DENTAL AND MEDICAL JOURNAL - REVIEW

e-ISSN 2667-7288 **Vol** 6, **Issue** 2, (2024) ***Review Article / Derleme Makale***

PEDIATRIC ZIRCONIA CROWNS: A LITERATURE REVIEW

PEDİATRİK ZİRKONYA KRONLAR: BİR LİTERATÜR DERLEMESİ

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Abstract

Early childhood caries remains a problem that needs to be addressed by pediatric dentists and is a frequently encountered clinical situation. Zirconium-supported restorations, a material frequently used in adult dentistry practices, have also been used in pediatric dentistry practice in recent years. Prefabricated pediatric zirconium crowns (PZCs) are used as alternatives to stainless steel crowns (SCCs), which are widely used in pediatric dentistry because of their insufficient aesthetic properties. PZCs have superior aesthetic and physical properties and high biocompatibility. Full coronal restorations are preferred, especially in cases where it is not possible to compensate for the loss of material in the tooth with traditional methods, and are aimed at increasing the structural strength of the tooth. PZCs have found clinical use in pediatric dentistry applications due to their durability and hardness resistance against forces and being an aesthetic material compatible with tooth color. In this review, the introduction of PZCs in clinical use, their physical properties, application principles, parental satisfaction, relationship with surrounding tissues, importance of microleakage in long-term success, and current clinical and laboratory studies are included.

Keywords: *Pediatric zirconia crowns, Aesthetic, Biocompatibility, Microleakage, Periodontal health.*

Özet

Erken çocukluk çağı çürükleri (EÇÇ), klinikte sıklıkla karşılaşılan ve çocuk diş hekimleri tarafından ele alınması gereken bir sorun olmaya devam etmektedir. Yetişkin diş hekimliği uygulamalarında sıklıkla kullanılan bir materyal olan zirkonyum destekli restorasyonlar son yıllarda çocuk diş hekimliği pratiğinde özellikle EÇÇ' nin yönetilmesinde sıkça kullanılmaktadır. Prefabrik pediatrik zirkonyum kronlar (PZK), yetersiz estetik özellikleri nedeniyle çocuk diş hekimliğinde yaygın olarak kullanılan paslanmaz çelik kronlara (PÇK) alternatif olarak ortaya çıkmıştır. PZK' lar üstün estetik görünüme, fiziksel özelliklere ve yüksek biyouyumluluğa sahiptir. Tam koronal restorasyonlar özellikle dişteki madde kaybını geleneksel yöntemlerle telafi etmenin mümkün olmadığı durumlarda tercih edilmekte ve dişin yapısal dayanımının artırılması amaçlanmaktadır. Dayanıklılığı, kuvvetlere karşı dirençleri ve diş rengi ile uyumlu estetik bir materyal olmaları nedeniyle pediatrik diş hekimliği uygulamalarında klinik kullanım alanı bulmuştur. Bu derlemede PZK' ların klinik kullanıma girişi, fiziksel özellikleri, uygulama ilkeleri, ebeveyn memnuniyeti, çevre dokularla ilişkisi, uzun dönem başarıda mikrosızıntının önemi, güncel klinik ve laboratuvar çalışmalarına yer verilmiştir.

Anahtar Kelimeler: *Pediatrik zirkonya kronlar, Estetik, Biyouyumluluk, Mikrosızıntı, Periodontal sağlık.*

OVERVIEW / GENEL BAKIŞ

Zirconium is a biocompatible material with superior chemical and mechanical properties. It has superior properties in terms of durability and hardness resistance against occlusal and lateral forces and is an aesthetic material compatible with tooth color (1). Zirconium, which was first used for medical purposes in 1969, used in dentistry practice in the 1990s and is used in crown bridge construction, orthodontic bracket applications, and treatments, such as endodontic posts (2,3).

There are three types of polycrystalline ceramics: a monoclinic form, which is pure zirconium stable at 1107 oC, a stable tetraclonic form above 1107 oC, and a stable cubic surface form at 2370 oC. Cracks caused by volume expansion resulting from form changes cause significant stress in zirconium. Crowns with high compressive strength, high fracture and corrosion resistance, durability, and biocompatibility have been developed by various additions in order to eliminate the phase changes of the material (4).

