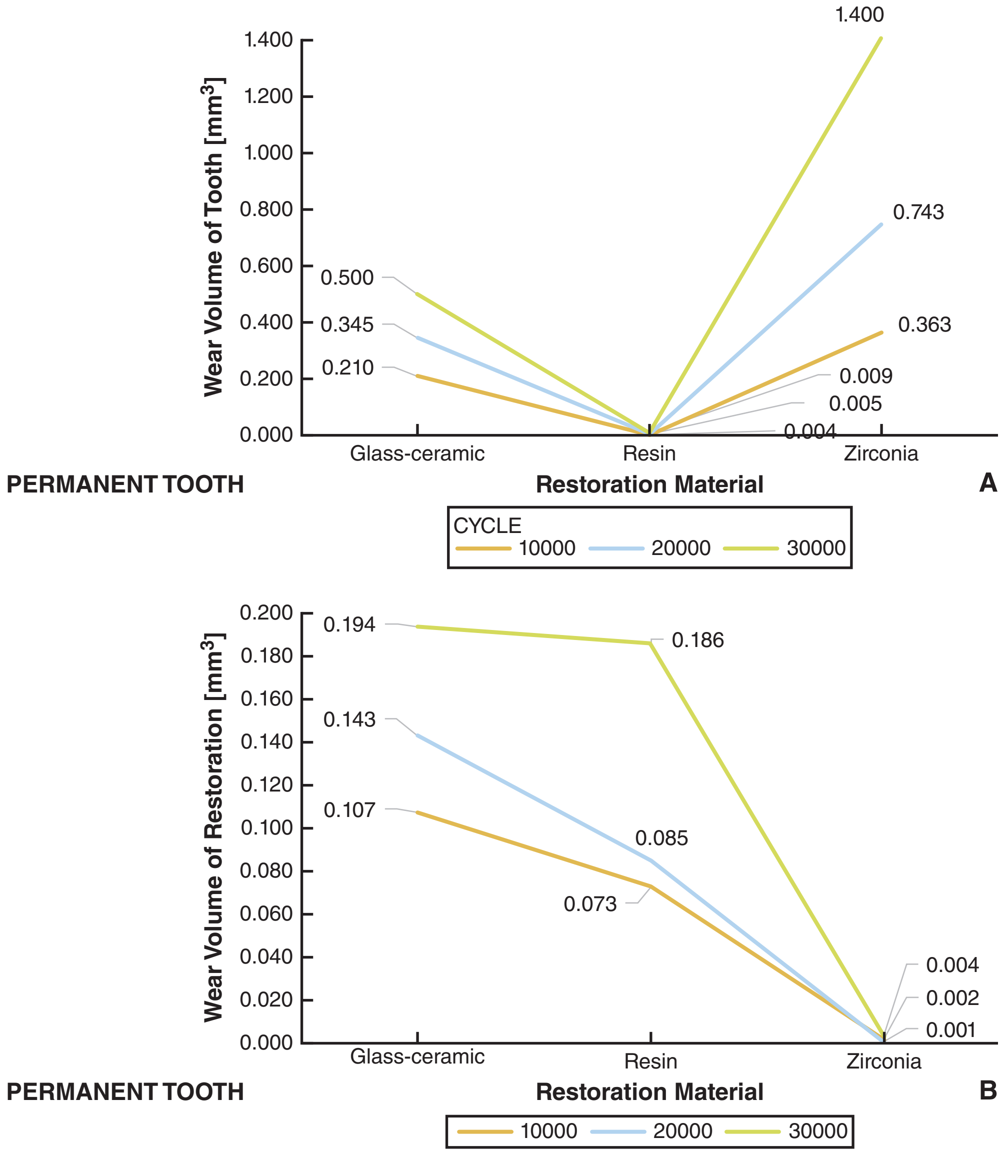

Figure 3. A. Wear volume of tooth after tests. B, Wear volume of restorations after tests on permanent tooth.

