RANDOMIZED CONTROL TRIAL

Prospective, Randomized, Clinical Evaluation of Preformed Zirconia Crowns and Stainless Steel Crowns on Permanent First Molars: 12-Month Results

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Abstract: ***Purpose:*** *The purpose of this prospective, randomized, parallel-group clinical study was to evaluate and compare the clinical outcome of preformed zirconia crowns and preformed stainless steel crowns when used to restore permanent first molars.* ***Methods:*** *Patients with severely decayed, badly broken down hypomineralized or hypoplastic permanent first molars that required a full-coverage restoration were invited to participate in the study. Sixty-nine healthy, cooperative children, ages six to 12 years, were recruited for the study. Following informed consent, 36 preformed zirconia crowns and 36 stainless steel crowns were placed and assessed at one week, three months, nine months, and 12 months according to the modified United States Public Health Service Ryge criteria. The parameters evaluated were: the time required for preparation and cementation; plaque accumulation; marginal integrity; fracture of the crown; retention of cement; interference with the eruption of the permanent second molar; and parental acceptance.* ***Results:*** *The clinical evaluation revealed statistically comparable performance in crown retention, fracture, marginal integrity, and plaque retention at 12 months between crown types. Preformed zirconia crowns were preferred by the parents primarily because of esthetics. However, a significant difference was seen in the clinical time required for the preparation and placement of preformed zirconia crowns, which was nearly twice that for stainless steel crowns.* ***Conclusions:*** *After 12 months of clinical evaluation, preformed zirconia crowns performed comparably to stainless steel crowns in their ability to restore decayed or hypomineralized permanent first molars. However, zirconia crowns took nearly twice as long to prepare, fit, and cement.* *(Pediatr Dent 2023;45(3):232-9.E21) Received July 15, 2022 / Last Revision December 14, 2022 / Accepted December 14, 2022*

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The restoration of permanent first molars in a mixed and early permanent dentition that demonstrate significant amounts of decay or are moderately to severely affected by molar hypomineralization (**MH**) presents a clinical challenge to the clinician. Various epidemiological studies have demonstrated that the first molar is the permanent tooth most frequently affected by caries.[1-5] Molar incisor hypomineralization (**MIH**) was first described by Weerheijm et al. in 2001.[6] The teeth commonly affected by MIH are the permanent first molars and the incisors, which may demonstrate soft and porous enamel that can break down easily and contribute to rapidly progressing caries.[7-9] The average prevalence of MIH is estimated to be 14.2 percent worldwide.[10] Providing long-lasting restorations in molars affected with MH and severe caries can be challenging. Treatment options have historically included restorations utilizing a variety of dental materials such as amalgam, resin-based composites, glass ionomers, and resin-modified glass ionomers, onlays, as well as full-coverage restorations.[11,12]

The full-coverage restoration most often utilized in these young patients are preformed metal or stainless steel crowns (**SSCs**) and occasionally lab-fabricated crowns.[11,13,14] Since its introduction in 1950,[15] SSCs have frequently been used for treating badly broken-down primary molars and have been a very reliable method of restoring these teeth.[16,17] Additionally, a few studies have examined the clinical outcomes of SSCs that have been used as interim restorations in carious and deteriorated hypomineralised permanent first molars.[18-23] While SSCs have been shown to demonstrate good clinical success on young permanent molars, many parents express distaste for the silver color of the SSCs and prefer a more tooth-colored restoration.[12] Until recently, tooth-colored full coverage for permanent molars could only be produced with standard crown procedures, requiring preparation, impressions, lab fabrication, try-in, and cementation. This requires considerable chair time and cost, patient cooperation, and technique sensitivity, which are often a challenge when attempting these procedures in pre-pubescent children.

Another restorative possibility is the use of CAD-CAM milling machines[24] to eliminate some of the steps of customized laboratory crowns, thereby creating crowns in a single, albeit lengthy, appointment. A drawback with CAD-CAM milling machines is that they are expensive, require good patient cooperation, and are not often found in pediatric-oriented offices. Metal and composite onlays can provide a slightly more conservative treatment option for restoring permanent molars.[12]

In 2019, a preformed zirconia crown specifically made for permanent molars was introduced by NuSmile® (NuSmile®, Ltd., Houston, Texas, USA). Preformed zirconia crowns for primary teeth have been available for over 10 years, with the