Zirconium-containing ceramics, which are frequently used in crown restorations of permanent teeth, have become preferred materials owing to their clinical properties. They were approved by the United States Food and Drug Administration (FDA) in 2010 and have been used in crown restorations in pediatric dentistry as pediatric zirconium crowns (PZCs) (5,6). EZ-Pedo™, the first PZC to be introduced in monolithic zirconium form, is produced in both anterior and posterior regions. With the grooves called Zir-lock prepared on the inner surface of the crown, the inner surface area has expanded and resistance to mechanical retention and bite forces has increased. Aesthetic properties have been improved using polychromatic coatings (6,7). There are many types of PZCs currently used today (NuSmile, Houston, Texas, USA; Kinder Crown, St. Louis Park, Minn., USA; Cheng crown, Exton, Pa., USA).

NuSmile zirconium crowns have a more durable structure than enamel. Owing to its translucent structure, an aesthetic close to the natural tooth color is provided, and with this feature, the problem of color reflection in teeth treated with pulp can be overcome. A NuSmile trial crown (pink) allows testing in the stages before cementation. Thus, the time spent at the chairside is shortened, and the need for additional steps and crown disinfection is eliminated (8).

Nanotechnology was used in the construction of the Kinder crown, which is another commercially available product. Polished surfaces were created to prevent the abrasion of the opposing enamel surface. A locking system was created which increased the retention in cementation and provided an additional surface area for bonding. The marginal edge structure was designed to mimic the natural tooth form. These are available in two different sizes (9)

Advantages of pediatric zirconium crowns

- ❖ It has a rigid and durable structure,
- ❖ It is highly resistant to attrition and abrasion,
- ❖ It has a translucency close to natural tooth color,

- It protects teeth against environmental factors and reduces tooth tissue loss by preventing caries formation,
- It is biocompatible,
- Color, shape, and size options are available,
- It is a good alternative in case of nickel allergy,
- It can be sterilized,
- It is aesthetic,
- It has color stability,
- It reduces biofilm formation and plaque uptake (4,10,11).

Disadvantages of pediatric zirconium crowns

- Its rigid structure can cause abrasion on the opposing tooth,
- It is expensive,
- Cervical adjustment cannot be made,
- It is challenging to apply in cases of crowding,
- It is sensitive to blood and saliva contact and requires cementation experience,
- Adapting crowns to teeth requires experience,
- Clinical practice takes time,
- It requires more tooth preparation than other pediatric crowns,
- It cannot be repaired and must be replaced (4,10–13).

Clinical indications and application principles of zirconium crowns

Full coronal restorations are preferred in cases where it is not possible to compensate for the loss of material in the tooth with traditional methods, and are aimed at increasing the structural strength of the tooth. It can be preferred for application in the presence of multi-surface dental caries or a large carious lesion on a single tooth surface, crown fractures, developmental disorders, hypoplasia of tooth hard tissues, restorations after vital and non-vital pulp treatments, and restorative treatments of patients with high caries risk. There are issues to be considered in the clinical application of zirconium crowns that maintain their popularity today and stand out with their good properties (10).

In pediatric zirconium crown applications, after local anesthesia is applied and the appropriate crown size is selected, the preparation is started with diamond burs under water cooling, and the entire tooth surface is prepared in such a way that there is no undercut. It is recommended that the circumferential preparation amount be 1 mm, and the occluso-incisal preparation amount is approximately 1.5-2 mm. The gingival part of the tooth was prepared with a knife edge extending under the gingiva. Passive placement, occlusion, and gingival compliance should be checked by placing the initially selected PZC on the prepared tooth (6). The contact of the zirconium surface, which forms chemical bonds with the phosphate molecules in the material used for cementation, with blood or saliva, and the high amount of phosphate ions in these fluids block the phosphate receptors in the zirconium structure. This negatively affects cementation success. To remove the molecules on the restoration surface, decontamination agents can be used or blood and saliva contamination can be prevented by using trial crowns called 'Pink Zirconia (try-in)' developed by NuSmile (Houston, TX, USA). These trial crowns have the same dimensions as the PZCs to which they belong; they can be sterilized in an autoclave and reused (14).