Lithium disilicate on primary teeth provided excellent esthetics, with translucency that matches the natural tooth enamel, similar to their use on permanent teeth, beneficial in preserving the child's natural appearance.[31]

Lithium disilicate crowns exhibited high flexural force (360 to 400 MPa), making them durable and resistant to fracture, even under the dynamic forces typical of children's mouths.[7] The fracture toughness of lithium disilicate (2.25 to 2.75 MPa $m^{0.5}$) helped to prevent chipping and cracking, which was especially important in pediatric dentistry, where children may have less controlled mastication habits.[7] However, although durable, ceramics are brittle and prone to fracture under tensile stress, especially in patients with bruxism or other parafunctional habits.[32] Recent literature reviews showed that the prevalence of bruxism in children ranged from 13% to 49%. A systematic review found that parental reports often form the basis for the diagnosis of sleep bruxism in children, leading to variability in prevalence data.[32] Bruxism could cause significant tooth wear, fractures, and sensitivity in primary teeth, potentially affecting the maturing of permanent teeth.[33]

Lithium disilicate, although having similar wear properties to tooth enamel, may be more abrasive than some other materials, including polished zirconia crown and type III gold, and could lead to greater wear on opposing teeth, which was a concern in the mixed dentition stages,[34] and was the main reason for this study. However, to ensure the best clinical results in pediatric dentistry, the challenges of wear, surface finishing, processing complexity, cost, and the need for high technical skills must be carefully considered.[34]

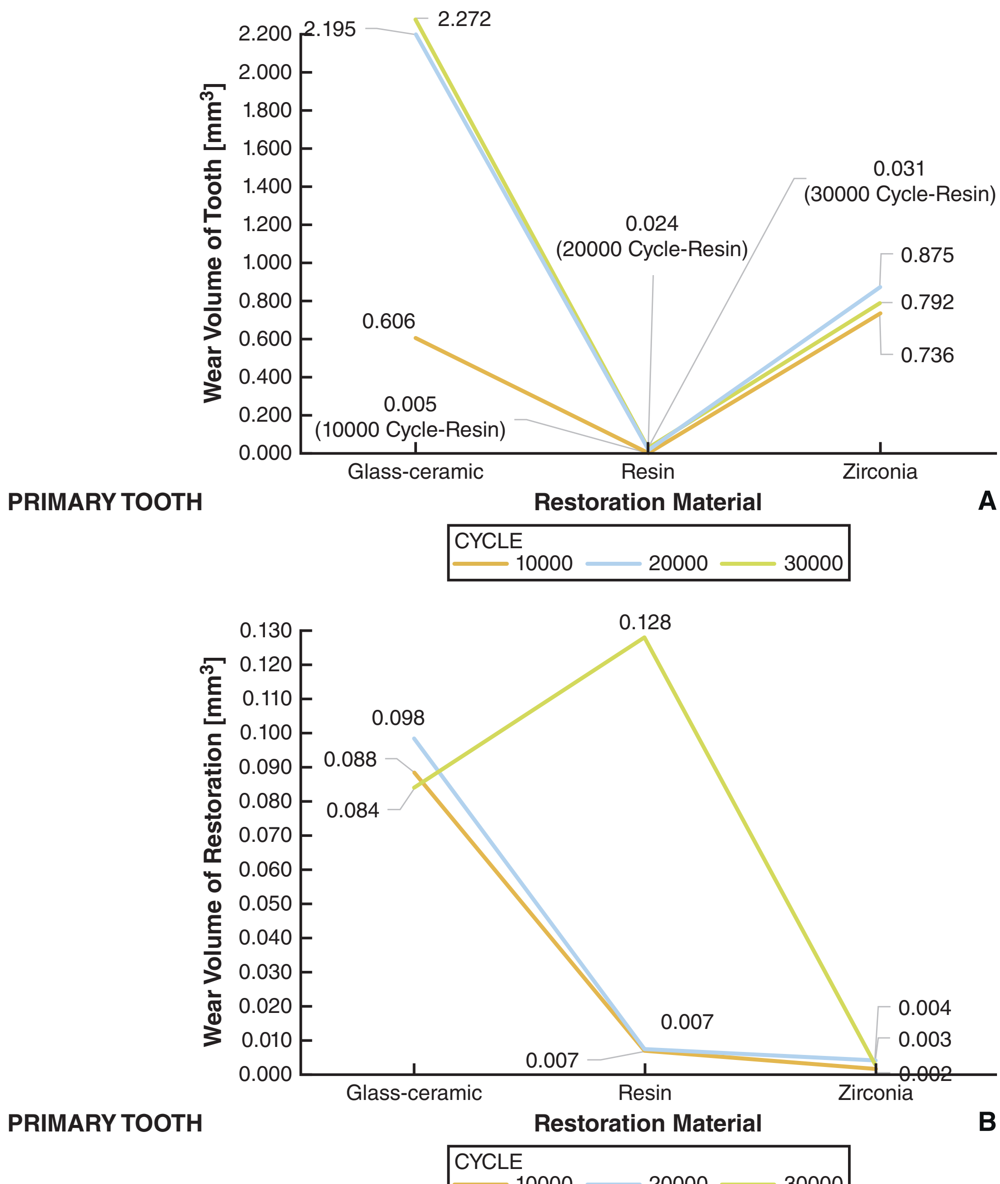

Figure 4. A, Wear volume of tooth after tests. B, Wear volume of restorations after tests on primary tooth.

