

ORIGINAL RESEARCH

Clinical success and its associated influencing factors in the placement of resin-bonded strip crowns on primary anterior teeth in children under general anaesthesia: a 1-year retrospective study

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Abstract

Background: Resin strip crowns (RSCs) are recommended for the restoration of primary incisors with caries. We aimed to explore the clinical outcomes and factors influencing the placement of RSCs on primary anterior teeth in children under dental general anaesthesia (DGA). **Methods:** We included patients who underwent RSC placement under DGA between January 2013 and December 2016. Data, including patient sex, age, arch type, tooth position, and number of carious surfaces of the tooth, were analysed. The chi-square test and logistic regression analysis were used for statistical analysis ($p < 0.05$). **Results:** A total of 63 patient files were included, with 308 restorations. At 12 months, the overall success rate of the RSCs was 87.01%. This study revealed the following: (1) The survival of RSCs placed on the teeth of patients aged >5 years was 3.61 times greater than that of RSCs placed on the teeth of patients aged ≤ 3 years (odds ratio (OR) = 3.61, $p = 0.029$). (2) The survival of RSCs placed on mandibular teeth was 2.7 times greater than that of RSCs placed on maxillary teeth (OR = 2.70, $p = 0.003$). (3) The survival of RSCs was 0.23 times greater for primary lateral incisors than for primary central incisors (OR = 0.23, $p = 0.011$) and 0.17 times greater for primary canines than for primary central incisors (OR = 0.17, $p = 0.002$). (4) The survival of RSCs placed on teeth with 1–2 carious surfaces was 13.5 times greater than that of RSCs placed on teeth with 3–4 carious surfaces (OR = 13.5, $p = 0.015$). **Conclusions:** Patient age, arch type, tooth position, and number of carious surfaces were associated with the clinical outcomes of RSCs. For older children, RSCs may be considered a preferable treatment for the restoration of primary anterior teeth, especially teeth in the lower jaw, primary incisors and teeth with fewer carious surfaces.

Keywords

Dental general anaesthesia; Primary anterior teeth; Resin-bonded strip crowns

1. Introduction

Primary anterior teeth are the first to erupt in the oral cavity. Poor dietary habits and oral hygiene can lead to a high rate of dental decay in children. Morphological defects of the primary anterior teeth can lead to problems in appearance, pronunciation, and mental health [1]. Consequently, despite the early replacement of primary anterior teeth, the treatment and restoration of caries are particularly critical [2].

For a long time, the aesthetic restoration of severely damaged primary anterior teeth has been challenging for paediatric dentists. This is not only due to the lack of available materials and techniques but also because children requiring such restoration are usually the youngest and most difficult to manage. Due to their young age and lack of cognitive ability, these children are often very uncooperative when receiving dental

treatment, and their behaviours play an influential role in the success of the treatment [3]. Additional factors contributing to the difficulty in treatment include small tooth volume, pulp close to the tooth surface, relatively thin enamel, and a smaller adhesive surface area [4].

The available evidence is inadequate for establishing an optimal restoration method or filling material for primary anterior teeth [5]. Currently, full-coverage crowns, including resin-bonded strip crowns (RSCs), veneered stainless steel crowns (PVSSCs), and prefabricated primary zirconia crowns (ZCs), are used to restore carious primary anterior teeth [6].

For many years, RSCs have been the most aesthetic restorative option for carious primary incisors [7]. The advantages of using RSCs include excellent aesthetics, multiple shade selections, the ability to fit the crown form into crowded spaces, and ease of repair [3], saving clinical operation time

and reducing the number of steps involved. Hence, RSCs are a reliable choice for restoring primary anterior teeth [8, 9].

However, the technical sensitivity of RSC restorations is very high. Controlling moisture and haemorrhage from the gingiva are challenges that need to be overcome to achieve successful results. Haemorrhage or saliva on the tooth can interfere with the bond, and haemorrhage can affect the shade or colour of the material. Additionally, adequate tooth structure must remain after caries removal to ensure a sufficient surface area for bonding [3]. The more decayed the tooth surface is, the greater the failure rate of transparent crown restoration [9]. Furthermore, the success rate of RSCs is linked to the effective bonding area of the teeth, and choosing RSCs is more effective for at least half of the remaining tooth tissue after dental decay removal [10].

