Review Article

SYSTEMATIC REVIEW OF DIFFERENT OUTCOMES FOR DENTAL TREATMENT PROVIDED TO CHILDREN UNDER GENERAL ANESTHESIA

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ABSTRACT

This systematic review aimed to assess the outcomes of dental treatment provided to children aged < 18 years under general anesthesia (GA). An electronic search was conducted of the Medline (via PubMed), Cochrane Library, Web of Science, and Scopus databases (up to December 2021). In addition, the bibliographic references of identified articles were hand-searched for relevant articles. The exclusion criteria were non-English articles, case reports, and review articles. The search yielded 886 articles (after the removal of duplicates). These articles were independently assessed by two reviewers at the title, abstract, and full-text levels. A total of 46 articles were included in the systematic review; 40 studies were retrospective, 3 were prospective, and 3 were case-control. The results revealed that some of the children suffered from relapse after receiving dental treatment under GA; 24–59% developed new caries lesions and 6.5–87% required further restorative dental treatment. The reported rate of repeat GA ranged between 0% and 31.8%, with an average interval between GA episodes of about 2 years. Stainless steel crowns and pulpotomies showed a higher success rate compared to direct restorations. Dental treatment provided under GA was successful in addressing the consequences of dental caries but did not help prevent the development of new carious lesions or the need for a subsequent dental treatment under GA. The focus of dental professionals should shift from the traditional approach of treating the consequences of oral diseases towards more preventative measures.

Key words: Early childhood caries, General anaesthesia, Children, Prevention.

Introduction

Dental caries during childhood has been a major health problem for many years and continue to be so today. Over time, different names and terminology have been used to describe dental caries in young children. Currently, the term early childhood caries (ECC) is used for preschool-aged children.

ECC has been defined as follows: "the presence of one or more decayed (cavitated or not cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child 71 months of age or younger. In children younger than 3 years of age, any sign of smooth-surface caries is indicative of severe early childhood caries (S-ECC). From ages 3 through 5 years, one or more cavitated, missing (due to caries), or filled smooth surfaces in primary maxillary anterior teeth or a decayed, missing, or filled score of ≥4 (age 3 years), ≥5 (age 4 years), or ≥6 (age 5 years) surfaces constitute S-ECC." [1].

The prevalence of the disease varies among countries and communities. In Europe, epidemiological data from national surveys indicate prevalence rates of 29–55.4% [2], whereas, in the United States, about 23% of children aged 2–5 years have experienced caries [3]. However, in developing countries and disadvantaged groups (immigrants and ethnic minorities) living within developed countries, the prevalence could be as high as 70% [4]. It should be noted that the variability of the reported prevalence can be attributed to differences in the ECC definition adopted by studies, as well as to differences in the characteristics of the studied populations.

Dental caries arise due to interactions among different etiological factors: cariogenic microorganisms, fermentable carbohydrates (substrate), and susceptibility of the tooth surface (i.e., host). In ECC, the biological process of caries is accelerated by the unique characteristics of the mouths of young children (e.g., the presence of virulent, newly established oral flora, low resistance of the newly developed tooth surface, and/or extreme dietary habits) [5].

Unfortunately, dental caries not self-limiting; thus, professional intervention is required to address the consequences of ECC [6]. Parents often wait until caries in their children's teeth is extensive and symptomatic before bringing their children in for treatment. At that point, treatment is invasive and focuses on the consequences of dental caries but has no effect on the etiology of the disease. Providing dental treatment to ECC pediatric patients is also challenging due to the complexity and extensive nature of the disease, especially

for children who are uncooperative due to their young age, lack maturity, or have physical or mental disabilities. Most of these patients can be managed using non-pharmacological behavior management techniques. Alternatively, conscious sedation can be used to decrease patient anxiety. However, in some circumstances, general anesthesia (GA) is considered the only option for treating these patients [7]. This approach is used primarily to treat children with extensive caries, due to the aggressive and complex nature of caries in high-risk patients, and the large amount of restorative work required. GA allows for safe, efficient, and extensive treatment of these patients in a short time, without the need for patient cooperation [8].

It is well known that GA is not a risk-free procedure; deaths and critical incidents, although relatively rare, continue to occur in association with GA [9]. Risks and complications during and after GA procedures range from non-life-threatening (e.g., nausea, vomiting, and fever) to life-threatening (e.g., bronchospasm, anaphylaxis, cardiac arrest, and respiratory failure) complications [10].

To our knowledge, no systematic review has been conducted to assess the outcomes of dental general anesthesia (DGA). Thus, here we present a systematic review to assess some of the outcomes of dental treatment provided to pediatric patients under GA. This systematic review was conducted to answer the following questions:

1. What is the prevalence of repeat DGA among children previously treated under DGA?
2. What is the attendance rate for follow-up and recall visits after DGA?
3. What are the future treatment needs of children who underwent dental treatment under GA?
4. What is the prevalence of new carious lesions among children after dental treatment under GA?
5. What is the success rate of dental treatments provided to children under DGA?

Materials and Methods

A systematic review was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [11].

Eligibility criteria

All relevant randomized controlled trials (RCTs), intervention studies, and observational studies (including cohort, case-control, and cross-sectional studies) were included. The participants were pediatric patients aged < 18 years. The exclusion criteria were non-English articles, case reports, review articles, articles reporting on both pediatric and adult patients in which data specifically related to the age group of interest could not be extracted, and articles reporting data for DGA and other modalities in which data specifically related to DGA could not be extracted.

Search strategy

Four electronic databases were searched up to 10 December 2021: Medline (via PubMed), Cochrane Library, Web of Science, and Scopus. The search terms were in PICO format **(Table 1)**. Detailed search strategies were prepared for each database. These search strategies can be reached through this link: shorturl.at/pvK57 In addition, the bibliographic references in identified articles were hand-searched for relevant articles.

Table 1. Search question in PICO format

Components	PICO question 1
Population	Children
Intervention	Dental treatment under GA
Comparison	None
Outcome	• DGA repeat • Development of new carious lesions • Longevity of provided treatment • Follow-up attendance rate • Future restorative treatments need

Study selection

The search results were imported into bibliography management software (Mendeley Desktop for Mac, version 1.19.8; Mendeley Ltd., London, UK). First, duplicates were identified and excluded. Then, titles and abstracts were screened independently by two reviewers. Disagreements between reviewers at this level were resolved by discussion. Studies that met the inclusion criteria or did not have enough information in the abstract to make a decision were screened at the full-text level. All retrieved full texts were assessed by both reviewers independently. Discrepancies between reviewers at this level were resolved by discussion, or by a third reviewer if a consensus could not be reached. The reasons for article exclusion at this level were noted.

Data extraction and quality evaluation

Data from the included studies were extracted by the author using specially designed data extraction forms. The forms were filled out by two independent reviewers, and any discrepancies between reviewers were resolved through further discussion.

Results and Discussion

The initial search strategy and hand search yielded 921 articles. After excluding duplicates, 886 records were screened based on the title/abstract; the full text of 55 of those records was retrieved for analysis. Nine of the full texts were excluded or were not retrievable. The final number of articles included in the systematic review was 46. The numbers of reports that were detected, screened, appraised for eligibility, excluded, and *included* in the review are presented in a PRISMA flow diagram **(Figure**

1).