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first preformed zirconia crowns for deciduous teeth marketed as EZ-Pedo, now Sprig, (Loomis, Calif., USA) in 2008.[25] Several other companies–including NuSmile®, Kinder Krowns (St. Louis Park, Minn, USA), Cheng Crowns (Exton, Pa, USA), and Kids-e-Crowns (Kids-e-Dental, Mumbai, India)–have since introduced their own preformed zirconia primary crowns.[25,26] While there is not much published information on the clinical outcomes of primary molar zirconia crowns, one randomized trial with 24- and 36-month results concluded that preformed zirconia crowns placed on primary molars had similar clinical success to SSCs.[27,28] Mathew et al.[29] also reported comparable clinical success rates for SSCs and zirconia crowns on primary molars after 36 months. Another report by Talekar et al.[30] found that preformed primary zirconia molar crowns performed very satisfactorily in an 18-month prospective study.

To date, the only known report in the literature about the clinical use of preformed zirconia crowns for permanent teeth was a case report by Casian et al.[31] That report described the use of these crowns in a case of severely destroyed permanent molar secondary to MIH and caries. No studies are currently available that examine the clinical performance of preformed permanent zirconia molar crowns.

The purpose of this prospective, randomized, clinical trial was designed to evaluate and compare the clinical performance of preformed permanent zirconia crowns with preformed stainless steel crowns on badly broken-down permanent first molar teeth in children.

Methods

Informed consent. The present clinical trial was reviewed and approved by the ethical committee of M. A. Rangoonwala College of Dental Sciences and Research Centre, Pune, Maharashtra, India. The trial has been reported under the Consolidated Standards of Reporting Trials (CONSORT statement)[32] and has been registered with a national registry (Clinical Trials Registry-India) with the ID CTRI/2020/01/022801 and Reference No. REF/2019/12/029914. The details of the trial, the procedure involved, and the risks and benefits associated with it were explained to the parents/guardians of the participating patients. Written informed consent was obtained from each participant prior to participation.

Study design. In this prospective, randomized, parallel-group clinical study, each subject had at least one permanent first molar that needed crown placement. For each participant, either at least one permanent zirconia crown ([**PZR**]; NuSmile® Ltd., Houston, Texas, USA) or a preformed SSC (3M™ Unitek™ USA) was randomly placed as a part of the clinical trial.

Sample size. Sample size selection was determined with a power analysis at a significance level at the 95th percentile confidence level and power of 80 percent with a 0.5 estimated effect size, checked by G* power 3.0.1 software (Franz Fail Universitat, Kiel, Germany). The sample size was calculated to require 27 crowns per group.

Setting and eligibility criteria. Children six to 12 years of age who reported to Kids Dental Corner, a private pediatric dental office in Camp, Pune, with permanent first molars that were indicated for crown placement were invited to participate in the study. Indications for crown placement included the following: following completion of vital or nonvital pulpal therapy; large multi-surface carious lesions; deteriorated hypomineralized and/or hypoplastic first molars that had an antagonist tooth. Other selection criteria included: only children in good physical health, with no presence of crossbite or history of bruxism, and who were cooperative (Frankl rating of one or two). Children with completely erupted permanent second molars, with extensive caries having more than one surface with a subgingival margin, and whose parents were not willing to participate were excluded from the study. Patients were enrolled between January and October 2020.

Randomization. The type of crown (i.e., PZR or SSC) to be placed was randomly assigned to the child by computer randomization (Random.org, Randomness and Integrity Services Ltd., Dublin, Ireland). The patient loss was estimated to be 10 percent per year. A total of 69 participants were enrolled, and a total of 72 crowns were placed. Three children received two crowns, both crowns being the same material. Of the 72 molars treated with crowns, 17 were affected by MH and the rest had large carious lesions. Twenty-four teeth were nonvital and treated with appropriate root canal therapy, while 48 teeth were vital.

Blinding. Blinding at the level of the operator and the clinical evaluator was not possible due to the distinct appearance difference in the crowns. The PZR is tooth-colored, and the SSC is silver in color. The outcome assessor was blinded at the data entry level.