Cementation

The cementation process aims to prevent microleakage by filling the gap between the tooth surface and the PZC passively sitting on the tooth and ensuring adhesion of the PZC to the tooth surface. Thus, the structural integrity of the restoration, tooth structure, and surrounding tissues are preserved, the durability of the tooth and restoration is increased, and the health of the surrounding periodontal tissues is maintained (15,16). Three critical steps must be considered during PZC cementation. These issues include isolation of the tooth and surrounding tissues without leakage, passive placement of PZC on the tooth, and selection of a cementation material that can compensate for caries-related material losses (17). In this context, the recommended cementation materials are as follows:

- ❖ Zinc phosphate cement
- ❖ Zinc polycarboxylate cement
- ❖ Conventional glass ionomer cement
- ❖ Resin-modified glass ionomer cement

❖ Resin cement (Etch-rinse cement, Self-etch resin cement, and Self-adhesive resin cement)

❖ Calcium aluminate cement (18,19).

Although there are sources suggesting polycarboxylate cement in PZC cementation, materials with improved mechanical properties are preferred (15,18-20).

Studies have reported that although glass ionomer cement (GIC) is chemically bonded to dentin, it cannot establish a stable bond to the zirconium surface, and microleakage is observed after cementation (21-23). To eliminate the disadvantages of GIC such as moisture contamination, a hybrid resin-modified glass ionomer cement (RMCIS) was developed by adding a water-soluble resin monomer to the GIC liquid (24,25). Despite its superior physical and mechanical properties, hydroxyethyl methacrylate (HEMA) has been a clinical problem because of its high hydrophilicity (26,27). In studies comparing RMCIS with GIC and zinc phosphate cement, RMCIS was reported that RMCIS has a higher bond strength (28).

Resin cements are bonded micromechanically with macro- and micro-resin tags to the enamel surface roughened with acid. It provides micromechanical adhesion to the acid-etched dentin surface by penetrating hydrophilic monomers into the demineralized apatite under the hybrid layer (27). Etch-rinse resin cements, a subgroup of resin cements, are washed after acid etching. This type of cement, which has a multistage application, has been reported in the literature as the most clinically successful cement in the long term (29,30). Self-etch systems are self-acidic and can be a two-stage system with the acid and primer in the same bottle and the bonding agent in a different bottle, or it can be a single-stage system combining three steps (31). Although they have less retention than the systems applied by washing, they can be preferred more among dentists because of their fewer clinical stages (32).

In a study performed on extracted teeth and evaluating the fracture strength of PZCs, it was reported that PZCs were cemented using RMCIS, self-etch resin cement, and self-adhesive cements, and there was no significant difference between the groups (33). Single-stage self-adhesive resin cements are frequently preferred for the cementation of PZCs because postoperative sensitivity is not observed. In a 3-year follow-up study of PZCs with dual-cure self-adhesive resin cement application, no loss of retention was observed in restorations (34).

Although calcium aluminate cements are mechanically bonded to zirconium, they are chemically bonded to the tooth surface. It is hydrophilic, and studies have shown that this cement induces the formation of hydroxyapatite in addition to its biocompatibility and moisture tolerance properties (14).

Microleakage

Microleakage occurs if there is a micro gap between the restoration and the tooth. PZCs carry a high risk of leakage because of their marginal gaps. In order to prevent this, the chemical and mechanical properties of cement are essential (21).

In PZCs, alignment of the tooth to the cervical anatomy is not performed by marginal shaping and bending, similar to stainless steel crowns (SSCs) (35). Therefore, restoration failures may develop in PZCs owing to marginal gap and microleakage after cementation (36). In a study of extracted teeth, microleakage values were examined after PZCs were cemented using two different types of RMCIS and self-adhesive resin cement, and no significant difference was observed between the groups (37).

Albert et al. (38) examined the microleakage values after cementation using zinc phosphate cement, CIS, RMCIS, and resin cement in full-ceramic and metal-supported ceramic crowns and concluded that the resin cement showed the lowest microleakage value. Chang et al. (36) cemented PZCs applied to permanent teeth with RMCIS and self-adhesive resin cement and observed significantly higher microleakage values in RMCIS than in self-adhesive resin cements. Alkac compared three different luting cements (Ketac Cem Plus RMCIS, FujiCEM Evolve RMCIS, and RelyX U200 self-adhesive resin cement) for PZCs' cementation. There was no statistically significant difference between the RMCIS and self-adhesive resin cement in terms of microleakage levels (39).