What other variables influence the outcomes of RSCs? The survival of RSCs can be improved by controlling adverse factors. However, clinical research on RSCs is difficult because children with anterior tooth caries are typically young. In these young children, unless they are completely unconscious, as with general anaesthesia (GA), their negative behaviours can influence the clinician's ability to place restorations under ideal circumstances. For a clinical trial to be valid or beneficial, children's behaviour should be consistent for all restorations [3].

Dental general anaesthesia (DGA) is a quick and relatively safe option for uncooperative patients, such as very young, healthy children and those with special needs [11]. Although comprehensive dental treatment under DGA is risky and expensive (including potential delays and waiting times that complicate treatment), it is effective because it allows dentists to perform all necessary dental treatments in one visit and reduces the potential psychological trauma associated with prolonged or multiple visits [12].

In summary, we aimed to explore the one-year clinical outcomes and associated influencing factors in the placement of RSCs on primary anterior teeth in children under DGA at Guangzhou Women and Children's Medical Center. Notably, few reports exist on the restoration of primary mandibular anterior teeth and primary canines.

2. Materials and methods

2.1 Data collection

The RSCs were placed on the teeth of children who received dental treatment under DGA at Guangzhou Women and Children's Medical Center between January 2013 and December 2016. Children who had been followed up for at least 12 months were included in this study. All treatments were completed by two certified paediatric dentists, and all operators used the same materials and treatment protocols.

The inclusion criteria were as follows: (1) had indications for DGA [13]; (2) had at least one anterior tooth restored with an RSC; and (3) had a postoperative follow-up duration of no less than 12 months. The exclusion criteria were as follows: (1) teeth affected by caries or trauma with less than 1/3 of the crown structure remaining; (2) teeth with periapical inflammation; and (3) tooth exfoliation time of less than one

year.

An Excel spreadsheet was used to record information by consulting the electronic medical records system. Factors potentially related to treatment failure were investigated, including individual and clinical characteristics: sex (boys or girls), age, arch type (in the upper or lower jaw), tooth position (primary incisors, primary lateral incisors and primary canines), and number of carious surfaces of the tooth (1–2 or 3–4 surfaces). The patients' follow-up time and evaluation of RSCs during follow-up visits were also recorded. The number of carious surfaces was counted using preoperative photographs (Fig. 1).

2.2 Restorative procedure

The decayed dentin of the anterior tooth was removed, the infected dentin near the medulla was retained, and 0.5–1.0 mm of dental tissue was evenly removed at the contact point. We then selected the appropriate strip crown (Kids Crown, Korean), trimmed and tested it. The restorative procedures were performed under cotton isolation. A thin layer of Calcimol LC (VOCO GmbH, Cuxhaven, Germany) was used in the deep and moderate cavities. Root canal treatment was performed on teeth with pulpitis. Under rubber dam isolation, the canal was mechanically prepared using a series of 21 mm long K-type endodontic files up to file #40. The working length was estimated using preoperative radiographs. The root canals were then irrigated after each file was prepared with 3% hydrogen peroxide and saline and dried with paper points. Vitapex paste (Neo Dental Chemical Products Co. Ltd, Tokyo, Japan) was used to fill the root canal, and glass ionomer cement (Fuji IX, Japan) was placed at the bottom. The strip crown was filled with composite resin (GC Phantom series, colour A2, Japan). Clearfil SE Bond (CSB; Kuraray Co. Ltd., Osaka, Japan) Primer was applied for 20 s and air-dried for 5 s, and the bonding agent was then applied using a microbrush and light-cured for 10 s. The strip crown was inserted into the tooth and fixed in the correct position. Excess resin was removed with the probe, and each tooth surface was cured in the light for 20 s. The cotton and strip crown were removed. Finally, the occlusion was checked. Typically, restorations require minimal finishing. If needed, the shape or reduction of excessively long incisor edges was performed using composite finishing disks and strips (Fig. 2).

2.3 Evaluation method

The evaluation method for the filling material was recorded in an outpatient system. The patient was evaluated by one of two paediatric dentists, and both dentists used the same evaluation criteria, which were based on Ram's evaluation criteria [8]: (1) The surface of the restoration is smooth and without pitting. (2) There are no fractures or secondary caries. (3) There is no obvious discolouration of the restoration that compromises the aesthetics (Fig. 3). Meeting the above three conditions was considered to indicate clinical success.



FIGURE 1. Preoperative photographs of the patient. (a) Preoperative frontal view showing that the labial surfaces of 53–63 and 73–83 all had caries; the mesial surfaces of 52, 62, 63, 71 and 81 had caries; and the distal surfaces of 52, 51, 61, 62 and 82 had caries. (b) Maxillofacial view showing that the lingual surfaces of 53–63 had caries. (c) Mandibular view showing no caries on the lingual surfaces of 73–83.