Of the 46 studies, 40 were retrospective, 3 were prospective, and 3 were case-control. The characteristics of the included studies are described in **Table 2**. Seven studies were excluded. One study reported protocol only [12], three studies reported data not limited to GA [13-15], and two studies reported data not limited to children [16, 17] and one study couldn't be retrieved [18].

Repeat of DGA
Twenty-five studies reported the frequency of repeat GA sessions **(Table 3)**. Twenty-two of these studies were retrospective and three were case-control. The rate of repeat GA ranged between 0% and 31.8%. Ten of these studies reported an average interval between GA episodes of about 2 years. The follow-up duration in these studies ranged between 2 and 10 years.

Follow-up Rate
Twenty studies reported the follow-up rate after dental treatment under GA **(Table 4)**. Nineteen of these studies were retrospective and only one study was prospective; nine studies reported a general attendance rate of between 18% and 95%, while the rest focused on the attendance rate or attendance pattern for recall visits. The follow-up rate for the first postoperative visit (1–2 weeks after GA) varied between 39% and 97.1%; the attendance rate for the 6-, 12-, 18-, and 36-month recall visits varied from 13% to 81%, 12% to 70.8%, 7% to 32%, and 5% to 26%, respectively. Thus, attendance decreased over time.

Only two studies reported the attendance pattern for patients who presented for follow-up visits. Kakaounaki *et al*., [19] reported that out of 143 patients who attended the follow-up visits, 52 patients had regular attendance, 61 had irregular attendance, and 27 were referred by a general dentist (GD) for further treatments. Sheehy *et al*., [20] reported a higher rate of regular attendance, with 37 patients out of 44 attending their follow-up visits regularly and 10 showing irregular attendance.

Success of dental restorations after GA
Twelve studies reported the success or failure rate for dental restorations under GA **(Table 5)**. Ten of these studies were retrospective, while two were prospective. The highest success rates were reported for stainless steel crowns (range: 92–98%) and pulpotomies (range: 84–98%), followed by amalgam (range: 57–79%) and composite (range: 26–83%) restorations. The follow-up duration for these studies ranged between 6 and 89 months.

Relapse after DGA
Several studies reported relapse after dental treatment under GA **(Table 6)**, for the following reasons:

- Failure of the restorations, as reported in the previous section
- Development of new carious lesions

For seven studies, the percentage of patients who developed new caries ranged between 24% and 59% for follow-up periods of 6 months to 3 years. Another study, by EzEldeen *et al*., [21], assessed oral health in adolescents with a history of ECC treated under GA at preschool age; they reported that these patients continued to develop carious lesions, with an average of 9.2 and 9 carious surfaces observed 1 and 2 years after DGA, respectively.

There were also two case-control studies. The first, by Almeida *et al*., [22], compared the development of new carious lesion between patients with ECC and a control group and reported that 79% of the ECC group developed new carious lesions compared to 29% of the control group. The second case-control study, by Sheller *et al*., [31], found that a higher percentage of patients who had multiple episodes of DGA developed new carious lesions compared to those who experienced a single DGA (29% and 2%, respectively).

Table 2. Characteristics of the included studies

Author	Study design	Aim of the study	Age and gender of the patient	Sample size	Status Healthy or medically compromised	Length of follow up	Detail of Tx	Measured Outcomes
O'Sullivan (1991) [23] Leeds Dental Institute, UK	Retrospective, data were collected from the charts (no examination)	To assess the efficacy of dental treatment under GA.	Not mentioned	80 patients	Not specified	2 years	General treatment	• Repeat of GA. • Need for further treatment. • Failure rate of restorations done under GA.

Sheehy *et al*., (1994) [20] New England Medical Center, Boston, MA	Survey of the parents by telephone interview who had full-mouth rehabilitation under GA.	To evaluate the self-reported compliance of families w/ preventive dental care.	Mean age: 4y 6m at the time of GA.	44 patients	Both	Meantime since GA = 14 months	General treatment	• Follow-up rate.
Wong *et al*., (1997) [24] Royal Hospitals NHS Trusts, London, UK	Retrospective, data were collected from the charts (no examination)	To provide evidence for future planning of GA services in pediatric dentistry.	Not mentioned	586 patients	Both	10 years	General treatment	• Repeat of GA.
Almeida *et al*., (2000) [22] Franciscan Children's Hospital and Rehabilitation Center, Boston, MA	Retrospective, Case-control design, data were collected from the charts (no examination)	To assess the future caries susceptibility for children who received a comprehensive dental treatment for ECC under GA.	• Mean age at the initial visit ECC: 3 years (range 1.9-4.9y) Control: 3 years (range 1.11-4.9y) • M/F: ECC: (55/45%) Control (55/45%)	ECC: 42 patients Control: 31 patients	Healthy	2 years	General treatment	• Repeat rate of GA. • Caries activity after GA.
Eidelman *et al*., (2000) [25] Hadassah School of Dental Medicine, Jerusalem, Israel	Retrospective, data were collected by clinical examination (not from the charts)	To assess the quality of restorations and recurrent caries in ECC patients who had dental treatment under GA or Sedation (S).	Mean age: GA (34.4 months) S (37.2 months)	GA (34 patients) S (31 patients)	Not specified	6-24 months	General treatment	• Follow-up rate. • Further treatment needs. • Caries activity. • Quality of the restoration (according to modified Cvar and Ryge index)
Harrison and Nutting (2000) [26] Guy's Hosp., London, UK	Retrospective, data were collected from the charts (no examination)	To investigate patterns of referral, disease, and treatment for children who had received two or more dental GA for exodontia.	Mean age: 5 years and 4 months (Range: 1y 5m- 12y 3m)	3872 patients treated w/ GA.	Healthy	5 years	Extraction	• Repeat of GA.
Jamjoom *et al*., (2001) [27] King Fahad Hospital, Jeddah, Saudi Arabia	Retrospective, data were collected from the charts (no examination)	To determine the characteristics of patients attending for treatment under GA and to describe the type of dental treatment carried out using DGA and in the subsequent 3-year period	Mean age: 5.3 years (Range: 2 to 22 y) M/F (276/279)	555 patients	Both	3years	General treatment	• Repeat rate of GA. • Further treatment needs.