Effect on periodontal health

When the marginal border of dental restorations extends to the gingival level, contact occurs between the restoration and gingival tissues. It has been reported that restoration margins close to gingival tissues may have a high risk of inflammatory reactions in the gingival tissues (40,41). It has been suggested that the subgingival position of the PZC should be 1-2 mm in prefabricated ceramic and metal restorations of the primary teeth (16).

Because bacterial colonization occurs on rough surfaces, the presence of smooth surfaces is extremely important for the success of restoration (42). In a study comparing PZC and SSCs, it was observed that mutans streptococci adhere less to the PZC surface and cause less gingival inflammation and plaque accumulation (43). In a study conducted by Donly et al. (44), there was no statistically significant difference between the surface roughness of SSC and PZC. In a study comparing the effects of PZC and SSC on gingival health and plaque formation, all values increased in teeth treated with SSC, but no statistically significant differences were observed (45). In a study by Gill et al. (46) in which gingival health was evaluated, it was reported that gingival inflammation was not observed in the teeth in the PZC group, but was observed at a high level in the SSC and strip crown groups.

Aesthetic perspective and clinical survival of PZCs

Aesthetic features, as well as functions, are essential for parents and patients in dentistry. It has been reported that the aesthetic appearance of the restorations is a priority for the parents, who care about the cost, toxicity, and durability of the material (47).

Many studies have investigated whether pediatric crowns provide the aesthetic expectations of parents. In a study in which parents' opinions were obtained by creating post-restoration images with SSC, strip crown, and PZC, the appearance of PZCs was found to be more optimistic by parents (48). A similar study reported that PZCs were liked by parents in terms of shape, size, and color (11). In another study showing similar results, SSC-applied teeth were liked by parents in terms of shape and size but not color. It has been observed that PZCs be significantly more liked (45).

Seminario et al. (49), who examined patients who underwent PZC for primary incisors under general anesthesia, reported survival rates of 93% at 12 months, 85% at 24 months, and 76% at 36 months. In another study, Gill et al. (8) evaluated the retention success of a composite strip crown, PZC, and SSC applied to primary incisors at the end of 12 months. Success rates were reported to be 79%, 95%, and 100%, respectively. PZCs do not show any material loss compared to other restorations and provide a color match with adjacent teeth at a rate of 98% (46).

SUMMARY / SONUÇ

Although PZCs are preferred in clinical practice, studies on their use in pediatric dentistry are insufficient. When the literature is examined, it is stated that PZCs are attached to the anterior primary teeth with high retention and high fracture resistance. In addition, it has been observed that there is superior color harmony with the adjacent natural teeth in the long term, which is welcomed by the parents. Visual appreciation is at the forefront of the effect of changing social dynamics. The polished surfaces of PZCs reduce plaque uptake, and the choice of luting cement reduces the possibility of microleakage, thus reducing the risk of secondary caries formation. Resin cement is superior to other bonding materials in terms of its impermeability. Based on the evidence in the literature, PZCs can be considered a successful restoration alternative in primary teeth for aesthetic rehabilitation purposes.

Acknowledgements / Teşekkürler

Funding: None

Conflict of interest: None

References / Referanslar

1. Piconi C, Maccauro G. Zirconia as a ceramic biomaterial. Biomaterials. 1999;20(1):1–25.

e-ISSN 2667-7288 **Vol** 6, **Issue** 2, (2024) ***Review Article / Derleme Makale***

2. Conrad HJ, Seong WJ, Pesun IJ. Current ceramic materials and systems with clinical recommendations: a systematic review. J Prosthet Dent. 2007;98(5):389–404.

3. Al Shobber MZ, Alkhadra TA. Fracture resistance of different primary anterior esthetic crowns. Saudi Dent J. 2017;29(4):179-84.

4. Tote J, Gadhane A, Das G, Soni S, Jaiswal K, Vidhale G. Posterior esthetic crowns in peadiatric dentistry. Int J Dent Med Res. 2015;1(6):197–201.

