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Clinical considerations for preformed zirconia crowns in early childhood caries: A case series and review of literature

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Highlights

- Rehabilitation of severely destroyed primary anterior teeth are among the challenges faced by pediatric dentists. The use of aesthetic restorations has become an important and necessary aspect nowadays.
- This paper reports important clinical considerations in detail for case selection, appropriate crown selection, and step-by-step tooth preparation for preformed pediatric zirconia crowns.
- Preformed zirconia crowns continue to exceed expectations due to their excellent aesthetics, superior durability, and better survival rates compared to conventional restoratives.

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Abstract

Early childhood caries (ECC) is a prevalent disease worldwide and the major reason for the destruction and early loss of primary anterior teeth in children. It is paradigmatic to manage and treat this predicament in early childhood, as the affected teeth play a key role in aesthetics, phonetics, eating, and pronunciation. These teeth are influential to proprioceptive inputs of pre-maxilla and maintaining space for the timely eruption of permanent teeth. Aesthetic alternatives to preformed metal crowns have been developed in recent years. This paper describes the clinical considerations, protocol for the implementation, and maintenance for successful rehabilitation of anterior teeth affected by ECC restored with preformed zirconia crowns.

Keywords: Aesthetics; Crown; Dental Caries, Primary Teeth, Zirconium

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INTRODUCTION

Early childhood caries (ECC) is a genuine public health problem in both developing and industrialized countries. It can begin early in life, advances rapidly in those who are at high risk, and often goes untreated. Its ramifications can affect the immediate and long-term quality of life of the child's family and can have significant social and economic consequences beyond the immediate family as well.[1] ECC is clinically defined as "the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled surfaces, in any primary tooth in a preschool-age child between birth and 71 months of age."[2] AAPD also specifies that, in children younger than 3 years of age, any sign of smooth-surface caries is indicative of severe early childhood caries (S-ECC).[3] ECC is a particularly virulent type of dental caries characterized by overwhelming infectious challenges and is associated with unusual dietary practices.[4] In advanced forms of this disease, severe ECC can devastate the primary dentition and is the important reason for hospital visits for young children. It differentially affects disadvantaged ethnic and socioeconomic groups and can affect over 50% of the children in these groups.[5] Children affected by ECC, often advance rapidly from white spot lesions requiring minimal treatment to large carious lesions requiring possible pulpal intervention in a rapid time frame of six months, leading to dental infection and possibly life-threatening facial space involvement. Such infections may result in a medical emergency requiring hospitalization, antibiotics, and sometimes extraction of the tooth in children as early as 2- 3 years of age.[6] Besides, the loss of primary teeth, children lose the ability to pronounce fricative and sibilant sounds, causing them to develop an inaccurate language pattern, and malnutrition. Such dental status can affect masticatory function, food preference, and dietary intake, relating to developmental delays.[7]

Evidence also demonstrates a possible relationship between caries and body mass index.[8, 9] Therefore, early discovery, diagnosis, and treatment of ECC are necessary. Over the years, several available options have been tried for providing full coverage restoration for anterior primary teeth each having its advantages and associated technical, functional, or aesthetic limitations.[10-12]

The last decade has witnessed the advent of promising advanced aesthetic restorative options in the form of preformed zirconium dioxide crowns. These crowns are made completely with ceramic materials (tetragonal zirconia). Zirconia crowns are exceptionally strong ceramic crowns and are known to offer better aesthetics. They are anatomically contoured, metal-free, completely bio-inert, and are resistant to decay. Their advantages include excellent aesthetics, resistance to fracture, biocompatibility, reduced plaque accumulation, color stability, and potentially less technique sensitivity.[12-16] Various zirconia crowns available today are NuSmile Zr crowns (NuSmile Ltd, Houston, Tx. USA), EZ-Pedo (Loomis, California, USA), Cheng Crowns zirconia (Orthodontic Technologies Inc., Houston, Tx. USA), HuFriedy Mfg. Co., LLC, Chicago, IL, USA; Kinder Krowns (St. Louis Park, Minn., USA) and more recently Kids-e-Crowns (Kids-e-dental LLP, Mumbai, IN). They are available for primary incisors, cuspids, molars, and most recently permanent first molar. (NuSmile ZR crowns)

CLINICAL CONSIDERATIONS

Indications and contraindications

Table 1 presents the indications and contraindications for zirconia crowns.