Ng *et al*., (2001) [28] Children Hospital, Boston, MA, and National Medical Center, Washington, DC	Retrospective, data were collected from the charts (no examination)	To evaluate the association between patient medical history and the outcomes of restorative procedures performed under GA.	Mean age: Boston: 43 months (range 17 to 86 m). Washington: 58 months (range 23 to 274 m).	504 Patients (241 fulfill the requirement of 6 months follow-up)	Both Healthy: 133 Non-healthy: 71	Not specified	General treatment	• Follow-up rate. • Failure rate of restorations done during GA.
Tate *et al*., (2002) [29] Children Hospital, Boston, MA, and National Medical Center, Washington, DC	Retrospective, data were collected from the charts (no examination)	To determine the failure rate of restorative procedures done under GA.	Mean age 51 months (range 17 to 274 m) M/F (57/43%)	541 Patients (241 fulfill the requirement of 6 months follow-up)	Not specified	Not specified	General treatment	• Follow-up rate. • Failure rate of restorations done during GA.
Al-Eheideb and Herman (2003) [30] Department of Pediatric Dentistry at Bellevue Hospital Center, NY, USA	Prospective	To evaluate the integrity and longevity of restorative and pulpal procedures performed on primary teeth under GA	Mean age= 4years 6 months M/F (34/20)	54 patients	Both	6 to 27 months (mean=16.5m)	Not specified	• Failure rate of restorations done during GA.
Sheller *et al*., (2003) [31] Children Hospital, Seattle, Washington	Retrospective, Case-control design, data were collected from the charts (no examination)	To investigate reasons for the repeat of dental treatment under GA.	Mean age at 1st GA=2.6 years (exp) and 2.7 years (Control) M/F (30/46)	Experimental=23 (w/ repeat GA) Control=23 (w/ single GA session)	Healthy	N/A	General treatment	• Interval between GA episodes. • Caries activity after GA. • The success rate of restorations done during GA.
Clewett and Treasure (2004) [32] Community Dental Services, County of Clwyd, North Wales	Retrospective, data were collected from the charts (no examination)	To determine the reasons for referral for dental treatment under GA and the level of repeat	Mean age at GA1 = 6.25 years	639 patients as a random sample of 6996 children.	Not specified	3 years	General treatment	• Repeat of GA.
Drummond (2004) [33] Faculty of Dentistry, University of Otago, New Zealand	Retrospective, data were collected from the charts (no examination)	To review the outcomes for three groups of children 2-4 years after dental treatment under GA.	Mean age = 4.3 years (range: 1.8-5.9 y).	292 patients	Not specified	2-4 years	General treatment	• Repeat of GA. • Follow-up rate. • Caries activity after GA. • Success of the restoration done under

								GA.
Graves *et al*., (2004) [34] University of Rochester Medical Center, Rochester, NY	Prospective	To assess the relationship between the number of SSC-placed surfaces at risk (SAR), and the risk of relapse after aggressive treatment protocol (under GA).	Mean age: 4.2 years. (Range 2.3 – 7.3 y) M/F (42/37%)	79 patients.	Not specified	6 months	General treatment	• Follow-up rate. • Caries activity after GA.
Albadri *et al*., (2006) [35] Liverpool Uni. Dental Hosp., Liverpool, UK	Retrospective, data were collected from the charts (no examination)	Frequency of repeat extraction under GA	Mean age (6.5±2.2 years)	278 patients	Not specified	Not specified	Extractions	• Repeat of GA.
Al-Malik *et al*., (2006) [36] King Fahad Armed Forces Hospital, Jeddah, Saudi Arabia	Retrospective, data were collected from the charts (no examination)	To determine the characteristics of the patient and type of dental treatment carried out using GA.	Mean age: 4.9 years (Range 30 m-16 y) M/F (56/44%)	182 patients	Both	2 years	General treatment	• Repeat of GA. • Follow-up rate. • Further treatment needs.
Foster *et al*., (2006) [37] Woman and Children's Hospital of Buffalo, Buffalo, NY	Retrospective, data were collected from the charts (no examination)	To determine the likelihood of developing a new carious lesion and if the attendance of immediate follow-up can prevent relapse.	Mean age 41 months (range: 19 – 60 m)	Of 448 patients w/ ECC, 193 satisfy the selection criteria.	Not specified	2 years	Treatment of ECC	• Follow-up rate. • Caries activity after GA.
Kakaounaki *et al*., (2006) [19] Leeds Dental Institute, UK	Retrospective, data were collected from the charts (no examination)	To investigate the further treatment needs for patients who had extraction under GA.	Mean age = 6.35 years (range: 1-16 y).	484 patients	Both	6 years	Extraction	• Repeat of GA. • Follow-up rate. • Further treatment needs.
Barberia *et al*., (2007) [38] Madrid Complutense University)	Retrospective, data were collected from the charts (no examination)	To evaluate the success and failure rates of the clinical procedures carried under GA.	Mean age = 5y10m (range: 2y -11y7m). M/F (24/23)	47 patients	Both	Not specified	General treatment	• Follow-up rate. • Success of the restoration done under GA.
Jamieson and Vargas (2007) [39] The University of Iowa Hospital and Clinic	Retrospective, data were collected from the charts (no examination)	To evaluate the recall rate and caries experience of the children after GA.	Mean age = 3.5 years (range: 2 -7y).	217 Patients	Healthy	3 years	General treatment	• Repeat of GA • Follow-up rate. • Caries activity after GA.
Schroth and Smith (2007) [40] GA paid by FNIHB in Alberta, Canada	Retrospective, data were collected from the charts (no examination)	To review data from the province of Alberta, Canada for First Nations children who required more than one GA for dental surgery.	Mean age at GA1 = 38.6 months (range: 12.9 m -134.6 m). M/F (50/50%).	339 patients	Not specified	9 years	General treatment	• Frequency of more than 2 GA.

Amin *et al*., (2010) [41] Private Dental Practice in Alberta, Canada	Retrospective, data were collected from the charts (no examination)	to assess the recurrence of dental caries and the affecting factors after dental surgery for ECC	Mean age at GA = 45±13 months M/F (53.5/46.5%).	269 patients	Healthy	Up to 24 months	Treatment of ECC	• Follow-up rate. • Caries activity after GA.
Kakaounaki *et al*., (2011) [42] Leeds Dental Institute	Retrospective, data were collected from the charts (no examination)	To investigate the number of children who required further (DGA), and identify any common factors related to these repeat DGAs.	Mean age at GA = 6.35 years (ranged between 1 and 16y)	484 patients	Not specified	6 years	Extractions	• Repeat of GA
Kolisa *et al*., (2013) [43] Pretoria Oral and Dental Hospital, South Africa	Retrospective, data were collected from the charts (no examination)	to describe the demographic profile of children receiving DGA, the type of treatment received, and the level of compliance with preventive follow-up visits.	Mean age at GA = 3.67 years (SD=2.01) M/F (46.2/53.8%)	78 patients	Both	15 months	General treatment	• Follow-up rate.
Bücher *et al*., (2014) [44] Ludwig-MaximiliansUniversity, Munich, Germany	Retrospective, data were collected from the charts (no examination)	To describe the type and extent of composite fillings completed under GA and analyze restoration survival probability	Mean age at GA = 4.5 years M: F (1.34:1).	157 pts (1017 restorations)	Not specified	84 months Mean observation period = 30.9 months	73.3% treatment of ECC	• Repeat of GA • Survival of the restoration done under GA.
El Batawi (2014) [45] Private Dental Practice in Jeddah, Saudi Arabia	Retrospective, data were collected from the charts (no examination)	To investigate factors that might affect the clinical outcome of early childhood caries treatment under GA	Mean age at GA = 44 months (range: 28 m -131 m). M/F (52.6/47.4%).	431 patients	ASA I and II	2 years	Treatment of ECC	• Repeat of GA • Follow-up rate. • Caries activity after GA.
Savanheimo and Vehkalahti (2014) [46] Helsinki Public Dental Service, Helsinki, Finland	Retrospective, data were collected from the charts (no examination)	to describe the details of treatments under GA and explore the outcome of their dental care during a 5-year follow-up	Mean age at GA=6.2 years (SD=2.7) M/F (56/44%)	199 pts	Healthy (ASA 1 and 2)	47.6 months (SD = 13.7)	General treatment	• Repeat of GA • Follow-up rate. • Further treatment needs.
Tahmassebi *et al*., (2014) [47] Leeds Dental Institute, UK	Retrospective, data were collected from the charts (no examination)	To analyze the characteristics of comprehensive dental care provided under GA and to review the additional treatment required by children.	Mean age at GA=6.7 years (range between 1 and 16 y) M/F (56.3/43.7%)	263 pts	Both	6 years	General treatment	• Repeat of GA • Follow-up rate. • Further treatment needs.