Nano-hybrid resins, being relatively new, have limited studies supporting long-term success, which remains one of the major disadvantages. However, from an esthetic standpoint—an important factor for parents—nano-hybrid resin offers superior esthetics compared with traditional stainless steel (for primary teeth) or metal-ceramics (for permanent teeth), providing a natural, tooth-like appearance, especially crucial for anterior teeth.[35] Nano-hybrid resin crowns were less durable than metal crowns, prefabricated crowns, or the other 2 esthetic materials and were more susceptible to wear, fracture, and deterioration over time, especially in high-stress areas.[31,36] In the present study, when the number of cycles increased, serious wear occurred in material, while proportional wear did not occur in the opposing healthy tooth tissue. However, if these crowns fractured or were damaged in the mouth, they can be easily repaired without being completely replaced, which could provide a great advantage over other crown materials.[7] Nano-hybrid resin material has started to be used in the production of restorations that could be produced at the clinic with the development of the production technique with the 3D printing method.[5]

When comparing all 3 materials in primary teeth in terms of wear after 30 000 cycles, zirconia showed a volume loss of 0.003 mm^3, glass-ceramic 0.084 mm^3, and resin 0.128 mm^3, which shows that zirconia was the most resistant to wear and nano-hybrid resins had the least resistance. Elian et al[30] reported a similar difference in resistance to fracture in the studies. Unfortunately, literature support was not available about abrasion, especially on nano-hybrid resin material, and in the existing publications, a study had been conducted on fracture, and an environment that will mimic the mastication function in the oral environment had not been created. The authors are unaware of a study that compared the materials used in pairs, and in the existing studies that will be compared with the SSCs, which were generally accepted as the standard, all have resulted in the superior performance of the crowns in terms of margin adaptation and esthetics, but when it came to abrasion of the opposing teeth, more abrasion was found because of the rigid structure.[37,38] In the resistance zone (teeth), volume loss was 2.272 mm^3 for the glass-ceramics, 0.792 mm^3 for the zirconia, and 0.031 mm^3 for the resin. Due to its lower hardness, nano-hybrid resin exhibited the least wear resistance under the same conditions, causing the least abrasion, consistent with Elian et al.[30]

For permanent teeth, the wear volume of restoration after 30 000 cycles was 0.194 mm^3 for the glass-ceramics, 0.0186 mm^3 for the resin, and 0.004 mm^3 for the zirconia, with the glass-ceramics showing the most wear and the zirconia the least. Because of the higher hardness of permanent teeth (enamel), glass-ceramics experienced sudden volume loss from chipping during wear, a result consistent with other studies.[39,40] The authors are unaware of a previous study on nano-hybrid resins. When looking at the tissue in the resistance area, the zirconia caused a volume loss of 0.792 mm^3, the glass-ceramic 2.272 mm^3, and the resin 0.031 mm^3. In other words, while the material loss in permanent teeth caused by the hard and rigid structures of zirconia crowns was the highest, nano-hybrid resins caused the least material loss with a much softer structure, consistent with the restoration material loss reported in other studies.[41]

Limitations of this study included the in vitro design, and in vivo studies will be needed for clinically relevant findings. Additionally, it was performed at a constant room temperature (25 °C), not accounting for natural temperature fluctuations in the oral environment.

CONCLUSIONS

Based on the findings of this in vitro study the following conclusions were drawn:

1. Zirconia and lithium disilicate-based glass-ceramic materials caused more wear on primary teeth than nano-hybrid materials
2. Zirconia and lithium disilicate-based glass-ceramic materials wore less than nano-hybrid resins on primary teeth.
3. Zirconia and lithium disilicate-based glass-ceramic materials caused more wear on permanent teeth than nano-hybrid materials.
4. Zirconia and lithium disilicate-based glass-ceramic materials wore less than nano-hybrid resins when opposing the permanent tooth.

PATIENT CONSENT

The consent of all included patients was obtained.