Table 1. Indications and contraindications for zirconia crowns

Indications	Contraindications
Teeth with extensive coronary destruction (more than two affected walls) or teeth with coronary fractures	Severe destruction that does not allow reconstruction
Endodontically treated teeth due to the risk of coronary fracture and sealing.	Physiological or pathological root resorption involving more than 2/3 of the root.
Enamel and dentin defects (amelogenesis imperfecta, dentinogenesis imperfecta, hypoplasias, and hypomineralization).	Excessive bruxism
Aesthetic requirements	Anterior crossbites and severe crowding cases

Clinical considerations

Unlike, preformed Stainless steel crowns, zirconia crowns cannot be crimped and the fitting of a pediatric zirconia crown on a mandibular molar is easier to do than fittings on anterior teeth or upper molars. Performing a single-unit restoration first is easier than performing back-to-back restorations. Good patient cooperation is necessary, and the use of sedation could be helpful. Relative to preformed metal crowns, zirconia crowns require additional preparation.[14]

Zirconia crown selections

The most important step in zirconia crowns is the proper selection of crown size. This was selected by placing the incisal edge of the zirconia crown against the incisal edge of the tooth. We considered the mesiodistal dimension and selected the crown size to be used based on the original size of the tooth.

Tooth preparation

Local anesthesia should be administered before tooth preparation and it is necessary to isolate the operative field. Due to the characteristics of preformed zirconia crowns (rigid, thicker, and larger), it is recommended to follow the reduction protocols recommended by the manufacturer in order to avoid unnecessary excessive reductions. Adequate preparation of the tooth will significantly improve aesthetics and crown fit and will save operating time. The tooth must be prepared to fit the crown so that the crown fits the tooth passively without applying any pressure during seating.

Incisal reduction

Reduce the incisal length by approximately 1.5-2 mm, using a tapered diamond bur in a high-speed handpiece. An adequate occlusal reduction is extremely important for the proper fit and placement of zirconia crowns. The final occlusal plane of the seated zirconia crown is determined by the amount of occlusal reduction. Preparations should always be convergent towards incisal with no retention areas to prevent passive seating of the crowns. The preparation margin should be carefully extended and refined to a feather-edge so that no undercuts or subgingival ledges remain approximately 1-2mm sub-gingivally on all surfaces.

Peripheral reduction

Preparations are always convergent towards the occlusal surface. Line angles and point angles should be removed so that all surfaces of the prepared tooth are slightly rounded. The tooth should be reduced circumferentially by

approximately 0.5-1.25mm as necessary. Adequate reduction of the tooth is extremely important for the crown to seat passively. This reduction should be performed gradually and on all planes of the tooth. It results in a preparation that is parallel to slightly converging incisally/occlusally following the natural contours of the existing clinical crown and on anterior teeth meeting in a thin, tapered incisal edge.

The lingual surface is reduced with a minimum of 1-1.25 mm of tooth structure from the lingual surface, extending from 1 to 1.5 mm sub-gingivally to the middle of the incisal edge of the prep following the natural contours of the existing clinical crown to facilitate the passive fit. Preparation is then rounded and sharp angles removed.[12 13]

Subgingival extension

The subgingival extension ensures no crown margin exposure, healthy gingival adaptation, and maximizes retention. A thin, tapered diamond bur should be used to avoid tissue maceration while performing these subgingival tooth reductions. The same principles apply to the preparation of primary teeth molars.[13]

Try-in and adjustment

Crown is then carefully tried as preformed zirconia crowns are not flexible. A small cervical reduction of the crown can be made using a bur under a water spray to ensure a uniform fit. However, if the crown does not fit, further preparation (incisal and sub-gingival steps) can be reconsidered.