Amin *et al*., (2015) [48] Two private pediatric dental practices who received referrals from a private dentist, Vancouver, BC, Canada	Retrospective, data were collected from the charts (no examination)	To evaluate rates of caries relapse and explore factors affecting relapse rates after comprehensive dental treatment under (GA)	Mean age at GA=46.8 months (SD=13.6) M/F (60.4/39.6%)	278 pts	Healthy (ASA 1 and 2)	36 months	Treatment of ECC	• Follow-up rate
EzEldeen *et al*., (2015) [21] University Hospitals of the Catholic University of Leuven, Belgium	Retrospective, data were collected from the charts (for the 1st y visit. Pts were examined clinically for the 12-y visit.	To assess oral health in adolescents with a history of ECC treated under GA at the young age	Mean age at GA=4.8 years (range between 3 and 9 y) M/F (45.9/54.1%)	98 pts	Healthy (ASA 1)	1 year and 12 years	Treatment of ECC	• Caries experience (surfaces with caries)
Lin (2015) [49] Kaohsiung Chang Gung Hospital, Kaohsiung, Taiwan	Retrospective, data were collected from the charts (no examination)	To assess all restorative outcomes and evaluate the efficacy of comprehensive dental rehabilitation under GA	Mean age at GA=49.4 months (range, between 27 and 71 m)	68 pts	Healthy	24 months	80.9% treatment of ECC	• Success rate
Amin *et al*., (2016) [50] Two private clinics in Vancouver, British Columbia, Canada, and Calgary, Alberta	Retrospective, data were collected from the charts (no examination)	To assess the success rate of various treatments provided under general anesthesia for early childhood caries (ECC)	Mean age at GA=46.2months (range between 19 and 71 m) M/F (45.9/54.1%)	818 pts	Not specified	3 years	Treatment of ECC	• Success rate
Guidry *et al*., (2017) [51] Tufts University School of Dental Medicine and Franciscan Hospital for Children in Boston, MA, USA	Case-control study	To investigate the common factors that exist in pediatric patients requiring a repeat dental treatment under GA	Range (1 to 12 years)	581 pts	Both	4 years	Treatment of ECC	• Repeat of GA
McAuliffe *et al*., (2017) [52] Cork University Hospital (CUH), Cork, Ireland	Retrospective, data were collected from the charts (no examination)	To investigate the records of a cohort of preschool children for extractions under GA between the years 2000 and 2002.	Median age at GA1 = 4 years (Range 1-5y) M/F (55/45%)	347 pts	Not specified	Not specified	Extraction	• Repeat of GA. • Further treatment needs.

Bakkal (2018) [53] Bezmialem Vakif University, Istanbul, Turkey	Retrospective, data were collected from the charts (no examination)	to evaluate the characteristics and treatment modalities of children whose dental treatments were performed under GA.	Mean age at GA=5 years (range between 1.6 and 11.8y) M/F (54.5/55.5%)	196 patients	Not specified	Up to 42 months	General treatment	• Repeat of GA.
Jiang *et al*., (2019) [54] Tertiary stomatological hospital in Chongqing, China	Prospective	To evaluate the success rates of dental procedures, the recurrence rates of caries, and changes in oral health-related quality of life (OHRQoL) in children following dental treatment under GA	Mean age at GA1 = 3.2 years (SD=0.6) M/F (49.7/50.3%)	159 pts	Healthy (ASA1)	at 6 months and 12 months	Treatment of ECC	• Follow-up rate • Caries activity after GA • Success rate
AlMotawah *et al*., (2020) [55] Riyadh Elm University, Riyadh, Saudi Arabia	Retrospective, data were collected from the charts (no examination)	to compare the survival outcomes for teeth that were restored with stainless-steel crowns alone to those that were pulpotomized and then restored with a stainless-steel crown in patients who received DGA	Mean age at GA1 = 4.73 years (SD=1.4) M/F (45/55%)	131 patients (340 teeth)	Healthy (ASA1)	2 years	General treatment (involving SSC)	• Success rate
Azadani *et al*., (2020) [56] Nationwide Children's Hospital, Columbus, OH, USA	Retrospective, data were collected from the charts (no examination)	To examine the time to need new treatment of primary second molars in very young children treated under GA.	Mean age at GA1 = 38.4 months (SD=6.8) M/F (53.5/46.5%)	865 pts 3166 primary second molars	Healthy	Range from 6 to 89 months	Treatment of ECC	• Survival probability
Chen *et al.*, (2020) [57] Guangzhou Women and Children's Medical Center, China	Retrospective, data were collected from the charts (no examination)	Investigate the survival and related predictors associated with failure of pulpectomies performed under GA for ECC	Range (2-18 years) M/F (59.7/40.	124 patients (389 teeth)	87.1% with good health 12.9% with poor health	Every 3 months until primary teeth are replaced with permanent teeth	Treatment for ECC (including pulpectomy)	• Relapse of pulpitis and periapical periodontitis
Kirby *et al*., (2020) [58] Sheffield Teaching Hospitals NHS Foundation Trust, Sheffield, UK	Retrospective, data were collected from the charts (no examination)	To determine the frequency of repeat paediatric dental GA within 2 years.	No specified	6467 pts	Not specified	Not specified	Extraction (68%) and comprehensive dental treatment (32%)	• Repeat of GA