Clinical procedure. Prior to the initiation of the clinical procedure of the study, two operators, one an experienced pediatric dentist (AT), and the other a pediatric dental resident (GC), practiced both types of crown preparation (see **Supplemental Electronic Data—sTable 1**) along with placement and cementation of crowns on several extracted teeth in a laboratory setting according to each crown manufacturer's instructions. As mentioned previously, the type of crown to be placed

Table 1. MODIFIED UNITED STATES PUBLIC HEALTH SERVICE (USPHS) RYGE CRITERIA FOR DIRECT CLINICAL EVALUATION OF RESTORATION[28,31,40]

1. Plaque accumulation
Plaque retention:
Alpha (A) – No plaque retention
Bravo (B) – Minimal plaque retention
Charlie (C) – Excessive plaque retention (More than two-thirds of crown surface)
2. Marginal integrity
Alpha (A) – Closed margin
Charlie (C) – Open margin
3. Fracture of crown
Alpha (A) – Intact
Bravo (B) – Chipped/small but noticeable area of loss of material
Charlie (C) – Large loss of material
4. Retention of crown
Alpha (A) – Intact
Charlie (C) – Complete loss of crown
5. Eruption of second molar
Alpha (A) – Active eruption
Charlie (C) – Obstructive eruption
6. Parent's acceptance
Alpha (A) – Highly satisfied
Bravo (B) – Neutral
Charlie (C) – Strongly dissatisfied

was randomly assigned to a patient by computer randomization software (*Random.org*) at the time of the operative procedure. The operator was blinded to the type of crown until the beginning of tooth preparation. All crowns were clinically assessed by a single evaluator at one week, three months, six months, and 12 months follow-up using the modified United States Public Health Service Ryge criteria[27,30] (Table 1). Each crown was assessed for: the total time required for preparation, fitting, and cementation; plaque accumulation; retention of the crown; crown fracture; and marginal integrity.

Before beginning crown preparation, caries removal and any pulpal treatment or protection were completed and a composite resin core buildup was done on all teeth (Filtek™ Bulk Fill, 3M™, St. Paul, Minn., USA). This core buildup was done to assure the best seal over the pulpal area and create a uniformly intact clinical crown to provide optimal crown preparation. The measurement of time required for crown preparation, fitting, and cementation did not begin until these steps were completed. It started when the bur was placed on the tooth for crown preparation and was stopped when the crown was placed onto the tooth with the cement.

Per the manufacturer's recommendations, a resin-modified glass ionomer cement (BioCem, NuSmile®, Houston, Texas, USA) was used to cement the zirconia crowns, and a glass ionomer cement (GC Gold Label 1 Luting and Lining Cement, also available as GC Fuji I Cement, GC Corp., Tokyo, Japan), was used to cement the SSCs. Plaque accumulation was measured using a disclosing solution (GC Tri Plaque ID Gel™ GC Corporation, Tokyo, Japan) and assessing how much of the crown was covered by plaque. Crown retention was measured based on the total loss or retention of the crowns. Crown fracture was measured by any loss or chipping of crown structure. Marginal integrity was performed with an explorer to tactilely evaluate an open or closed gingival margin on buccal, lingual, mesial, and distal surfaces.

At 12 months, the eruption of the second molar was evaluated with an intraoral periapical radiograph to ensure there was no impedance to the eruption of the second molars due to the distal margin of the crowns. Also, at 12 months the parents were asked to complete a simple six-item Likert scale questionnaire to evaluate their satisfaction with the procedure.

Statistical analysis. All data were entered into a spreadsheet using MS Office Excel 2019 (Microsoft Corp., Redmond, Wash, USA). Data were subjected to statistical analysis using SPSS 26.0 software (IBM Corp., Armonk, NY, USA). Descriptive statistics, like frequencies and percentages for categorical data and mean and standard deviation for numerical data, were determined. Inter-group comparison (two groups) was done using a *t*-test. Comparison of frequencies of categories of variables with groups was done using a chi-square test. For all the statistical tests, $P<0.05$ was considered to be statistically significant, keeping α error at five percent and β error at 20 percent, thus giving a power to the study of 80 percent.

Results

A total of seven clinical parameters were assessed. The clinical time for placement was assessed at the first appointment only, and parental acceptance and eruption status of the permanent second molar was assessed only at the 12-month appointment. All other criteria were assessed at one week, three months, six months, and 12 months (Table 2). A total of 64 children were enrolled in the study, and 72 crowns were placed. Of these, 36 SSCs were placed in 30 patients and 36 PZR crowns were placed in 34 patients. In the PZR group, one patient with two crowns was lost to follow-up and was, therefore, excluded. In the SSC group, two patients with one crown each were lost to follow-up and, hence, were excluded (Figure 1).

Clinical time. The mean time taken for preparation, fitting, and cementation of PZR was 9.49 minutes (range equals 7.18 to 12.40 minutes); for SSCs it was 4.55 minutes (range equals 3.45 to 7.0 minutes). On average, it took nearly twice as long to prep and place the PZR crowns as it did SSCs. This difference in placement time was statistically significant ($P<0.001$; see Supplemental Electronic Data—sTable 2).