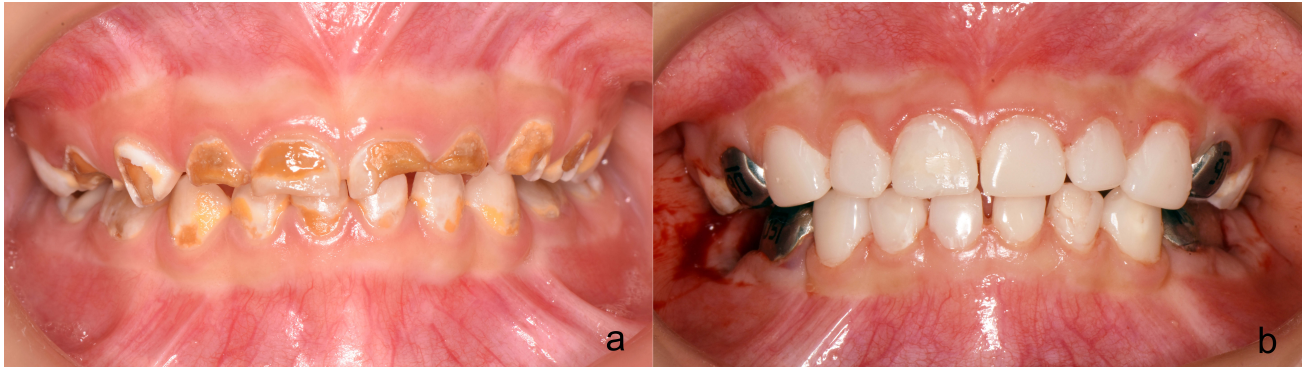


FIGURE 2. Preoperative and postoperative comparisons of RSC restoration. (a) Before RSC restoration, all the primary anterior teeth suffered from varying degrees of dental caries. (b) After the RSCs were restored, all the primary anterior teeth achieved a good appearance, smooth surface, uniform colour, and appropriate occlusal.



FIGURE 3. Frontal view at 12 months after RSC restoration. The restorations of 52–61 remained intact, with a smooth surface and good colour.

2.4 Statistical analysis

SPSS software version 20.0 (SPSS Inc., an IBM Company, Chicago, IL, USA) was used for the statistical analysis of all the data. The chi-square test was used to determine the success rate of RSCs for different parameters. For variables with a p value less than 0.05 in a preliminary analysis, a logistic regression analysis model was used to identify factors associated with the survival of restorations. Dummy variables were used for age and dental position, and $p < 0.05$ was considered to indicate statistical significance.

3. Results

A total of 63 children (with 308 teeth) aged 22–95 months (average age: 50.03 ± 17.29 months) were included. Each child had an average of 4.89 ± 2.62 restored anterior teeth, with a maximum of 10 and a minimum of 1. A total of 268 teeth were successfully restored within 12 months, for a success rate of 87.01%.

A single-factor analysis of the one-year success rate of RSCs is shown in Table 1. Patient sex, age, arch type, tooth position, and number of carious surfaces of the teeth were included as influencing factors. Chi-square tests were performed on the success and failure rates of the RSCs for these five parameters. The results showed a statistically significant difference in age, arch type, tooth position, and the number of carious surfaces of the teeth ($p < 0.05$, Table 1).

After the initial analysis, age, arch type, tooth position, and the number of carious tooth surfaces were included in the regression equation. The data from the logistic regression analysis are presented in Table 2. The number of successfully restored teeth was the dependent variable, and age, arch type, tooth position, and number of carious tooth surfaces were the independent variables. Dummy variable analysis was used for age and tooth position (with “age ≤ 3 years” and “primary incisors” as dummy variables), and $p < 0.05$ was considered to indicate a statistically significant difference.

Patient age, arch type, tooth position, and the number of carious surfaces of the teeth were associated with the risk of

TABLE 1. Single-factor analysis of factors influencing the success rate of RSC restoration.