Cementation

The teeth should be cleaned of any saliva, blood, or debris, and gingival bleeding reasonably controlled prior to cementation. Pressure, tissue infiltration, or a hemostatic agent may be used for this purpose as necessary.

CASE REPORT

Case 01

A 3-year-old boy visited our center accompanied by his parents with a complaint of decayed upper anterior teeth. The patient's systemic health was observed within the normal range. The mother revealed the child was breastfed on demand until the age of 2.5 years and reported the beginning of proper oral hygiene maintenance only after the appearance of carious lesions. The child on his first visit exhibited negative Frankl behavior. Clinical examination revealed the presence of several carious lesions with 52, 51, 61 & 62 besides, dental caries on cuspids and posterior teeth. (Figure 1A & Figure 1B) It was diagnosed as affected by early childhood caries. Radiographic examination revealed a caries lesion involving pulp with upper anterior teeth. The treatment plan recommended to parents included diet counseling, oral prophylaxis, pulpectomy for the maxillary incisors, followed by full coronal restoration with zirconia crowns, composite restorations for cuspids, and molars on both upper and lower arch. The child was managed with non-pharmacological tell-show-and modeling techniques. Multi-visit pulpectomy under local anesthesia was performed during the first two appointments. The canals were obturated with calcium hydroxide paste (Metapex, Meta Biomed Co. Ltd, Cheongju, Korea). The canals were further prepared and restored with a layer of GIC (Ketac molar, 3M Corp., Minnesota, USA) to isolate the root filling material. The coronal tooth structure was cleaned with saline, dried, etched (Eco-Etch, IvoclarVivadent, Asia), washed, dried, and cured after application of the adhesive system (Tetric N Bond Universal Vivadent, IvoclarVivadent, Asia). The core and crown build-up were done using freehand build-up with composite resin (Te-econom plus, IvoclarVivadent, Asia). Composite restorations for the cuspids and molars were restored with composite resin in subsequent visits. Preformed

zirconia crowns (Kids-e-dental LLP, Mumbai, IN) were placed in the next visit. Glass ionomer cement (Ketac Molar, 3M Corp., Minnesota, USA) was used for cementation.

Outcome and follow-up

Parents and the child were counseled about oral hygiene, diet, and maintenance and motivated to maintain regular recall appointments every 3 months. A week after the treatment, the child was examined and the crowns showed a perfect fit and the gum looked healthy. The patient was followed for 24 months. The adaptation of the preformed zirconia crown, the gingival health, and the attrition of the antagonist's tooth were considered. During follow-up visits, crowns were evaluated for adaptation, discoloration or fracture, wear, tear, and gingival health. The evaluation revealed proper functioning of the crowns with no discoloration or loss of restoration (Figure 1A-Figure 1I).

Case 02

A 4-year-old boy was referred to our center with a complaint of decayed upper anterior teeth. The child complained of occasional pain and discomfort over the past few weeks and reluctance to masticate using anterior teeth. Medical history was non-contributory. Parents revealed that the child had a history of bottle feeding until the age of 2. The child exhibited a negative Frankl rating. Intraoral examination revealed grossly decayed upper anterior teeth. Smooth surface caries on cuspids and molars. The child was diagnosed as affected by ECC. Thorough counseling of parents was done and a detailed treatment plan was formulated and discussed in the first appointment. Treatment was started in the second appointment with composite resin restoration (Te-econom plus, Ivoclar Vivadent, Asia) with 73,74,83 & 84. 64 was restored with GIC, followed by a preformed stainless-steel crown. Multi-visit Pulpectomy was performed with upper anterior teeth followed by placement of Zirconia crowns (NuSmile Primary crowns, NuSmile Ltd, Houston, Tx. USA) in two consecutive subsequent appointments. (Centrals placed first, followed by Laterals in next appointment). The patient has been followed up at regular intervals for 24 months (Figure 2A-Figure 2I).