REFERENCES

1. Wagle M, D'Antonio F, Reierth E, et al. Dental caries and preterm birth: A systematic review and meta-analysis. *BMJ Open*. 2018;8:1–7.
2. Lampl S, Gurunathan D, Krithikadatta J, et al. Reasons for crown failures in primary teeth: Protocol for a systematic review and meta-analysis. *JMIR Res Protoc*. 2023;12:1–10.
3. Hallett KB, O'Rourke PK. Pattern and severity of early childhood caries. *Community Dent Oral Epidemiol*. 2006;34:25–35.
4. Ahmed SA, Lakavath K, Kulkarni S, et al. Introspecting the clinical performance and satisfaction between pre-formed stainless-steel crowns versus zirconia crowns in primary posteriorteeth. *Neuroquantology*. 2022;20:4675–4680.
5. Geduk N, Ozdemir M, Erbas Unverdi G, et al. Clinical and radiographic performance of preformed zirconia crowns and stainless-steel crowns in permanent first molars: 18-month results of a prospective, randomized trial. *BMC Oral Health*. 2023;23:1–11.
6. Maciel R, Salvador D, Azoubel K, et al. The opinion of children and their parents about four different types of dental restorations in a public health service in Brazil. *Eur Arch Paediatr Dent*. 2017;18:25–29.
7. El Hayek JE, Tohme H, Nasr L, et al. Fracture strength of preformed zirconia crown and CAD–CAM zirconia, ceramic, and hybrid composite crowns for the restoration of primary molars: An in vitro study. *Int J Paediatr Dent* 2024:1–8.
8. Nakase Y, Yamaguchi S, Okawa R, et al. Physical properties and wear behavior of CAD/CAM resin composite blocks containing S-PRG filler for restoring primary molar teeth. *Dent Mater*. 2022;38:158–168.
9. Mahoney P. Two-dimensional patterns of human enamel thickness on deciduous (dm1, dm2) and permanent first (M1) mandibular molars. *Arch Oral Biol*. 2010;55:115–126.
10. Deeb JG, McCall C, Carrico CK, et al. Retrieval of prefabricated zirconia crowns with Er,Cr:YSGG laser from primary and permanent molars. *Materials (Basel)*. 2020;13:1–12.
11. Lee H, Chae YK, Lee HS, et al. Three-dimensional digitalized surface and volumetric analysis of posterior prefabricated zirconia crowns for children. *J Clin Pediatr Dent*. 2019;43:231–237.
12. Ajayakumar LP, Chowdhary N, Reddy VR. Use of restorative full crowns made with zirconia in children: A systematic review. *Int J Clin Pediatr Dent*. 2020;13:551–558.
13. Jayakumar P, FelsyPremila G, Muthu MS, et al. Bite force of children and adolescents: A systematic review and meta-analysis. *J Clin Pediatr Dent*. 2023;47:39–53.
14. Shiramizu M, Hasegawa Y, Yoneda H, et al. Factors affecting masticatory performance during the mixed dentition period. *J Oral Rehabil*. 2022;49:1144–1154.
15. Ghazal M, Yang B, Ludwig K, Kern M. Two-body wear of resin and ceramic denture teeth in comparison to human enamel. *Dent Mater*. 2008;24:502–507.
16. Lambrechts P, Braem M, Vuylsteke-Wauters M, Vanherle G. Quantitative in vivo wear of human enamel. *J Dent Res*. 1989;68:1752–1754.
17. Walia T, Brigi C, KhirAllah ARMM. Comparative evaluation of surface roughness of posterior primary zirconia crowns. *Eur Arch Paediatr Dent*. 2019;20:33–40.
18. Kim MJ, Oh SH, Kim JH, et al. Wear evaluation of the human enamel opposing different Y-TZP dental ceramics and other porcelains. *J Dent*. 2012;40:979–988.
19. Ablal MA, Kaur JS, Cooper L, et al. The erosive potential of some alcopops using bovine enamel: An in vitro study. *J Dent*. 2009;37:835–839.
20. Lakshman Sri SV, Karthick A, Dinesh C. Evaluation of mechanical properties of 3D printed PETG and polyamide (6) polymers. *Chemical Physics Impact*. 2024;8:100491.