Plaque accumulation. Plaque accumulation was assessed at one week, three, six, and 12 months. There were significantly

Table 2. CLINICAL OUTCOMES OF CROWNS AT ONE WEEK, THREE MONTHS, SIX MONTHS, AND 12 MONTHS

Score*	1 week			3 months			6 months			12 months		
	Group 1**	Group 2		Group 1	Group 2		Group 1	Group 2		Group 1	Group 2	
	N=36	N=36	*P*-value†	N=36	N=36	*P*-value†	N=36	N=36	*P*-value †	N=36	N=36	*P*-value†
Parent's acceptance												<0.001
Nil										1	2	
Alpha*										33	8	
Bravo										0	24	
Charlie										2	2	
Plaque retention			1.00			0.317			0.490			0.850
Nil	0	0		1	0		1	2		3	4	
Alpha	24	24		30	27		31	27		29	27	
Bravo	12	12		5	9		4	7		4	5	
Marginal integrity			0.151			0.549			0.612			0.702
Nil	0	0		1	0		1	2		3	4	
Alpha	34	36		33	33		32	29		29	26	
Bravo	2	0		2	3		3	5		4	6	

* Refer to Table 1 for scoring criteria. ** Group 1: Preformed zirconia crown; Group 2: Stainless steel crown. † Chi-square test; level of significance=$P<0.05$.

more crowns from both groups ($P<0.05$) scored as having some plaque accumulation (Bravo) at one week than at any other assessment period. After the one-week assessment, plaque buildup became less at each successive evaluation period, with a majority of crowns in both groups scoring Alpha (no plaque retention; Figures 2 and 3). There was no statistically significant difference in plaque retention seen between the crown types at any of the assessment periods (Table 2).

Retention of crown. There was no significant difference in crown retention between crown types in the 12 months of the study. At one week and at three months, no crowns had been lost in either group. At the six-month follow-up, there were two SSC crowns found to be missing but all PZR crowns were present. At 12 months, no more SSCs had been lost; however, two PZR crowns had been lost (Table 3). All lost crowns were replaced or re-cemented but were excluded from the remainder of the study (Figure 1).

Crown fracture. There were no fractures of either type of crown for the duration of the study (Table 3).

Marginal integrity. The marginal fit/adaptation of the two crown types, as evaluated by a dental explorer, was judged to be very good throughout the study, and there were no significant differences in marginal adaptation between crown types (Table 2).

Active eruption of second molar. A total of 27 crowns were placed in children who were 10 to 12 years old. There were 15 SSCs and 13 zirconia crowns placed. None of these crowns placed on the permanent first molars hindered the path of eruption of the permanent second molar when evaluated radiographically at the 12-month follow-up (Figure 4).

Parental acceptance. Parental acceptance of the crowns was only assessed at 12 months. Parents were significantly ($P<0.001$) more satisfied with the PZR crowns than the SSCs. The aesthetic appearance of PZR crowns and the factor of not potentially replacing the crown again were the most acceptable factors for parents' acceptance over SSCs. The economical aspect and quick placement of SSCs were positive factors for a parent's acceptance of SSCs (Table 2).