Variables	N	Failure (%)	Success (%)	χ^2 value	<i>p</i> value
Sex					
Male	209	25 (11.96)	184 (88.04)	0.61	0.437
Female	99	15 (15.15)	84 (84.85)		
Age (yr)					
≤ 3 yr	97	19 (19.59)	78 (80.41)	6.90	0.032*
3~5 yr	167	19 (11.38)	148 (88.62)		
> 5 yr	44	2 (4.55)	42 (95.45)		
Arch type					
In the upper jaw	198	32 (16.16)	166 (83.84)	4.94	0.026*
In the lower jaw	110	8 (7.27)	102 (92.73)		
Tooth position					
Primary incisor	79	4 (5.06)	75 (94.94)	6.02	0.049*
Primary lateral incisor	101	15 (14.85)	86 (85.15)		
Primary canine	128	21 (16.41)	107 (83.59)		
Number of carious surfaces					
1~2	236	25 (10.59)	211 (89.41)	5.12	0.024*
3~4	72	15 (20.83)	57 (79.17)		

*Statistically significant. *N*: number.

TABLE 2. Logistic regression analysis of factors influencing the one-year success rate of RSC restoration.

Variables	OR	95% CI	<i>p</i> value
Age			
≤ 3 yr	Reference		
3~5 yr	1.80	0.94–3.47	0.078
> 5 yr	3.61	1.14–11.47	0.029*
Arch type	2.70	1.40–5.20	0.003*
Tooth position			
Primary incisor	Reference		
Primary lateral incisor	0.23	0.07–0.72	0.011*
Primary canine	0.17	0.05–0.51	0.002*
Number of carious tooth surfaces	13.5	0.22–0.85	0.015*

*Statistically significant. *OR*: odds ratio; *CI*: Confidence interval.

RSC restoration failure. In terms of the one-year success rate of RSC restoration for primary anterior teeth, that for children aged > 5 years was 3.61 times greater than that for those aged ≤ 3 years. That placed on teeth in the lower jaw was 2.7 times more than that placed on teeth in the upper jaw. That for primary lateral incisors was 0.23 times more than primary incisors, and 0.17 times more primary canines than primary incisors. Teeth with 1–2 carious surfaces were 13.5 times more common than those with 3–4 carious surfaces. There were no statistically significant differences in any of these variables between children aged 3–5 years and those aged ≤ 3 years.

4. Discussion

This retrospective study provides valuable information regarding the survival and risk factors associated with RSC failure in a paediatric population under DGA. Age, arch type, tooth position, and the number of carious surfaces were associated with restoration failure.

A study by Waggoner demonstrated the challenge of establishing clinical studies to assess restorative choices for primary incisors, as the limited cooperative ability of young children affected the outcome of that experiment. In addition, few clinicians consider placing children in an experimental situation where restoration failure can cause a significant replacement problem [3]. Therefore, prospective experiments evaluating restorative options for primary incisors are difficult. The disad-

vantage of retrospective studies is that data are usually obtained from charts and often do not follow standardized protocols. In contrast, these studies are closer to real-life findings than prospective studies and may be useful, especially when current prospective clinical trials are difficult to implement [9]. In this study, the procedures were conducted under DGA, excluding the influence of factors such as patient visits and cooperation, reducing experimental bias and making the research results more reliable. However, since the sex and age distributions are not homogeneous, there are limitations to the study, and more thorough research is necessary.

The survival rate of the restorations reached 87.01% after 12 months of follow-up, which is close to the success rates reported by Kupietzky [14] and Ram *et al.* [9]. Ram suggested that the high success rate may be linked to the type of practice and the socioeconomic status of the parents. Most of these parents were proactive and willing to take their children for check-ups and regularly used fluoride after 3–6 months. These factors may have affected the decrease in the number of children who continued their nightcare habits and the number of new caries detected in subsequent examinations [9]. The patients included in our study were also characterized by the above factors, which might be linked to the high RSC success rate observed in this study.

4.1 Influence of arch type on the restoration

The restoration of primary mandibular incisors presents an even greater challenge than that associated with other teeth. These teeth are very small, and the pulp cavity is very close to the enamel layer, making it difficult to prepare for the restoration of these teeth without exposing the pulp [3]. Consequently, direct composite resin restoration of primary mandibular incisors is difficult.

In this study, we used RSCs designed for maxillary primary incisors and primary lateral incisors to restore the mandibular primary anterior. Surprisingly, we found that the retention rate of the RSCs placed on teeth in the lower jaw was greater than that of RSCs placed on teeth in the upper jaw.

