

ORIGINAL RESEARCH

Long-term outcome of oral health in uncooperative children with caries treated under general anesthesia

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Abstract

Although uncooperative children with extensive caries can be treated under general anesthesia (GA), they remain at high-risk for caries recurrence. This study aimed to assess the long-term outcome of the dental health of uncooperative healthy children (HC) and special needs patients (SNP) treated under GA at least 2 years before this study. Data were collected *via* questionnaire and oral examination. Oral hygiene was assessed using the Hygiene Index, while caries were recorded using ICDAS II. The dmfs/DMFS score was calculated for every participant. A total of 69 patients completed the questionnaire, and 37 were clinically examined (HC = 15, SNP = 22). The mean (\pm SD-standard deviation) follow-up time was 5.5 (\pm 2.55) years, the mean DMFS score for HC was 6.39 (\pm 4.99), and the mean DMFS score for SNP was 12.95 (\pm 12.29). The SNP group had significantly more filled surfaces on permanent teeth than the HC group (6.18 (\pm 6.17) vs. 1.54 (\pm 3.27), $p = 0.004$). In regard to primary teeth, HC had a higher dmfs, indicating a clear trend for more decayed surfaces in this group of participants ($p = 0.08$). The DMFS score was significantly higher in children who underwent GA more than 5 years ago. Oral health-related behavior was not improved as expected. Altogether, HC and SNP have poor oral hygiene and high caries risk in primary and permanent dentition, and their treatment remains challenging.

Keywords

Dental general anesthesia; Long-term outcome; Special needs patients; Caries recurrence; Follow-ups

1. Introduction

Dental treatment under general anesthesia (GA) is a quick and relatively safe option for uncooperative patients such as very young healthy children (HC) and those with special needs (SNP). However, the main disadvantage of this approach is that the treatment mainly focuses on restorations and improvement of oral health through regular follow-ups [1, 2]. Existing literature showed that children treated under GA usually failed to attend both short (one to two weeks after GA) and long-term follow-up visits, resulting in a lack of disease control [3–5] and caries recurrence in patients with primary [6, 7] and permanent dentition [8, 9]. Depending on the follow-up period [5, 6], caries relapse varies between 24% and 79%, of whom some may even need a second treatment under GA [6, 10].

Few studies have evaluated the long-term outcome of oral health after dental treatment under GA. In most of the reported studies, the children were followed up to 3 years post-treatment [11, 12], while in two studies, they were followed for 5 and 10 years, the longest reported in the literature [13, 14]. However, the results of these studies were inconclusive, and the authors reported a very low attendance rate for follow-ups and poor oral health after treatment. Thus, considering the scarcity of

related studies, here, we aimed to assess the long-term outcome of the oral health and the dental behavior of patients (HC and SNP) that had undergone dental treatment under GA at least 2 years prior to this present study.

2. Materials and methods

2.1 Study design and settings

In this cross-sectional study, the data of HC and SNP treated between January 2019 and October 2020 at the Postgraduate Clinic of Paediatric Dentistry of the National and Kapodistrian University of Athens (NKUA) were retrieved and assessed.

2.2 Participants

Patients who received dental treatment under GA between January 2005 and April 2017 were contacted to participate in this study. The inclusion criteria were: (a) children younger than 18 years, (b) a history of dental treatment under GA at least 2 years before this study, and (c) uncooperative HC or SNP cases. The only exclusion criterion was the inability to contact the patients. Patients that fulfilled the inclusion criteria were contacted by phone within working hours (9 AM–3 PM)

for a maximum of three times [15]. For participants with inactive or unavailable telephone numbers from the records, their current contact number was searched in phone directories or online, and they were excluded from this study if they could not be reached

2.3 Data collection

Data regarding patients' current dental status and attitudes toward dental treatment were gathered through a structured questionnaire and clinical examination. All procedures were performed by a single pediatric dentist blinded to the participant's previous medical and dental history. Calibration of the examiner was performed against a qualified pediatric dentist before study initiation until a $k > 0.8$ was reached for caries registration.

The patient's medical and dental records were reviewed, and information regarding medical history, oral health status at the initial dental visit, age at the time of GA and the performed dental treatment were collected. The guardians were also interviewed using a previously validated 44-item questionnaire comprising mostly closed-type questions on demographic and socio-economic characteristics of the family, patient's medical history, current oral hygiene and dietary habits (tooth brushing pattern, fluoride exposure, and frequency of sugar consumption), and dental follow-up [16]. A designated dental assistant was available to help the respondents.

For patients able to re-visit our institution for dental examinations, the questionnaire was completed at that time, while for patients who could not come for a dental examination at the clinic, their parents completed the questionnaire over the phone, forming a second group that did not have clinical data.