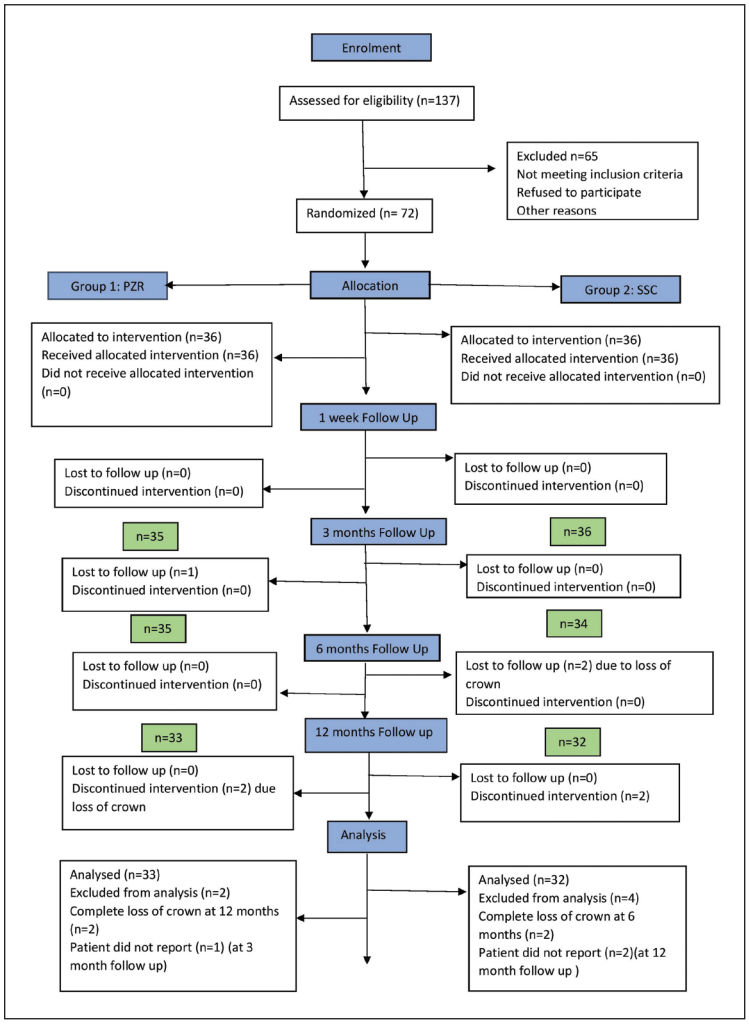

Figure 1. CONSORT flow diagram.

Discussion

Years after its introduction, SSCs are still widely used to restore both primary and permanent molars.[14] Their primary drawback is the lack of aesthetics and, when used in permanent molars, the need to replace them at some point in the future with a lab-fabricated crown.[23] Replacement is often due to the desire to provide a more wear-resistant, custom-fit crown.[22] In 2019, NuSmile® introduced preformed zirconia crowns for permanent molars. Preformed zirconia crowns for primary molars

Table 3. CLINICAL OUTCOMES OF CROWNS AT ONE WEEK, THREE MONTHS, SIX MONTHS, AND 12 MONTHS

Score*	1 week			3 months			6 months			12 months		
	Group 1**	Group 2		Group 1	Group 2		Group 1	Group 2		Group 1	Group 2	
	N=36	N=36	*P*-value†	N=36	N=36	*P*-value†	N=36	N=36	*P*-value †	N=36	N=36	*P*-value†
Fracture of crown			–			0.314			0.555			0.691
Nil	0	0		1	0		1	2		3	4	
Alpha*	36	36		35	36		35	34		33	32	
Retention of crown			–			0.314			0.555			0.840
Nil	0	0		1	0		1	2		1	2	
Alpha	36	36		35	36		35	34		33	32	
Charlie										2	2	

* Refer to Table 1 for scoring criteria. ** Group 1: Preformed zirconia crown; Group 2: Stainless steel crown. † Chi-square test; level of significance=$P<0.05$.

provide the advantage of being aesthetic and durable and can be placed in a single appointment. Casian et al.[31] suggested that, due to the marginal fit that can be achieved with preformed zirconia crowns, unlike SSCs, future replacement may be put off unless failure is encountered. Zirconia crowns also have a high wear resistance.[33] Considering the high prevalence of MH, enamel defects, and significant caries in young permanent first molars, preformed zirconia crowns may make an excellent aesthetic treatment option. The results of this short-term clinical study indicate that to be true for the period studied.

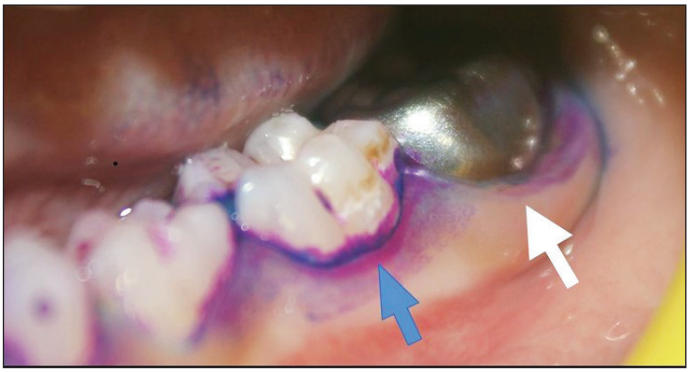

Figure 2. Plaque retention assessed following staining with disclosing solution for stainless steel crown restored permanent mandibular left first molar (white arrow) and non restored primary left second molar (blue arrow) teeth.