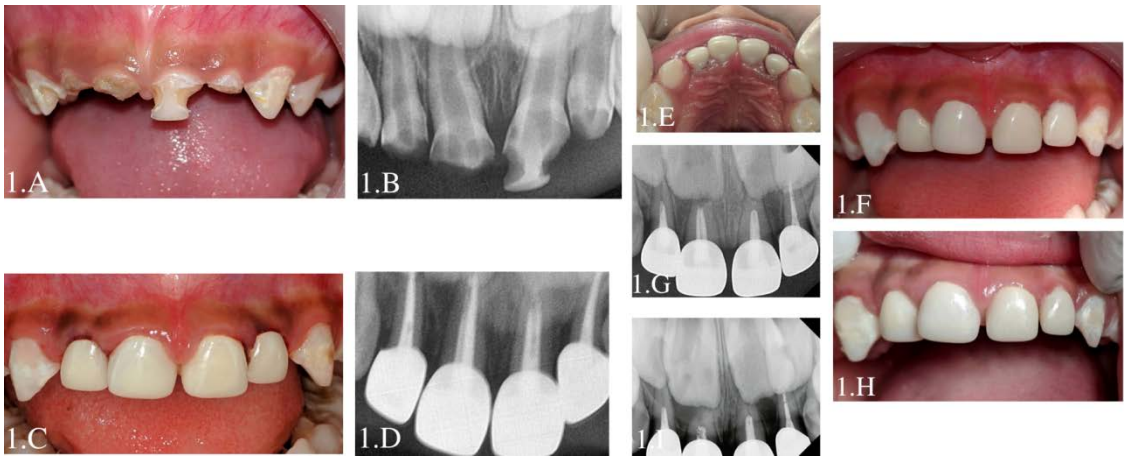

Figure 1. A: Pre-operative clinical view; B: Pre-operative radiograph; C: Immediate post-operative clinical view; D: Immediate post-operative radiograph; E: Post-operative palatal view; F: Clinical view upon 1-year follow-up; G: 1-year follow-up radiograph; H: 2-year follow-up clinical view; I: 2-year follow-up radiograph