König *et al.*, (2020) [59] University Medical Center, Göttingen (Germany).	Retrospective, data were collected from the charts (no examination)	To evaluate potential risk factors predicting repeated dental treatment of children under GA	Mean age at GA1= 4.6 years (SD= 2.4) M/F (56.4/43.6%)	935 patients	Both	Not specified	General treatment	• Repeat of GA • Attendance of follow-up
Warren *et al*., (2020) [60] Northern Plains tribal community, IW, USA	Retrospective, data were collected from the charts (no examination)	To assess the occurrence of treatment under general anesthesia (GA) for dental caries among American Indian (AI) children from a Northern Plains tribal community.	Not specified	79 patients	Not specified	36 months	Treatment for ECC	• Repeat of GA
Alhissan and Pani (2021) [61] Riyadh Elm University, Riyadh, Saudi Arabia	Retrospective, data were collected from the charts (no examination	To evaluate the success of anterior zirconia crowns placed children treated under GA and evaluate the impact of pulp therapy of the tooth on the rate of failure	Mean age at GA1= 32.14 months (SD= 2.1) M/F (55/45%)	21 patients (70 crowns)	Not specified	24 months	Treatment for ECC	• The survival rate of zirconia crowns
Bayram *et al.*, (2021) [62] School of Dentistry, Istanbul Medipol University, Istanbul, Turkey	Retrospective, data were collected from the charts (no examination)	Evaluate health status as a new patient risk factor and analyze its influence on the survival of posterior composite restorations in patients with (ECC)	Mean age at GA=3.98 years (SD= 0.95) M/F (55.9/44.1%)	907 pts (5063 teeth)	Healthy and children with mild systemic disease (ASA 1 and 2)	Up to 24 months	Treatment for ECC	• Attendance of follow-up • The survival rate of the composite restorations
Liu *et al*., (2021) [63] Stomatology Hospital of Xi'an Jiaotong University, Northwest China	Retrospective, data were collected from the charts (no examination)	Analyze the characteristics, tendencies, and success rates of dental treatments for ECC under GA	≤ 3 years (12.88%) of the pts 3-6 years (87.12%) of the pts M/F (56.4/43.4%)	846 867 (6 months follow up) 599 (12 months follow up)	Healthy	6 months and 12 months	Treatment for ECC	• Attendance of follow-up • Success rate
Vertullo *et al.*, (2021) [64] Hospital of Sick Children, Toronto, Ontario, Canada	Retrospective, data were collected from the charts (no examination)	To determine the rate of repeat DGA over 10 years and to assess the relationship between the frequency of repeat DGA and medical comorbidities.	Not specified for the original cohort	7019 patients treated with GA	80 % of the repeat patients were ASA II and III	Not specified	Treatment of ECC	• Repeat of GA

Table 3. Studies reported the repeat rate of DGA

Author	Sample size	Length of follow up	Results

O'Sullivan (1991) [23]	80 patients	2 years	• Repeat of GA: 2.5%
Wong *et al*., (1997) [24]	586 patients	10 years	• Repeat of GA: 14%.
Almeida *et al*., (2000)[22]	ECC: 42 patients Control: 31 patients	2 years	• Repeat of GA: 17%
Harrison and Nutting (2000) [26]	3872 patients treated w/ GA.	5 years	• Repeat of GA: 15% Interval: 1y 9m (range: 1.5m – 4y7m)
Jamjoom *et al*., (2001) [27]	555 patients	3 years	• Repeat of GA: 1 out of 555
Sheller *et al*., (2003) [31]	Experimental=23 (w/ repeat GA) Control=23 (w/ single GA session)	N/A	• The mean interval between GA1 and GA2 was 2.1 years.
Clewett and Treasure (2004) [32]	639 patients as a random sample of 6996 children.	3 years	• 26% had received an additional GA, but 203 patients had more than 2 GA which represents a true rate of 31.8%.
Drummond (2004) [33]	292 patients	2-4 years	• Repeat of GA: 5.1%.
Albadri *et al*., (2006) [35]	278 patients	Not specified	• Repeat rate: 11.9 %. • Interval between GA episodes: 2.3±1.6 years. • Patients who had a repeat of GA were younger 4.9±2.0 years at GA1. • The radiographs were available for only (21.2%) of the patients w/ GA repeat compared w/ 34.3% for the patient who had a single GA. • Mean number of extractions was (4.6±2.5 extractions) for the patient w/ GA repeat compared w/ (3.2±2.0 extractions) for the patient who had a single GA.
Al-Malik *et al*., (2006) [36]	182 patients	2 years	• Repeat rate: 1 episode (0.6%).
Kakaounaki *et al*., (2006) [19]	484 patients	6 years	• Repeat of GA: 10.7%. • The median time interval between GA episodes: 20 months.
Jamieson and Vargas (2007) [39]	217 patients	3 years	• No repeat.
Schroth and Smith (2007) [40]	339 patients	9 years	• 76% experienced only 2 GA. • 24% received more than 2 GA. • Interval between GA1 and GA2: 26.1±15.5m. • The average time between the GA decreased as the number of episodes increased.
Kakaounaki *et al*., (2011) [42]	484 patients	6 years	• Repeat rate: 8.9% • The interval between the GA1 and GA2 ranged from 1 to 77 m • The interval between the GA2 and GA3 ranged from 20 to 78 m
Bücher *et al*., (2014) [44]	157 patients (1017 restorations)	84 months Mean observation period = 30.9 months	• Repeat rate: 3.8% of pts had a previous treatment under GA
El Batawi (2014) [45]	431 patients	2 years	• Repeat rate: 15 pts (4.2%) out of 352 pts who attended at least one recall appointment.
Savanheimo and Vehkalahti (2014) [46]	199 patients	47.6 months (SD = 13.7).	• Repeat of GA: 11% • The interval between the initial GA and the repeat GA was on average 22.5 m (SD = 12.6).

Tahmassebi *et al*., (2014) [47]	263 patients	6 years	• Repeat of GA: 12.9%
Guidry *et al*., (2017) [51]	581 patients	4 years	• Repeat of GA = 4.9%
McAuliffe *et al*., (2017) [52]	347 patients	Not specified	• Repeat of GA: 10% were referred for other GA (before entering the school)
Bakkal (2018) [53]	196 patients	Up to 42 months	• Repeat of GA: 2 pts (1%) • Intervals between GA1 and GA2 were 15 m for the 1st pt and 26 m for the 2nd pt.
Kirby *et al*., (2020) [58]	6467 patients	Not specified	• Repeat rate = 0.63%
König *et al*., (2020) [59]	935 patients	Not specified	• Repeat of GA: (13.6%) received or were planned to receive repeated dental treatment under GA for the 2nd or 3rd time. Time intervals between first and second GA and second and third GA amounted to 22 ± 18 and 23 ± 20 months, respectively. • Factors affecting the repeat of GA: The use of fluoridated toothpaste and attending 2 or more recall appointments per year significantly decreased the risk for repeated dental treatment under GA.
Warren *et al*., (2020) [60]	79 patients	36 months	• Repeat of GA: 30.4%
Vertullo *et al*., (2021) [64]	7019 patients treated with GA	Not specified	• Repeat of GA: 973 patients (13.8%) Meantime between GA visits GA1-GA2=2.7 m GA2-GA3=2.5 m GA3-GA4=1.9 m GA4-GA5=1.8 m

Table 4. Studies reported the attendance of follow-up visits after DGA

Author	Sample size	Length of follow up	Results
Sheehy *et al*., (1994) [20]	77 patients	N/A	• Response rate: 57%. • Follow-up rate at 6m: 77% • Follow-up: Consistent (34 pts), Inconsistent (10 pts) of the 44 pts who attended for follow-up.
Eidelman *et al*., (2000) [25]	GA (34 patients) S (31 patients)	6-24 months	• Follow-up rate: 65/120 patients (54%).
Ng *et al*., (2001) [28]	504 patients (241 fulfill the requirement of 6 months follow-up)	Not specified.	• 45% of the patients in Boston and 50% in Washington attend follow-up visits six months after GA.
Tate *et al*., (2002) [29]	541 Patients (241 fulfill the requirement of 6 months follow-up)	Not specified.	• 48% of the patients attend follow-up visits six months after GA.
Drummond (2004) [33]	292 patients	2-4 years	• Follow-up rate: 95%.
Al-Malik *et al*., (2006) [36]	182 patients	2 years	• Follow-up rate: 83, 36, 32, 26% after 1week, 6m, 18m, and 36m, respectively.
Foster *et al*., (2006) [37]	Of 448 patients w/ ECC, 193 satisfy the selection criteria.	2 years	• Follow-up rate: 39% for immediate (2 weeks) follow-up visit. • Children who failed to come to their immediate follow-up visit were more likely to relapse.
Kakaounaki *et al*., (2006) [19]	484 patients	6 years	• Follow-up rate: 143 patients (27.5%) had a record of follow-up (51 pt regular attendance, 61 irregular attendances, 27 referred by GD).