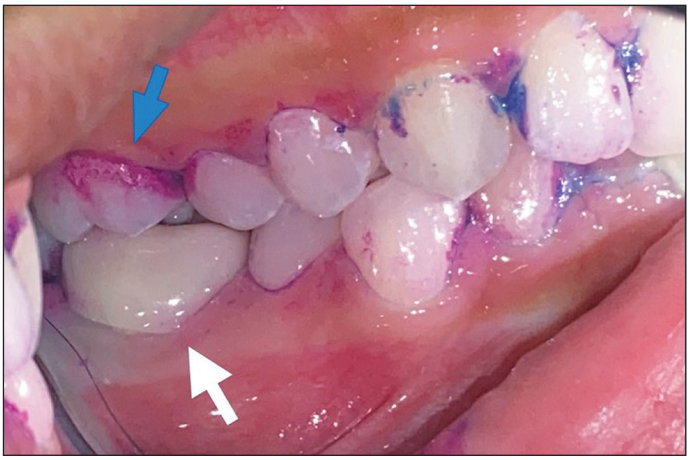

Figure 3. Plaque retention assessed following staining with disclosing solution for Zironcia crown restored permanent mandibular left first molar (white arrow) and non restored permanent left first molar (blue arrow) teeth.

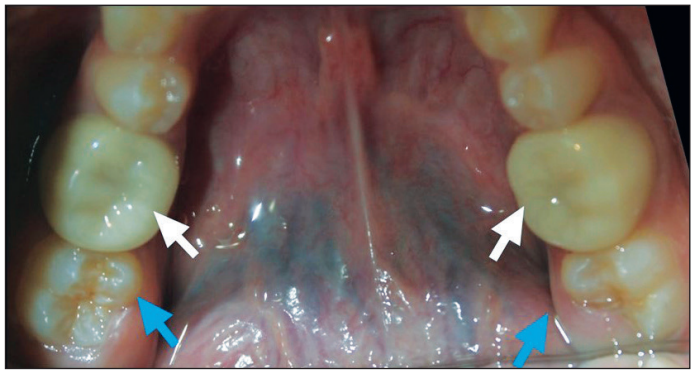

Figure 4. Twelve-month follow-up with zirconia crowns placed on permanent mandibular right and left first molars (white arrows) showing unimpeded eruption of corresponding permanent mandibular second molars (blue arrows).

A parallel group design was utilized in this study, even though a split-mouth design, with both types of crowns placed into the same mouth, would have been preferable. However, convincing the parents to place two different types of crowns into their children's mouths and finding a large enough sample of children that required two crowns was problematic, so the parallel group design was used. In this study, various clinical parameters were assessed to evaluate and compare the success of preformed zirconia crowns and SSCs on permanent first molars over 12 months. The time taken for the preparation of teeth for both crowns was calculated from the beginning of crown preparation to crown cementation. Tooth reduction required for PZRs is more than for SSCs as PZRs require a completely passive fit, while for SSCs a tight or snap fit onto the preparation is desired. The placement of separators prior to the scheduled appointment has been advocated to minimize the tooth structure removed from proximal areas.[34] Problems encountered while treating hypomineralized first molars are hypersensitivity and the inability to obtain profound anesthesia. The use of articaine (four percent) along with intraligamental and intraosseous techniques has been found to provide better results for these affected teeth.[35] The use of pre-emptive analgesics (Ibuprofen) has also been shown to increase anesthetic efficiency in children.[36]

The time required to place PZR was almost double the time for an SSC. For PZR crowns, the preparation must be made to fit the internal shape of the crown; for SSCs, the crown can be modified to fit the shape of the preparation. This increase in chairside time to prepare and fit a PZR crown can become particularly challenging if the child receiving the crown is marginally cooperative or has a difficult time sitting still. Both behaviors might be considered a contraindication to trying to place a PZR.

The current study demonstrated no significant difference in plaque accumulation at 12 months between the zirconia group and the SSC group. In fact, one week post-operatively was the only time there was significantly more plaque in both groups than at any other time during the 12 months. This is likely due to the gingiva being a little irritated and traumatized during crown preparation and, therefore, a bit more sensitive during brushing, causing the children to avoid cleaning the area to avoid discomfort. However, as the gingiva healed, brushing likely became better. Heidari et al.[37] assessed the health of the periodontium around permanent molars and concluded that the health of the periodontium improves following SSC placement. The reason for this might be that there is more plaque accumulation in carious and hypoplastic teeth compared to the smooth SSC surface. A systematic review by Ajaykumar et al.[25] demonstrated better gingival health and less plaque accumulation with zirconia crowns versus SSCs in primary teeth.