RSCs are composite resin restorations. Research on RSCs is limited; accordingly, to obtain a suitable reference we searched the literature on composite resin restorations. Demarco *et al.* [15] reported that restorations in the maxilla are more prone to failure in anterior teeth than in mandibular teeth. This is most likely related to the important role of the upper front teeth in the aesthetic appearance of patients. Sande *et al.* [16] reported that restorations in the lower jaw generally showed a greater survival rate than those in the upper jaw. Patients may have more easily perceived imperfections in their upper teeth, resulting in more interventions. Moreover, restorations performed in the upper jaw are affected by different masticatory forces and increased incisal stress compared to those in the lower jaw, which may also affect the results. Ideally, variables linked to the patient, such as the Angle's classification, the incisal relationship, bruxism, and dietary habits, should be evaluated [16].

In this study, the high survival of RSCs placed on mandibular teeth may also be associated with fewer caries on the

surface of the lower jaw teeth. A study showed that the prevalence of caries was greater in maxillary anterior teeth than in mandibular anterior teeth [17]. However, further analysis is required to confirm this finding. This discovery is surprising because using RSCs to restore mandibular anterior teeth simplifies the operation and can result in an aesthetically pleasing appearance. Moreover, a higher success rate was achieved. Therefore, paediatric dentists are encouraged to consider RSCs to be an ideal choice for the restoration of the lower anterior teeth.

4.2 Influence of tooth position on the restoration

Few reports exist in the literature on the use of RSCs in primary canines and mandibular anterior teeth. In this study, we placed RSCs on primary canines. However, the survival of RSCs placed on canine teeth did not achieve ideal results, which may be correlated with the large bite force borne by that of primary canine teeth. It is possible that crowns specifically designed for deciduous canine teeth can achieve the best results. To address this problem, we designed an RSC for deciduous canines and obtained a patent (Patent No.: ZL 2017 3 0648427.7). However, the effect of this new RSC must be validated clinically. In terms of the reason for the lower survival rate of primary lateral incisors, we could not explain it. Therefore, further clinical trials are needed.

4.3 Influence of the number of carious surfaces on the restoration

For all variables, the number of carious surfaces significantly affected the number of restorations. The survival of teeth with 1–2 carious surfaces was far greater than that of teeth with 3–4 carious surfaces. This is consistent with the findings of Ram and Fuks *et al.* [9]. The carious surface of the tooth can be considered an adverse factor that affects the survival of RSCs. This may be associated with the effective adhesion area. The adhesion region may remain less efficient as the amount of caries on the tooth surface increases. The longevity of the crown is likely to be jeopardized if a considerable amount of tooth structure is missing, as the composite crown relies on dentin and enamel adhesion for retention [18].

4.4 Influence of patient age on restoration

The results of this study revealed that the retention rate of RSCs placed on the teeth of older children was greater than that in younger children. Research has shown that older children (aged >3 years) have a lower risk of secondary caries than younger patients. This is naturally linked to difficulties in treating young children because of their limited ability to cooperate [19]. However, all children involved in this study underwent treatment under DGA; therefore, the children's uncooperative behaviour had no effect on the treatment outcome.

The risk of caries is one of the most crucial factors affecting longevity. The longevity of restorations is challenged in patients at a greater risk of caries, as new carious lesions are likely to develop adjacent to restorations (secondary caries) [19]. One study showed that young children who underwent dental

rehabilitation under DGA had poor oral health parameters and poor oral health-related behaviour [11].

In this study, the success rate was higher in the group aged >5 years than in the group aged 3–5 years, and the success rate was lowest in the group aged ≤3 years. We considered that the effect of patient age was likely linked to the greater risk of caries in these children. In addition, chewing habits may be another influencing factor, as older children have better compliance and are better able to follow medical advice to avoid biting hard objects with their front teeth, leading to a higher restoration survival rate.

4.5 Bonding problems

Generally, RSCs are bonded using an etch-and-rinse system. Selective enamel etching before the use of self-etching adhesives is highly recommended [20]. Another study demonstrated that one-step self-etching is inferior to multistep strategies for bonding to primary enamel [21]. However, a systematic review of the application of bonding to primary teeth reported that a mild universal adhesive system could substitute for etch-and-rinse and self-etch systems for restoring primary teeth [22]. In addition, Dijken *et al.* [23] reported no significant differences in durability between self-etch and etch-and-rinse adhesives. Another study revealed that after a one-year period, the self-etch adhesives tested presented clinical efficacy similar to that of the etch-and-rinse adhesive in restoring class II cavities in primary molars [24]. Furthermore, is it necessary to use a complete adhesive etching system for strip crown restoration? The rinsing of the acid etching causes discomfort and panic in children. In addition, it is crucial to reduce the operation time of DGA because prolonged surgery carries a greater risk of complications than what would normally be expected [25]. In paediatric dentistry, there is also a great need to shorten the application time. Reducing the number of clinical application steps can shorten the chair side time, providing additional advantages for treating young patients [26, 27]. This has motivated the use of self-etching adhesive systems and universal adhesives to bond enamel and dentin [20].