Barberia *et al*., (2007) [38]	47 patients	Not specified	• Follow-up rate (after a minimum of 6 months up to 4 years): 87%.
Jamieson and Vargas (2007) [39]	217 patients	3 years	• Follow- up rate: 54% for the post-operative, 13%, 12%, 7%, 6%, 5% and 5% for 6, 12,18, 24,30 and 36-month follow-up, respectively. 13% return to emergency visit
Amin *et al*., (2010) [41]	269 patients	Up to 24 months	• Follow-up Rate: - 12 m: 166 pts (62%) - 13 – 24 m: 36 pts (13.4%)
Kolisa *et al*., (2013) [43]	78 patients	15 months	• Follow-up rate: 18%
El Batawi (2014) [45]	431 patients	2 years	• Follow-up rate: - 352 pts attended at least one recall appointment (81.7%)
Savanheimo and Vehkalahti (2014) [46]	199 patients	47.6 months (SD = 13.7).	• Follow-up rate: 93%
Tahmassebi *et al*., (2014) [47]	263 patients	6 years	• Follow-up rate: 67.3% had records of at least one follow-up
Amin *et al*., (2015) [48]	278 patients	36 months	• Follow-up rate: 45% attended all the follow-up visits.
Jiang *et al*., (2019) [54]	159 patients	6 months and 12 months	• Follow-up rate: 73.6% and 63.5% for 6m and 12m, respectively.
König *et al.*, (2020) [59]	935 patients	Not specified	• Attendance of follow-up: 2-week postoperative follow-up=50.1% Preventive recall appointment after the postoperative follow-up=29.5%
Bayram *et al.*, (2021) [62]	907 patients (5063 teeth)	Up to 24 months	• Attendance of follow-up: -97.5% for the 1-week follow-up -30.9% for the 24 m follow-up
Liu *et al*., (2021) [63]	846 687 (6 months follow up) 599 (12 months follow up)	6 months and 12 months	• Attendance of follow-up: -6m: 81.2% -12m: 70.8%

Table 5. Studies reported the longevity of dental restorations provided under GA

Author	Sample size	Length of follow up	Results
O'Sullivan (1991) [23]	80 patients	2 years	• Failure rate: -SSC: 3% -Amalgam and composite: 29% -Vital Pulpotomies: 2%.
Ng *et al*., (2001) [28]	504 Patients (241 fulfill the requirement of 6 months follow-up)	Not specified.	• Failure rate: -SSC (8%) -Amalgam (22%) -Composite (29%) -Composite strip crown (51%). There was a significantly higher failure for SCC in patients diagnosed with developmental disabilities (not w/ significant medical histories) compared to patients w/out such a disability. There was no significant effect of the medical history on the failure rate for amalgam and composite restorations.
Tate *et al*., (2002) [29]	541 Patients (241 fulfill the requirement of 6 months follow-up)	Not specified.	• Failure rate: SSC (8%) Amalgam (21%) Composite (30%) Composite strip crown (51%)

Al-Eheideb and Herman (2003) [30]	54 patients	6 to 27months (mean=16.5 m)	• Failure rate Ant. Composite: 29% Ant strip crown: 30% Post. Composite/Amalgam: 50% SSC: 4.5% Sealant: 31.7% Pulpotomy: 2.9% Pulpectomy: 50%
Drummond (2004) [33]	292 patients	2-4 years	• Success rate of the restoration Amalgam: 57.1% Composite: 73.4% Compomer: 85.2% SSC: 92.8% Pulpotomy: 84.6%
Barberia *et al*., (2007) [38]	47 patients	Not specified	• Success rate Preformed metal crowns=93%. Pulpotomies= 96.4 Restorations=90.1
Bücher *et al*., (2014) [44]	157 patients (1017 restorations)	84 months Mean observation period = 30.9 m	• Survival rate: 81.5% (annual failure rate of 4.2 %)
Lin (2015) [49]	68 patients	24 months	• Success rate: Anterior composite restorations = 71.7% Posterior composite restorations = 90.3% Indirect pulp capping = 100% Pulpotomy = 94.9% SSC = 99%
Amin *et al*., (2016) [50]	818 patients	3 years	• Success rate: Indirect pulp capping = 96.8% Pulpotomy = 93.1% Pulpectomy = 75.7% SSC = 97.2% Anterior composite restorations -1 surface = 92.4 -2 surfaces = 90.2 -multi-surface = 90.9% -crown = 88.6% Posterior restorations -Amalgam Cl I = 98.5% -Amalgam Cl II = 98.8% -Amalgam multi-surface = 100% -Composite Cl I = 93.1% -Composite Cl II = 84.8% -Composite multi-surface = 89.7%
Jiang *et al*., (2019) [54]	159 patients	6 months and 12 months	• Success rate: -Amalgam: 57.1% -Composite: 73.4% -Compomer: 85.2% -SSC: 92.8% -Pulpotomy: 84.6%
AlMotawah *et al*., (2020) [55]	131 patients (340 teeth)	2 years	• Success rate: 91.4% No significant effect of the pulpotomy on the success rate.
Azadani *et al*., (2020) [56]	865 patients 3166 primary second molars	Range from 6 to 89 months	• Survival probability SSC: 98.01% by 84 m Sealant: 33.87% by 84 m Composite: 26.39% by 72 m Fluoride: 34.7% by 72 m Unerupted: 23.01% by 72 m
Chen *et al*., (2020) [57]	124 patients (389 teeth)	Every 3 months until	• 45% of teeth with pulpitis and 46% of teeth with periapical periodontitis were estimated to relapse; the median number of years to relapse was 3.5

		primary teeth are replaced with permanent teeth	and 3.0 years, respectively.
Alhissan and Pani (2021) [61]	21 patients (70 crowns)	24 months	• Survival rate of zirconia crowns= 94.3% • Complication rate = 20%
Bayram *et al.*, (2021) [62]	907 pts (5063 teeth)	Up to 24 months	• 24 m Survival of the composite restorations: -Cl I: 72% -Cl II: 74% -Multi-surface: 48% -Cl V: 78%
Liu *et al.*, (2021) [63]	846 867 (6 months follow up) 599 (12 months follow up)	6 months and 12 months	• Success rate: -Composite restoration (83.48%) -Composite crown (90.43%) -SSC (97.09%) -Indirect Pulp Capping (92.98%) -Pulpotomy (93.98%) -Pulpectomy (86.17%)