2.4 Anxiety level recording

Before the clinical examination, the participant's anxiety level was recorded by asking them to point out (with parental help when necessary) on a facial image scale that best represented his/her dental anxiety at that particular moment [17].

2.5 Clinical examination

Clinical examination using a unit light and a blunt probe was performed to evaluate oral hygiene (Hygiene Index-HI), caries experience and restorative index (RI/ri). After dental plaque removal, caries lesions were recorded using the ICDAS II criteria, which were then converted to dmfs/DMFS, including only the cavitated lesions. When a surface was evaluated with code 3 or higher from the ICDAS II first digit, the tooth was considered restored and was calculated as the f/F component of the dmfs/DMFS index. Codes 3–6 of the second digit of ICDAS II were used to calculate the d/D component of the dmfs/DMFS, while codes 1 and 2 were reported separately.

3. Statistical analysis

Statistical analyses were conducted using GraphPad Prism V8.0.1 (GraphPad Software, San Diego, CA, USA). Data are presented as percentage (%) and mean \pm SD, while normal distribution was assessed with the Shapiro-Wilk test. Differences

were evaluated by independent samples *t*-test and the Mann-Whitney test. Linear regression analysis was performed to assess the association between independent categorical variables and dependent numerical variables (HI, RI, DMFS, D, M, F). Statistical significance was set to 5%.

4. Results

4.1 Study sample

From the total 176 full medical records retrieved, 120 cases met the inclusion criteria and were initially contacted. Of them, 79 patients could be reached, while 10 refused to participate in this study. The remaining 69 patients completed the questionnaire, of whom 39 were able to come for clinical examination. As clinical examination was not possible for two patients due to a lack of cooperation, the clinical data of 37 patients were included in the final analysis (Fig. 1). The most frequent health disorders in SNP were mental retardation, syndrome/chromosomal disorders and autism. The follow-up ranged from 2 to 12 years (mean \pm SD, 5.5 ± 2.55 years).

4.2 Questionnaire

The demographic data, oral hygiene, dietary habits and dental attendance after GA of all children who responded to the questionnaire are presented in Tables 1 and 2. Participants who answered only the questionnaire were older ($p = 0.0068$), had Greek origin (mothers $p = 0.0005$, fathers $p = 0.0002$) and both their parents were working more frequently ($p = 0.0081$) compared to those who came for clinical examination.

The majority of the participants reported tooth brushing at least once per day. The parents of nearly 36% HC and 34% SNP described their children's oral hygiene as good. In regard to diet, more than half of the participants (51%) reported daily consumption of sweet snacks/drinks, most of which were consumed between main meals.

Most of the children were treated in the dental chair when needed after the first GA, while 4 had a second and 1 had a third treatment under GA. After GA, 87% of the patients returned to the dentist at least once for a check-up (23%) for regular professional cleaning and fluoride application (60%) or other reasons (17%; *i.e.*, trauma, orthodontic problems). Nine children did not attend the first scheduled follow-up one week after GA because they visited another dentist or reported that "they were not informed about this visit". Of all the subjects who underwent GA, 25% had canceled at least one scheduled dental appointment, and 35% had not rescheduled it. Around 13% (most of them were SNP) had never been to the dentist after GA. Comparison between children who only answered the questionnaire and those who had a clinical examination showed that the former had more missed appointments ($p = 0.051$).

4.3 Dental anxiety

Regarding dental anxiety, only 4 patients in the SNP group could not point to an image on the facial scale due to severe mental disability, while the majority seemed very happy or happy at their dental visit. Only 6% of the children mentioned