5. Denry I, Kelly JR. State of the art of zirconia for dental applications. Dental materials. 2008;24(3):299–307.

6. Babaji P. (2015), Crowns in pediatric dentistry. New Delhi: Jaypee Brothers Medical Publishers.

7. EZCrowns 2023. Available from: https://sprigusa.com/ezcrowns/

8. NuSmile 2023. Available from: https://nusmile.com/pages/nusmile-zr-primary

9. Kinder Krowns 2023. Available from: https://www.kinderkrowns.com/zirconia%20pediatric%20crowns/

10. Waggoner WF. Restoring primary anterior teeth: updated for 2014. Pediatr Dent. 2015;37(2):163–70.

11. Holsinger DM, Wells MH, Scarbecz M, Donaldson M. Clinical evaluation and parental satisfaction with pediatric zirconia anterior crowns. Pediatr Dent. 2016;38(3):192–7.

12. Townsend JA, Knoell P, Yu Q. In vitro fracture resistance of three commercially available zirconia crowns for primary molars. Pediatr Dent. 2014;36(5):125-9.

13. Clark L, Wells MH, Harris EF, Lou J. Comparison of amount of primary tooth reduction required for anterior and posterior zirconia and stainless steel crowns. Pediatr Dent. 2016;38(1):42–6.

14. Garg V, Panda A, Shah J, Panchal P. Crowns in pediatric dentistry: A review. Journal of Advanced Medical and Dental Sciences Research. 2016;4(2):41.

15. Cohn C. Zirconia-Prefabricated Crowns for Pediatric Patients With Primary Dentition: Technique and Cementation for Esthetic Outcomes. Compend Contin Educ Dent. 2016;37(8):554-8.

16. Taran PK, Kaya MS. A comparison of periodontal health in primary molars restored with prefabricated stainless steel and zirconia crowns. Pediatr Dent. 2018;40(5):334–9.

17. Uludamar A, Aygün Ş, Özkan Y. Tam Seramik Restorasyonların Simantasyonu. Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi. 2011(2):150–62.

18. Sahana S, Vasa AA, Sekhar R, Prasad K. Esthetic crowns for primary teeth: A review. Ann Essences Dent. 2010;2(2):87–93.

19. Kern M, Wegner SM. Bonding to zirconia ceramic: adhesion methods and their durability. Dental materials. 1998;14(1):64–71.

20. Kachhara S, Ariga P, Jain AR. Recommended cementation for monolithic zirconia crowns. Drug Invention Today. 2018;10(4):566–8.

21. Aksoy İ, Varol S, Özkan Y. Zirkonyum Restorasyonların Simantasyonu. Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi. 2012(Supplement 6):124–31.

e-ISSN 2667-7288 Vol 6, Issue 2, (2024) Review Article / Derleme Makale

22. Stepp P, Morrow BR, Wells M, Tipton DA, Garcia-Godoy F. Microleakage of cements in prefabricated zirconia crowns. Pediatr Dent. 2018;40(2):136–9.

23. Piwowarczyk A, Lauer HC, Sorensen JA. The shear bond strength between luting cements and zirconia ceramics after two pre-treatments. Oper Dent. 2005;30(3):382-8.

24. Gargari M, Gloria F, Napoli E, Pujia AM. Zirconia: cementation of prosthetic restorations. Literature review. Oral Implantol (Rome). 2010;3(4):25-9.

25. Mitra SB. Adhesion to dentin and physical properties of a light-cured glass-ionomer liner/base. J Dent Res. 1991;70(1):72–4.

26. Nothdurft FP, Pospiech PR. Clinical evaluation of pulpless teeth restored with conventionally cemented zirconia posts: a pilot study. J Prosthet Dent. 2006;95(4):311–4.

27. Hill EE, Lott J. A clinically focused discussion of luting materials. Aust Dent J. 2011;56:67–76.

28. Diaz-Arnold AM, Vargas MA, Haselton DR. Current status of luting agents for fixed prosthodontics. J Prosthet Dent. 1999;81(2):135–41.

29. Piwowarczyk A, Lauer HC, Sorensen J. In vitro shear bond strength of cementing agents to fixed prosthodontic restorative materials. J Prosthet Dent. 2004;92(3):265–73.