Table 6. Studies reported the further treatment needs and development of new caries after DGA

Author	Sample size	Length of follow up	Results
O'Sullivan (1991) [23]	80 patients	2 years	• Need for further treatment: 8.75%.
Almeida *et al*., (2000) [22]	ECC: 42 patients Control: 31 patients	2 years	• 79% of ECC and 29% of control had a detectable carious lesion during recall. • Significantly higher mean the number of new carious lesions (3.2±3.3) in ECC compared to 0.8±1.6 for the control. • Significantly higher smooth surface caries in the ECC group.
Eidelman *et al*., (2000) [25]	GA (34 patients) S (31 patients)	6-24 months	• 59% of GA and 74% of S required further dental treatment. • 57% of GA and 60% of S developed new caries.
Jamjoom *et al*., (2001) [27]	555 patients	3 years	• Need for further treatment: 6.5%
Sheller *et al*., (2003) [34]	Experimental=23 (w/ repeat GA) Control=23 (w/ single GA session)	N/A	• New caries: 39% (exp.) and 2% (control).
Drummond (2004) [33]	292 patients	2-4 years	• 55% had new caries.
Graves *et al*., (2004) [34]	79 patients.	6 months	• 21/57 patients (37%) relapsed. • No statistically significant difference between the relapsed and non-relapsed patients in terms of the number of SSC and SAR.
Al-Malik *et al*., (2006) [36]	182 patients	2 years	• Further treatment needs: • 15% preventive treatment • 32% Rest. treatment under LA, 4% under LA, and IS.

Foster *et al*., (2006) [37]	From 448 patients w/ ECC, 193 satisfy the selection criteria	2 years	• New carious lesion: Within 2 years, 53% had developed a new lesion. • Children who failed to attend their immediate follow-up visit were more likely to relapse.
Kakaounaki *et al*., (2006) [19]	484 patients	6 years	• 14.5% of the patients came w/ at least one episode of pain and/or infection. • 67 patients had a record of the subsequent restoration and/or extraction after GA. (46 under LA, 10 under LA and S, 7 without LA OR S, and 4 with LA or GA) • 21 patients received preventive treatment only. • 72% of the treated teeth were recorded as caries-free or unerupted.
Jamieson and Vargas (2007) [39]	217 Patients	3 years	• 26% developed new carious lesion
Amin *et al*., (2010) [41]	269 patients	Up to 24 months	• New carious lesion: - 40 pts out of the 166 who attended the 12 m recall. - 19 pts out of the 36 who attended the 24 m recall.
El Batawi (2014) [45]	431 patients	2 yearas	• New carious lesion: 58.5 % of the 352 pts who attended at least one recall appointment.
Savanheimo and Vehkalahti (2014) [46]	199 patients	47.6 months (SD = 13.7)	• Further treatment need: 87% needed operative treatment during the follow-up period
Tahmassebi *et al*., (2014) [47]	263 patients	6 years	• Further treatment needs: 34% needed further operative treatment.
EzEldeen *et al*., (2015) [21]	98 patients	1 year and 12 years	• Caries experience - 1 y: 9.2 (SD=3) - 12 y: 9.0 (SD=2.8)
McAuliffe *et al*., (2017) [52]	347 patients	Not specified	• Further treatment needs: -1st year of school: 34% require restoration for dental caries. 3% ER extraction under GA 10.3% referred for other GA. -3rd year of school: 41% require restoration for dental caries. 20% extraction under LA 6% referred for other GA. -6th year of school: 40% require restoration for dental caries. 9% extraction under LA

Future treatment needs

Nine studies reported on restorative treatment needs after DGA. Between 6.5% and 87% of the patients required restorative dental treatment during the follow-up period, which ranged between 6 months and 6 years. One of these studies. by McAuliffe *et al*., followed up patients who received DGA during the preschool years and reported that 47%, 67%, and 49% of the participants required further restorative treatments after 1, 3, and 6 years of primary school, respectively.

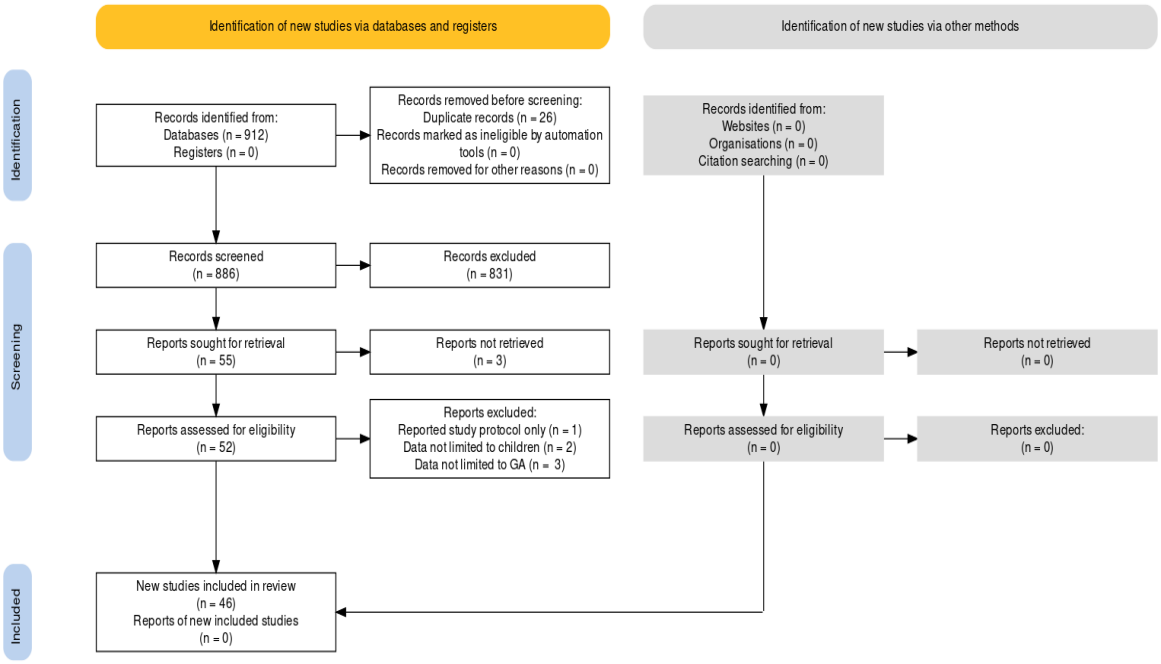

Figure 1. Prisma flowchart for the studies selection

Despite the popularity of GA as a modality to facilitate dental treatment for some pediatric patients, no previous systematic review has assessed the outcomes.