There was no significant difference found in the crown retention of the groups at 12 months. As mentioned previously, different cements were used for the different crown types, per the manufacturer's instructions. Zirconia crowns were cemented using a light-cured resin-modified glass ionomer (**RMGI**) cement (BioCem, NuSmile®, Houston, Texas, USA) while SSCs were cemented using type I (luting) glass ionomer (**GI**) cement (GC Gold Label 1). RMGI cements tend to be more sensitive to moisture and hemorrhage contamination

than GI cements (GC Fuji I Cement, GC Corp., Tokyo, Japan); however, most manufacturers recommend the use of RMGI to cement zirconia crowns over GI cements, due to its higher bond strength to zirconia. It would have been ideal to utilize the same cement for both types of crowns; however, the RMGI cement used to cement the zirconia crowns has an initial set that is initiated by light curing, so using it for the cementation of the SSCs would have led to a very prolonged time for the initial set of the cement, since light curing would not have been possible. The loss of crowns in both the groups was seen due to failure of luting between cement and tooth structure, not cement and crown. The crowns were recemented but excluded from further follow-ups of the study.

No crowns from either group were chipped or fractured during the length of the study. Historical use of SSCs, as well as numerous clinical studies with SSCs, have never reported a broken crown due to the metallurgic properties of the stainless steel.[38] Anecdotally, zirconia crowns have reportedly fractured in the mouth, but these fractures are considered to have been a result of either external trauma to the tooth/crown or the forceful placement of a crown over a nonpassive preparation that has created micro-fractures in the zirconia during seating, causing the crown to become more prone to fracture later, when under function.

SSCs have the advantage of being able to be crimped and trimmed at the gingival margins, while zirconia crowns cannot be crimped and can only be trimmed with considerable effort. Therefore, it was anticipated that SSCs might outperform zirconia crowns in their marginal fit (integrity), but this was not seen in the present study. Both preformed crowns used in the study have subgingivally placed margins, which offers the advantage of better marginal seal over custom-made restorations in partially erupted permanent molars.[39] There was no difference in marginal integrity between the two crown types, as measured by the crown margins on the buccal, lingual, mesial, and distal surfaces with an explorer. Marginal fit, or marginal integrity, is important for several reasons. First, a poorly fit crown at the margins can lead to periodontal health issues. This may be due to excessive plaque accumulation or poor margins impinging upon the gingiva. Poorly fit gingival margins could also allow for secondary decay to occur at the margins, leading to crown failure. Also, in the mixed dentition, a poorly fit crown with over-extended or poorly contoured margins could create a situation where an erupting tooth adjacent to the crowned tooth is impeded in its eruption by becoming lodged under the over-extended margins.

In the present study, the eruption of permanent second molars was evaluated with periapical radiographs. In hindsight, evaluation using posterior bitewing radiographs might have given even better observations of the gingival margins and proximity to the erupting teeth. Both groups studied showed similar marginal integrity. When evaluated radiographically at the 12-month follow-up in children with an active eruption of a permanent second molar (10 to 12 years), neither crown demonstrated any obstruction of the pathway of eruption.

A six-item informal questionnaire was used to inquire about the parental acceptance of their child's crown at 12 months (see **Supplemental Electronic Data—sFigure**). While this questionnaire has not been validated in the literature, it was meant to merely gauge the parents' thoughts and feelings toward the crowns. Parents liked that SSCs were more economical compared to zirconia crowns. However, their unaesthetic appearance and the need to replace them with a different crown after the full development of occlusion made zirconia a more preferable treatment modality for parents in the current study.

When considering possible limitations of the study, there were a few things that were limiting and possibly could be improved upon. As mentioned previously, a split-mouth design (placing both types of crowns into a single mouth) would have been preferable; however, there was parental resistance to this suggestion. There were a few children who received more than one crown; hence, the independency assumption practiced with the performed statistical tests would have been expected to be violated, although it was found to be insignificant. A bitewing radiograph would likely have been a more precise method for analyzing the marginal fit and the eruption of the second molar rather than intraoral periapical radiographs. In retrospect, a plaque and periodontal assessment prior to crown preparation and placement on the affected teeth, as well as contralateral teeth, and a continued objective evaluation of both with a well-established scoring index, rather than visual inspection, would have provided useful comparative information on the crowns.