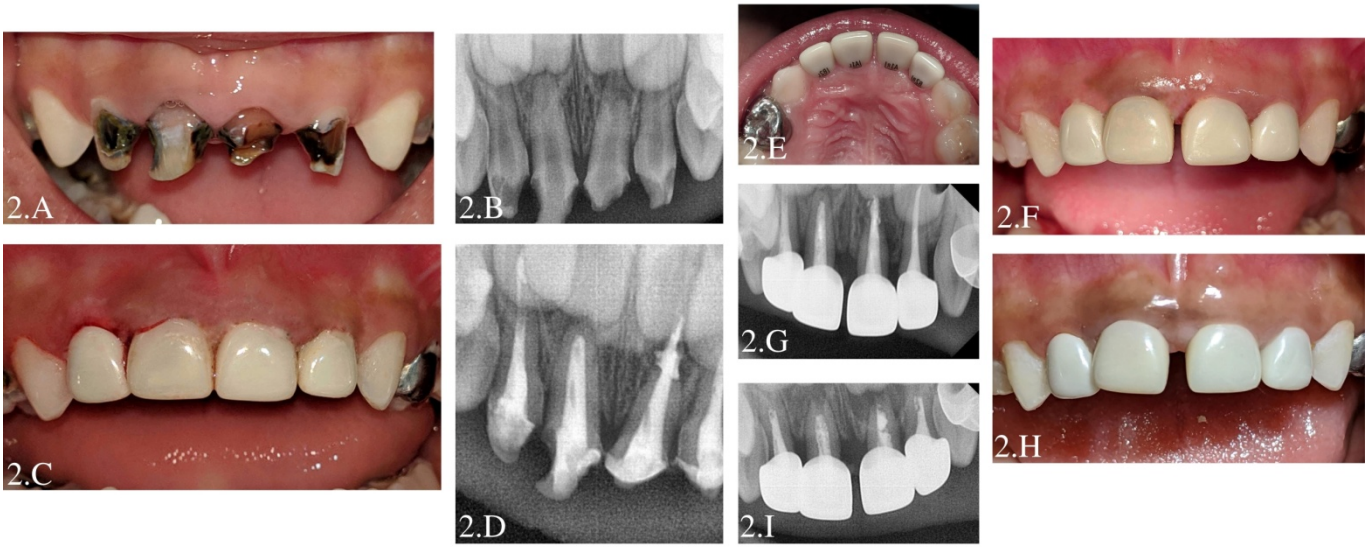

Figure 2. A: Pre-operative clinical view; B: Pre-operative radiograph; C: Immediate post-operative clinical view; D: Post-operative radiograph; E: Clinical view upon 1-year follow-up; F: 1-year follow-up radiograph; G: 1-year palatal view; H: 2-year follow-up clinical view; I: 2-year follow-up radiograph

Case 03

A 3-year-old boy attended our center accompanied by his father with a complaint of decayed upper anterior teeth for a few months. Clinical and radiographic examination revealed grossly decayed upper anterior teeth. Multi-surface caries with cuspids and molars. The child had shifted from a normal solid diet to on soft and semi-solid diet owing to discomfort and loss of function with anterior teeth. The child exhibited a positive Frankl rating and was keen to have good teeth and chewing ability restored. The child was diagnosed as affected by ECC. After parental counseling and establishing a detailed treatment plan discussion, restoration of maxillary and mandibular molars and cuspids were completed in the initial appointment followed by multi-visit pulpectomy upper anterior teeth followed by placement of zirconia crowns (NuSmile Primary crowns, NuSmile Ltd, Houston, Tx. USA) in two-step placements (Centrals followed by laterals). Both appointments lasted roughly 20 minutes each. The patient has been followed up at regular intervals for the last 24 months (Figure 3A – 3H).

Case 04

A 3-year–old boy visited our clinic accompanied by his mother with a complaint of a lip injury. During the clinical examination, we noticed that the cervical edge of a stainless-steel crown was scraping and hurting the upper lip. After clinical and radiographical examination we decided to remove the crown of the upper right lateral incisor. Some local anesthesia was administered and the crown was cut and removed, the tooth preparation to place the crown was done and a prefabricated zirconia crown (NuSmile Primary crows, NuSmile Ltd, Houston, Tx. USA) was cemented. The same procedure was performed on the right and left central incisors on a second appointment. No pulpotomy or pulpectomy was done on any tooth and the patient has been followed up at regular intervals for 3 years. During this period of time, the crowns look clean, and in good condition and both the child and their parents are satisfied with the treatment performed (Figure 4A- 4E).