21. Levallois B, Fovet Y, Lapeyre L, Gal JY. In vitro fluoride release from restorative materials in water versus artificial saliva medium (SAGF). *Dent Mater*. 1998;14:441–447.
22. Branco AC, Colaço R, Figueiredo-Pina CG, Serro AP. A state-of-the-art review on the wear of the occlusal surfaces of natural teeth and prosthetic crowns. *Materials (Basel)*. 2020;13(16):10.
23. Chen K, Lei Q, Xiong H, et al. A 2-year clinical evaluation of stainless steel crowns and composite resin restorations in primary molars under general anaesthesia in China's Guangdong province. *Br Dent J*. 2018;225:49–52.
24. Alzanbaqi SD, Alogaiel RM, Alasmari MA, et al. Zirconia crowns for primary teeth: A systematic review and meta-analyses. *Int J Environ Res Public Health*. 2022;19:18–22.
25. Möhn M, Frankenberger R, Krämer N. Wear and marginal quality of aesthetic crowns for primary molars. *Int J Paediatr Dent*. 2022;32:273–283.
26. Ashima G, Bhatia SK, Gauba K, Mittal HC. Zirconia crowns for rehabilitation of decayed primary incisors: An esthetic alternative. *J Clin Pediatr Dent*. 2014;39:18–22.
27. Stober T, Bermejo JL, Schwindling FS, Schmitter M. Clinical assessment of enamel wear caused by monolithic zirconia crowns. *J Oral Rehabil*. 2016;43:621–629.
28. Heintze SD, Cavalleri A, Forjanic M, et al. A comparison of three different methods for the quantification of the in vitro wear of dental materials. *Dent Mater*. 2006;22:1051–1062.
29. Uno M, Ishigami H. Replacement of unesthetic posterior metal crowns with monolithic zirconia crowns: A case report. *Open J Stomatol*. 2023;13:334–341.
30. Elian El Hayek J, El Osta N, Farhat Mchayleh N. Fracture strength of preformed zirconia crown and new custom-made zirconia crown for the restoration of deciduous molars: In vitro study. *Eur Arch Paediatr Dent*. 2022;23:333–339.
31. Ali AAEM, Abo-ELsoud AAE, Helmy YS. The fracture resistance of pulpotomized primary molars restored with zirconia crowns, lithium disilicate or resin based ceramic endocrowns. *BMC Oral Health*. 2024;24:1–12.
32. María PSalido, Martínez-Rus F, Fernando del Río, et al. Prospective clinical study of zirconia-based posterior four-unit fixed dental prostheses: Four-year follow-up. *Int J Prosthodont*. 2012;25:4–6.
33. Restrepo-Serna C, Winocur E. Sleep bruxism in children, from evidence to the clinic. A systematic review. *Front Oral Health*. 2023;4:1–14.
34. Zarone F, Di Mauro MI, Ausiello P, et al. Current status on lithium disilicate and zirconia: A narrative review. *BMC Oral Health*. 2019;19:1–14.
35. Jorquera G, Mahn E, Sanchez JP, et al. Hybrid ceramics in dentistry: A literature review. *J Clin Res Dent*. 2018;1:1–5.
36. Sabbah AAH, Kamel MH. Fracture resistance of primary molars restored with endocrowns versus zirconia crowns (an in vitro study). *Braz Dent Sci*. 2021;24:18–22.
37. Leal SC, Takeshita EM. Pediatric restorative dentistry. *Paediatr Rest Dent* 2018:1–221.
38. Kist S, Stawarczyk B, Kollmuss M, et al. Fracture load and chewing simulation of zirconia and stainless-steel crowns for primary molars. *Eur J Oral Sci*. 2019;127:369–375.
39. Zarone F, Russo S, Sorrentino R. From porcelain-fused-to-metal to zirconia: Clinical and experimental considerations. *Dent Mater*. 2011;27:83–96.
40. Amer R, Kürklü D, Kateeb E, Seghi RR. Three-body wear potential of dental yttrium-stabilized zirconia ceramic after grinding, polishing, and glazing treatments. *J Prosthet Dent*. 2014;112:1151–1155.
41. Stober T, Bermejo JL, Schwindling FS, Schmitter M. Clinical assessment of enamel wear caused by monolithic zirconia crowns. *J Oral Rehabil*. 2016;43:621–629.

Corresponding author:

Dr Ilhan Uzel
Department of Pedodontics
School of Dentistry
Ege University
Izmir
TURKEY
Email: uzel_ilhan@hotmail.com

CRediT authorship contribution statement

Behrang Ghabchi: Writing–original draft, Investigation, Project administration, Conceptualization, Funding acquisition. **Fırat Mavi**: Conceptualization, Investigation, Writing – review and editing, Data curation, Visualization, Formal analysis, Software**. Erhan Çömlekoğlu**: Supervision, Resources, Methodology, Validation. **İbrahim Etem Saklakoğlu**: Supervision, Resources, Methodology, Validation, Conceptualization. **İlhan Uzel:** Project administration, Supervision.

https://doi.org/10.1016/j.prosdent.2025.02.040