Two operators placed the crowns, one an experienced operator and the other a pediatric dental resident in her final year of training. The operative procedures of the two were calibrated, prior to beginning the clinical study, in a small pilot study, and it was found that there were no statistical differences between operators. Still another limitation of the present study is the lack of blindness during the clinical evaluation. It is impossible to blind the assessor to the type of crown since one is silver and the other tooth-colored; however, the addition of a second clinical evaluator may have helped identify any evaluation bias of a single evaluator. The use of different cements for luting SSCs and zirconia is another limitation in this study. Ideally, for future studies, a self-setting RMGI cement would be recommended to cement both types of crowns. Finally, this study provided for only a 12-month follow-up; studies with longer recall periods and a larger sample size would be recommended to validate the results of the current study.

The aesthetics of the zirconia crowns make it a superior selection to the SSCs in many situations. While its durability as a prefabricated crown is largely unknown, lab-fabricated zirconia crowns have shown excellent durability in adults. As mentioned previously, due to the extra time required to prepare and fit these crowns and the increased level of technique sensitivity with fitting and cementing, their use may be limited in poorly cooperative children. Also, as there are no previous clinical studies on permanent prefabricated zirconia crowns, an unanswered question with the use of these crowns is whether the greater degree of tooth reduction for these crowns versus SSCs and the placement of a sub-gingival feather edge margin will create problems for future laboratory-fabricated crown preparations when and if a prefabricated crown needs replaced. Both in vitro and in vivo studies would be helpful to assess this potential issue with the use of prefabricated zirconia crowns.

Conclusions

Based on the study's results, the following conclusions can be made:

1. After 12 months, the clinical performance of stainless steel crowns and permanent zirconia crowns placed on permanent first molars demonstrated no significant difference.
2. PZR crowns were preferred over SSCs by parents due to their aesthetic appearance. Longer clinical

time with PZR crowns cannot be overlooked as compared to SSCs.
3. While the 12-month results are encouraging, longer-term evaluations of PZR crowns on permanent teeth are recommended prior to a strong endorsement of their use.

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Supplemental Electronic Data—Tables and Figure

sTable 1. STEPS IN CROWN PREPARATION

Step in crown preparation	PZR (permanent zirconia crown)	SSC (stainless steel crown)
Crown selection	Mesio-distal width size chart	Mesio-distal width size chart
Occlusal reduction	1-1.5 mm occlusal	1 mm occlusal
Proximal reduction	Reduction enough to fit the selected crown passively	Only for breaking the contact
Occlusal reduction	Maintaining occlusal anatomy	Maintaining occlusal anatomy
Buccal/lingual preparation	0.5-1.25 mm circumferentially	Minimal or no preparation required, reduction of buccal bulge if prominent
Subgingival preparation	Feather edge margin, 1-2 mm subgingivally	Slightly below the gingiva to break contact
Crown trial	Pink crown	SSC crown
Fit	Passive fit	Snug fit
Cementation of crown	Resin-modified glass ionomer cement	Type II glass ionomer cement (luting)

sTable 2. INTERGROUP COMPARISON OF TIME REQUIRED

Group*	Mean	Standard deviation	Standard error mean	T-value	*P*-value **
1	9.49	1.62	0.27	14.93	<0.001
2	4.55	1.15	0.19		

* Group 1: Preformed zirconia crown; Group 2: Stainless steel crown.

** Inter-group comparison was done using; level of significance=$P<0.05$.

Questionnaire for parental acceptance

1. Which crown was placed for your child?
   - Stainless Steel Crown
   - Tooth coloured (Zirconia) crown
2. What is your take on duration for treatment?
   A. Highly satisfied
   B. Satisfied
   C. Neutral
   • D. Dissatisfied
   E. Strongly dissatisfied
3. Are you satisfied with the treatment provided to your child?
   A. Highly satisfied
   B. Satisfied
   C. Neutral
   D. Dissatisfied
   E. Strongly dissatisfied
4. Would you consider the treatment provided to your child as pocket friendly/ economic?
   A. Highly satisfied
   B. Satisfied
   C. Neutral
   D. Dissatisfied
   E. Strongly dissatisfied
5. Are you satisfied with the aesthetics of the crown placed?
   A. Highly satisfied
   B. Satisfied
   C. Neutral
   D. Dissatisfied
   E. Strongly dissatisfied
6. Has your child complained of discomfort post treatment?
   A. Highly satisfied
   B. Satisfied
   C. Neutral
   D. Dissatisfied
   E. Strongly dissatisfied
7. If Stainless steel crown was placed in your child, what are your thoughts regarding the need for replacement of a more permanent crown in future?
   A. Highly satisfied
   B. Satisfied
   C. Neutral
   D. Dissatisfied
   E. Strongly dissatisfied

sFigure. Questionnaire for parental acceptance.