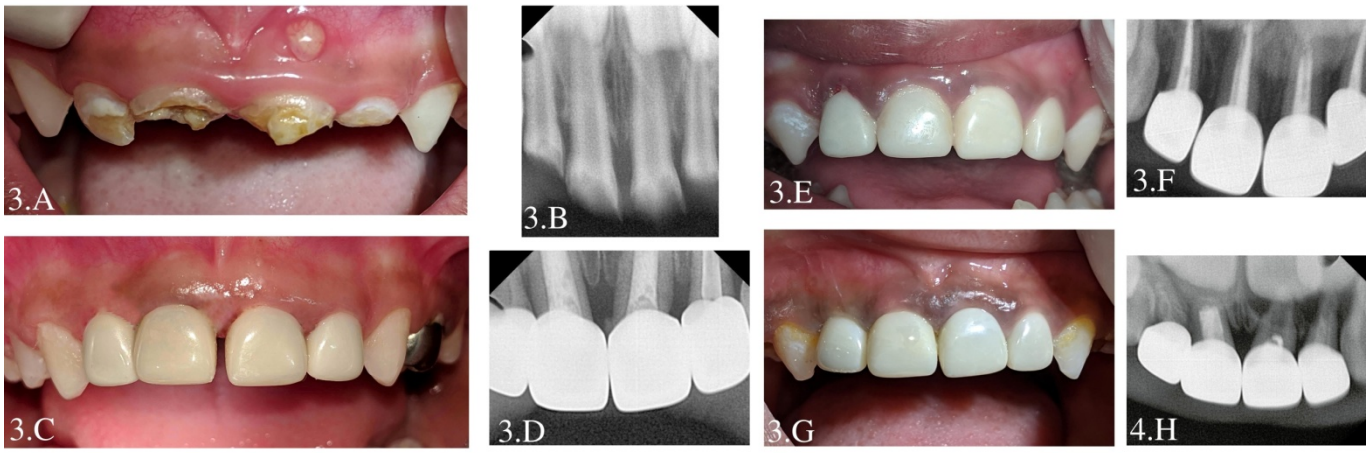

Figure 3. A:Pre-operative clinical view; B: Pre-operative radiograph; C: Immediate post-operative clinical view; D: Immediate post-operative radiograph; E: Clinical view upon 1-year follow-up; F: 1-year follow-up radiograph; G: 2-year follow-up clinical view; H: 2-year follow-up radiograph

Figure 4. A: Pre-operative clinical view; B: Immediate post-operative clinical view; C: Immediate post-operative radiograph; D: 3-year follow-up clinical view; 4: 3-year follow-up radiograph

DISCUSSION

Early childhood caries is a widely prevalent disease throughout the world. It is quintessential to treat this condition in early childhood. The affected teeth in ECC play a key role in phonetics, eating, aesthetics, and maintaining space for permanent teeth.[18] This rehabilitation has an important psychological impact on the recovery of a patient's self-esteem. Therefore, it is significant to invest efforts to keep these healthy until the time of their natural resorption and exfoliation. Over the years, numerous techniques for restoring primary teeth have been advocated namely polycarbonate crowns, composite strip crowns, stainless steel crowns (SSC), open-faced SSCs with veneer placed on chairside, and commercially available pre-veneered SSCs.

The effective and efficient usage of these techniques is complicated due to technical, functional, or aesthetic hurdles.[19] There is limited clinical data to suggest one type of restoration is superior to another. This does not discard the fact that dentists have been using many of these crowns for years with success. Clinicians' preferences, aesthetic demands by parents, the child's behavior, as well as moisture and hemorrhage control are all variables that affect the decision and outcome of whatever restorative treatment is chosen.[20] Composite strip crowns are another option for use in ECC, but they are

technique sensitive and intolerant to moisture contamination from saliva or blood during placement.[20,21] Furthermore, issues like shade mismatch, unaesthetic crown contours, loss of composite resin, marginal defects, and marginal gingivitis have been reported at follow-up.[22]

According to Serena Lopez Cazaux[23] parents reported overall good satisfaction with strip crowns, regardless of their dissatisfaction with color, shape, and appearance, but reported overall poor satisfaction when their child's strip crown was lost. These factors hence necessitate the use of aesthetic and durable zirconia crowns, which are now becoming increasingly popular in pediatric patients due to improved parental awareness and accessibility to such restorations.

It is important to note that placement of preformed zirconia crowns can be tricky owing to the tooth preparation time and placement, especially in the youngest and least manageable group of patients. Zirconia crowns work best with adequate tooth structure; thus, case selection is a vital precursor along with good patient cooperation. The cases discussed here were satisfactorily managed with behavior management techniques namely tell-show-do and modeling and were treated chair-side under local anesthesia. It is noteworthy that placement of a single unit crown in a child is easier than performing back-to-back crowns. Placement of a preformed pediatric zirconia crown on a mandibular molar is easier in comparison to anterior teeth or upper molars. Therefore, it would be up to the clinician's practical judgment to place all four anterior crowns together or in multiple appointments. All the above-discussed cases were placed in sets of two per appointment considering limited cooperation and ensuring minimal chair-time for the patients. When there is a loss of space (i.e. a mesiodistal space reduction), the situation is more complicated, but it is still possible to place a preformed zirconia crown. The specialized sizes developed by manufacturers are helpful in such cases.[24] To date, only a few studies have been published on these types of crowns.[14, 25, 26, 27, 28] All of the above cases have been followed up for a minimum period of two years.