The results of this systematic review showed that a significant number of pediatric patients who previously underwent DGA experienced a form of relapse and required further restorative dental treatment during the follow-up period. Relapse took the form of new carious lesions on teeth that were caries-free or unerupted during the first episode of DGA, or failure of existing restorations. Kakaounaki *et al*., [19] found that 72% of teeth that required further treatments were caries-free or unerupted at the time of the initial GA. Patients diagnosed with ECC during the initial GA episode, and those who had previously undergone DGA were at higher risk of developing new carious lesions. Unfortunately, some of these patients could not be managed in the dental office and required another episode of GA to facilitate dental treatment, which was repeated at a frequency ranging between 0% and 31.8%.

Several studies analyzed the reasons for repeat DGA. Albadri *et al*., [35] found that patients who had more than one GA were younger at the time of the first GA compared to those who had a single episode of GA; moreover, radiographs were available for only 21.2% of patients who had a second GA session, compared to 34.3% for the patient who had a single GA. In contrast, Schroth and Smith [40] failed to show any association between the age of the child during the first GA session and the likelihood of having two or more GA sessions.

Schroth and Smith also evaluated the association between practitioner experience and the rate of repeat DGA [40]. They reported that 74% of patients who had two or more GA sessions were treated by a general dentist during the initial GA episode. Although the significance of this observation is unclear due to the absence of a control group, it may be explained by lack of general dentist training and experience with respect to treatment planning, as reflected in their conservative approach (i.e., in performing more restorations rather than using crowns) compared to specialists during the first episode of GA. Thus, the results of this systematic review indicate that restorations are more susceptible to failure compared to metallic crowns.

Other studies investigated the association of the medical status of the patient with the likelihood of having repeat DGA. Guidry *et al*., [51] found that medically compromised patients were more likely to have repeat dental treatments under GA. Similarly, Kibry *et al*., [58] found that patients with a complex medical history were more likely to have a second dental treatment under GA.

Sheller *et al*., [31] investigated the characteristics of children requiring repeated dental treatment under GA and reported a 100% rate of central incisor involvement in caries at the time of the first GA. Moreover, the majority of the central incisors were non-restorable and a nursing bottle was often used at the time of the first GA. Also, the children tended to be responsible for brushing their teeth, exhibited poor cooperation in the medical and dental setting, had difficult personalities (as described by the parents), and were often dysfunctional in social situations. Finally, there was a lack of follow-up dental care.

The results of this systematic review revealed a higher success rate for stainless steel curettes (SSCs) in comparison to direct restorations. This has prompted some clinicians to consider a more aggressive plan for dental treatment

provided under GA. Azadani *et al*., [56] suggested that more aggressive treatment with SSCs should be considered for young children with severe ECC, especially those who are treated under GA at a young age. However, Graves *et al*., [34] found this approach to be ineffective; they found that the risk of relapse was not associated with the number of SSCs or surfaces at risk (SAR).

This systematic review identified studies that reported the attendance rate for follow-up and recall visits after DGA. The reported rates showed large variability **(Table 4)**, and most of the identified studies failed to report the reasons for irregular or non-attendance of follow-up visits.

Chase *et al*., [65] evaluated parents' behavior after their children's dental treatment under GA and found that the parents could be divided into two categories. In the first category were those who felt that caries was "fated" for their children and that they could do little to prevent it. In the second category were those who felt that the caries of their children was their responsibility. We speculate that the low recall rates reported after dental treatment under GA may be explained by the parents not assuming responsibility for their children's oral health.

Jamieson *et al*., [39] suggested that non-attendance of follow-up visits can be explained by long travel distances, a lack of transportation, a tight parental work schedule, continuing care provided by the referring dentist, lack of satisfaction with the treatment, and maternal psychological problems.

Foster *et al*., [37] assessed the association between attending the first follow-up appointment and relapse after DGA and found that children who failed to attend this follow-up visit were more likely to relapse. Similarly, Kakaounaki *et al*., [19] assessed the relationship between the regularity of attendance of dental office visits and the likelihood of repeat DGA and found that participants with irregular dental attendance were four times more likely to have repeated dental treatments under GA.

The outcomes reported by the studies in this systematic review revealed that comprehensive dental treatment for children provided under GA addressed the sequelae, but not the etiology, of the disease. EzEldeen and McAuliffe followed children with a history of ECC treated under GA at a young age and found that they had poor oral health in adolescence, and remained at high risk for caries [21, 52]. As expected, some of these children suffered relapses requiring additional DGA treatment. To break this cycle, the focus of dental treatment should be shifted from the traditional approach of treating the consequences of oral diseases towards preventive efforts.

Based on the strong need for prevention, the American and European Academies of Pediatric Dentistry published their recommendations for preventing ECC, to decrease the child's risks of developing the disease [1, 66]. Unfortunately, these practices may not be sufficient for patients receiving DGA due to the severity of the disease. In addition, parental compliance is needed to achieve the desired outcomes using these preventive approaches. Lack of compliance can result from a lack of motivation or challenges affecting the parents' ability to support the oral health of their children. Parental beliefs and attitudes appear to play an important role in moderating oral health-related behaviors in young children. Erroneous beliefs among parents may negatively impact their motivation to support their children's oral health. Karki *et al*., assessed parents' beliefs, and the behaviors of children undergoing DGA, and reported that some parents had erroneous beliefs that dental caries runs in the family or is simply a case of bad luck [67].

A recent systematic review assessed the effectiveness of different methods for ECC prevention, including preventive dental programs for pregnant women, dietary and feeding advice, prenatal oral health care, integration of maternal and pediatric oral health promotion into nursing practice, maternal oral health programs, dental health education in combination with the use of fluoride for children, early preventive dental visits, and the use of fluoride varnish and toothpaste with more than 1,000 ppm fluoride [68]. To our knowledge, no previous systematic review has shed light on the effectiveness of the different preventative approaches for DGA patients.

This systematic review had several limitations because the included studies exhibited certain flaws and deficiencies, as summarized below. Future studies should address these weaknesses to improve the quality of the literature in this field.

- The majority of the identified studies were retrospective, where the data were collected from the patients' charts rather than via clinical examinations by the researchers. The results of the included studies may have been affected by the completeness and quality of the records.
- Some of the studies failed to report the demographic characteristics and health status of the included patients.
- Some studies reported a range for the follow-up period and failed to report the mean follow-up time.
- Heterogeneity in the reportage and definitions of outcomes among the included studies may be an issue.
- Most of the included studies failed to report changes in outcomes over the follow-up period.
- Most of the reported associations were based on bivariate statistical analyses not controlling for potential confounders.
- The rate of loss to follow-up was high in some of the included studies.
- The method of reporting the data varied significantly among the included studies. Some studies reported the results as percentages relative to the whole cohort, while others reported percentages relative only to all

participants who attended the follow-up visits. This variability could lead to over-or underestimation of the results.

Conclusion

Dental treatment provided under GA successfully addressed the consequences of dental caries but did not help prevent the development of new carious lesions, or the need for subsequent dental treatments under GA. The focus of the dental team should move from the traditional approach of treating the consequences of oral diseases towards a more preventative approach. Novel family-centered health promotion programs tailored to DGA patients are needed. These programs should be based on current evidence about the effectiveness of different methods for ECC prevention. In addition, the programs should be ongoing and consider the social determinants of health.

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