In this study, we used a universal adhesive system instead of selective enamel etching during the restoration procedure, and satisfactory results were obtained. However, research on which bonding system is most suitable for RSCs is limited. More clinical trials are necessary to compare the efficacy of universal and etch-and-rinse systems for RSCs placed on primary teeth.

4.6 Comparison of PVSSCs, ZCs and RSCs

The three full-coverage crowns for primary anterior teeth have their own advantages and disadvantages. RSCs have the benefits of multiple shade selections, the ability to fit crowded dentitions, and ease of repair [28]. However, RSCs are technique sensitive and difficulty controlling haemorrhages and saliva can occur during the restoration procedure [29]. Compared with PVSSCs, RSCs require longer clinical operation times and have shorter longevity [30, 31]. The disadvantage of PVSSCs is the adaptability of the crown to the tooth due to limited crimping, contouring, or squeezing of the crown.

Moreover, the long-term retention and fracture resistance of the veneer are relatively low. Furthermore, PVSSCs are 5–8 times more expensive than RSCs [30].

The advantages of ZCs include colour stability, resistance to fracture or, good biocompatibility and autoclaving. The disadvantages are that the colour and shape are limited, the colour choices are more basic, and the shape cannot be adjusted. Consequently, more dental tissue must be removed to place a suitable dental crown [32]. As a result, ZCs can cause more dental tissue loss in teeth [33]. Finally, ZCs are more expensive than RSCs [34].

In summary, compared to PVSSCs and ZCs, RSCs have greater technical sensitivity and lower retention rates. On the other hand, RSCs require a smaller amount of tooth preparation; accordingly, more tooth tissue is preserved. Moreover, RSCs are less expensive.

Therefore, it is recommended that RSCs be chosen for vital teeth or patients with poor economic conditions. Due to the high technical sensitivity and the requirement for cooperation among children, RSCs are more suitable for older children, mandibular anterior teeth, central incisors, and teeth with fewer caries.

Notably, because data were collected from 2013 to 2016 there may be concerns about the timeliness and relevance of the findings in the context of current practices or advancements in the field. Although these data are not up-to-date, it is worth noting that over time, RSC restoration of primary anterior teeth has remained relatively stable and is still used today. In addition, the references cited in the study are new, providing a relatively new body of evidence for further validation research. Owing to older but relevant data and existing literature, we can understand this theme and highlight the objective value of this study better.

5. Conclusions

In conclusion, this retrospective study showed that after 12 months of follow-up, the survival of RSCs placed in children under DGA was satisfactory.

Restoration of the lower teeth was associated with a high RSC survival rate, probably because of the following reasons.

(1) Upper front teeth play an important role in the aesthetic appearance of patients. (2) Patients may perceive imperfections in the upper teeth more easily, resulting in more interventions. (3) Compared with those in the lower jaw, restorations in the upper jaw are subjected to different masticatory forces and increased incisal stress.

To evaluate the clinical outcome of RSCs, additional research must be conducted on the correlation between caries surface and arch type, diminished survival rate of primary lateral incisors, clinical application of new strip crowns for primary canines, and the most appropriate bonding system for RSCs.

When considering primary anterior tooth restoration, RSCs may be regarded as the preferred method for restoring vital teeth, treating patients with poor economic conditions, and restoring lower jaw teeth, primary central incisors, teeth with fewer carious surfaces, and teeth in older children.

ABBREVIATIONS

RSCs, resin-bonded strip crowns; DGA, dental general anaesthesia; OR, odds ratio; PVSSCs, preveneered stainless steel crowns; ZCs, zirconia crowns; GA, general anaesthesia; CI, Confidence interval.

AVAILABILITY OF DATA AND MATERIALS

The data are contained within this article.

AUTHOR CONTRIBUTIONS

KC—designed this study. YLL—performed the experiments; analysed the data and wrote the manuscript. HCX—provided help and advice for this study. All authors contributed to editorial changes in the manuscript. All authors have read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the Ethics Committee of Guangzhou Women and Children's Medical Center (project number: Sui Fu Er Ethics Review 2015020908). All methods were carried out in accordance with relevant guidelines and regulations. Oral informed consent was obtained from all subjects, and written informed consent was obtained from their legal guardians.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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