30. El-Badrawy WA, El-Mowafy OM. Chemical versus dual curing of resin inlay cements. J Prosthet Dent. 1995;73(6):515–24.

31. Peumans M, Van Meerbeek B, Lambrechts P, Vanherle G. Porcelain veneers: a review of the literature. J Dent. 2000;28(3):163–77.

32. Myers ML, Caughman WF, Rueggeberg FA. Effect of restoration composition, shade, and thickness on the cure of a photoactivated resin cement. Journal of Prosthodontics. 1994;3(3):149–57.

33. Salz U, Zimmermann J, Salzer T. Self-curing, self-etching adhesive cement systems. J Adhes Dent. 2005;7(1):7-17.

34. Palacios RP, Johnson GH, Phillips KM, Raigrodski AJ. Retention of zirconium oxide ceramic crowns with three types of cement. J Prosthet Dent. 2006;96(2):104–14.

35. Gherlone E, Mandelli F, Capparè P, Pantaleo G, Traini T, Ferrini F. A 3 years retrospective study of survival for zirconia-based single crowns fabricated from intraoral digital impressions. J Dent. 2014;42(9):1151–5.

36. Waggoner WF. Restoring primary anterior teeth. Pediatr Dent. 2002;24(5):511–516.

37. Chang B, Goldstein R, Lin CP, Byreddy S, Lawson NC. Microleakage around zirconia crown margins after ultrasonic scaling with self-adhesive resin or resin modified glass ionomer cement. Journal of Esthetic and Restorative Dentistry. 2018;30(1):73–80.

38. Alkac B. Prefabrike Zirkonya Kronlarda Kullanılan Farklı Simantasyon Materyallerinin Mikrosızıntısının Değerlendirilmesi. Kırıkkale: Kırıkkale University; 2021.

39. Albert FE, El-Mowafy OM. Marginal adaptation and microleakage of Procera AllCeram crowns with four cements. Int J Prosthodont. 2004;17(5):529-35.

40. Newcomb GM. The relationship between the location of subgingival crown margins and gingival inflammation. J Periodontol. 1974;45(3):151–4.

41. Develioglu H, Kesim B, Tuncel A. Evaluation of the marginal gingival health using laser Doppler flowmetry. Braz Dent J. 2006;17:219–2.

42. Go H, Park H, Lee J, Seo H, Lee S. Effect of various polishing burs on surface roughness and bacterial adhesion in pediatric zirconia crowns. Dent Mater J. 2019;38(2):311–6.

43. Mathew MG, Samuel SR, Soni AJ, Roopa KB. Evaluation of adhesion of Streptococcus mutans, plaque accumulation on zirconia and stainless steel crowns, and surrounding gingival inflammation in primary molars: Randomized controlled trial. Clin Oral Investig. 2020;24:3275–80.

44. Donly KJ, Sasa I, Contreras CI, Mendez MJC. Prospective randomized clinical trial of primary molar crowns: 24-month results. Pediatr Dent. 2018;40(4):253–8.

45. Ağmaz O. Süt Dişlerine Uygulanan Zirkonyum Ve Paslanmaz Çelik Kron Restorasyonlarda Aşınma, Dişeti Sağlığı Ve Veli Memnuniyetinin Değerlendirilmesi. Konya: Necmettin Erbakan University; 2020.

46. Gill A, Garcia M, Won An S, Scott J, Seminario AL. Clinical Comparison of three esthetic full-coverage restorations in primary maxillary incisors at 12 months. Pediatr Dent. 2020;42(5):367–72.

47. Zimmerman JA, Feigal RJ, Till MJ, Hodges JS. Parental attitudes on restorative materials as factors influencing current use in pediatric dentistry. Pediatr Dent. 2009;31(1):63–70.

48. Pani SC, Saffan AA, AlHobail S, Bin Salem F, AlFuraih A, AlTamimi M. Esthetic Concerns and Acceptability of Treatment Modalities in Primary Teeth: A Comparison between Children and Their Parents. Int J Dent. 2016;2016:3163904.

49. Seminario AL, Garcia M, Spiekerman C, Rajanbabu P, Donly KJ, Harbert P. Survival of zirconia crowns in primary maxillary incisors at 12-, 24-and 36-month follow-up. Pediatr Dent. 2019;41(5):385–90.