Holsinger Et al.[14] reported that zirconia crowns stand out among other options as excellent aesthetics as reported by clinicians and parents. Previous studies measured resistance to fracture in-vitro using an inappropriate model that did not represent physiologic forces applied to teeth. [15, 16] Biocompatibility and reduced plaque accumulation were found to be due to the polished surface of zirconia crowns leading to less gingival inflammation when compared to veneered stainless-steel crowns.[14,28] Color stability was reported but not measured, being visually compared to natural adjacent teeth.[14]

Cementation is a valid concern for preformed zirconia crowns. The process remains technique sensitive as they need to be cemented with glass ionomer cement, which is sensitive to moisture and saliva contamination. Etching and bonding of zirconia are not possible because of the lack of silicone of glass-ceramic. Sandblasting has been reported to introduce micro-crack into zirconia. Etching with phosphoric acid or hydrofluoric acid does not affect the overall retention of a restoration. Conventional or self-adhesive resin cement have been recommended as luting agents for zirconia crowns.[25] A much-simplified technique has been recommended using a bioceramic luting cement, ceramic crown, and bridge. This biomimetic material has high pH to resist acid and bacteria, is biocompatible, and does not require an optimal condition for a good seal. [11] The manufacturers claim it is easy to handle because no etching or priming is required and its viscoelastic consistency helps the crown to slip easily in its place. Also, it is easy to remove the excess during the “rubbery phase”. In the above cases, a glass ionomer cement (Ketac Molar, 3M Corp., Minnesota, USA) was used for luting.

A known disadvantage of zirconia crowns, when compared to strip crowns, is the increased necessary tooth preparation due to its inflexibility and thickness, so as to fit the zirconia crown to the tooth.[13] Anterior zirconia crowns are known to require more than double the amount of tooth structure reduction when compared to anterior stainless-steel crowns.[19] Furthermore, limited shade selection, the limited potential to alter the shape of the crown, and the cost per crown represented additional potential disadvantages of zirconia crowns.[13,14,17]

Pediatric zirconia crowns require subgingival preparation as they are thicker than preformed metal crowns, which influence the periodontal response and the overall periodontal health. However, the periodontal response to pediatric zirconia crown is similar to that of any other type of crown. This response depends on the oral hygiene of the patient. When oral hygiene is good, there is no gingival inflammation.[23] Our cases showed good health of the periodontal tissues during the follow-up appointments. Case no 02 exhibited gingival inflammation around the zirconia crown which was attributed to pre-shedding mobility of the tooth.

Previous literature suggests pediatric zirconia crowns to have a survival outcome ranging from 80.2% to 100% at 6 to 30 months.[14, 25, 28, 29, 30] Literature on primary zirconia crowns are limited to retrospective studies, case reports, one randomized control trial, and one prospective study.

El Shahawy et al.[28] reported that the lowest survival rate (80.2%) was found at 24 months in a prospective study using a newly described clinical technique. In that study, the operator restored maxillary primary incisors that were deemed non-restorable with conventional techniques. Severely degraded primary maxillary incisors were included in the study after parents requested treatment rather than extraction. The incisors were treated with a method using glass ionomer (Fuji IX) post and core following pulpectomy and then restored with zirconia crowns. This same study revealed a survival rate of 95.3% at 12 months.[28] Survival was defined as the presence of the zirconia crown. As this method does not mimic clinical reality, zirconia crowns potentially present a retention rate of 96 to 100% at 6 to 30 months, according to the current literature representative of clinical practice.[14,15, 25,28, 30] The above cases report survival outcomes over 24 months.

CONCLUSIONS

Preformed zirconia crowns by far offer excellent aesthetics, superior durability, and better survival rates compared to conventional restoratives for teeth affected by ECC. During follow-up periods, a very good integration of the crown, proper functioning, no discoloration, and optimum gingival health were observed. They certainly meet the increased aesthetic demands of parents. Significant improvements in self-esteem, self-confidence, and socialization of all patients were reported. Long-term radiographic and clinical evaluations are necessary to study and understand the behavior of these crowns. However, presently the preformed zirconia crowns can be considered as an excellent alternative in the rehabilitation of primary anterior teeth affected by early childhood caries.

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Informed Consent: *Informed consent was taken from parents and/or guardians.*

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