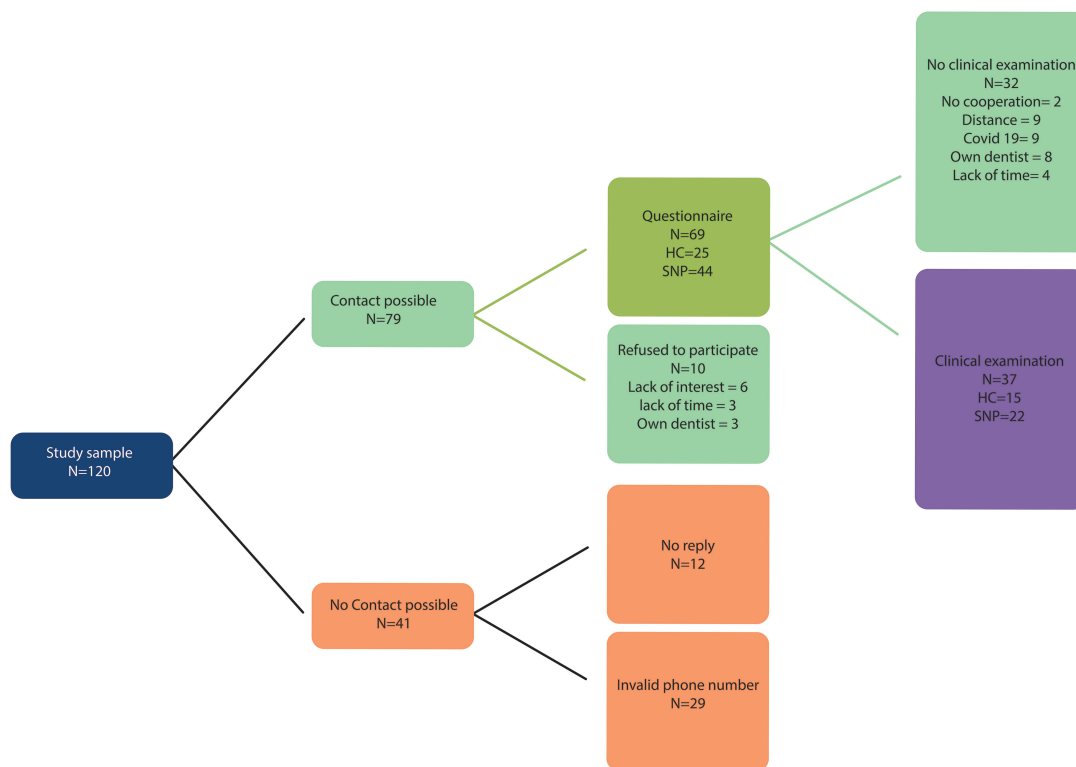


FIGURE 1. Flow diagram of study sample. HC: healthy children; SNP: special needs patients.

TABLE 1. Demographic data of the participants who only answered the questionnaire and those who answered the questionnaire and had a clinical examination.

	Questionnaire only (N = 32)	Questionnaire and clinical examination (N = 37)	<i>p</i> value
	(%) or (mean ± SD)	(%) or (mean ± SD)	
Gender (boys)	75.00	51.35	0.05
Age	13.03 (±3.34)	10.47 (±3.43)	<0.01*
More than 5 years from GA	40.62	43.24	0.99
Patients with special needs	68.75	59.46	0.46
Low Parental education			
Mother	25.00	32.43	0.60
Father	21.87	32.43	0.41
Parents origin (Greece)			
Mother	81.25	37.84	<0.01*
Father	84.37	37.84	<0.01*
Children's origin (Greece)	100.00	91.89	0.24
Urban place of residence	53.12	64.86	0.34
Both parents working	59.38	27.03	<0.01*

*Statistically significant. GA: general anesthesia. SD: standard deviation.

that they were very sad in the waiting room of the dental clinic (7% HC, 6% SNP).

4.4 Clinical examination

The *k* value for intra-examiner reliability using ICDAS II for caries was 0.85. Among the 37 subjects who were clinically examined, 2 (5%), 20 (54%) and 15 (41%) patients had primary, permanent and mixed dentition, respectively. Plaque accumulation (HI) was recorded in all subjects, and only 3

patients were found to be caries-free (Table 3). Regarding oral hygiene, the highest amounts of plaque were observed on the proximal surfaces, followed by buccal and lingual/palatal surfaces.

The mean (±SD) dmfs score of patients with primary dentition was 29 (±16.86), possibly due to the *f* and *m* components. In the permanent dentition, the mean (±SD) DMFS score was 10.51 (±11.16) with cavitated surfaces (DS ± SD, 5.20 ± 5.80), exceeding the filled ones (FS ± SD, 4.47 ± 5.74).

TABLE 2. Oral hygiene, dietary habits and dental attendance of the participants who only answered the questionnaire and those who answered the questionnaire and had a clinical examination.

	Questionnaire only (N = 32)	Questionnaire and clinical examination (N = 37)	<i>p</i> value
	(%)	(%)	
Oral hygiene and dietary habits			
Brushing frequency (at least once per day)	75.00	67.57	0.35
Use of fluoride toothpaste	100.00	100.00	-
Use of fluoride supplements	25.00	13.51	0.35
Use of dental floss	6.25	10.81	0.68
Daily consumption of sugary snacks	50.00	51.35	0.99
Daily consumption of juices or beverages	12.50	13.51	0.99
Dental attendance			
Attendance to 1-week follow up after GA	78.12	94.59	0.07
At least one follow-up since GA	81.25	91.89	0.29
At least one follow-up in the past year	81.25	83.78	0.99
Parents' dental attendance (at least once per year)	56.25	56.76	0.99
Canceled follow up appointments	18.75	29.73	0.40
Missed follow up appointments	28.12	8.11	<0.01*

*Statistically significant. GA: general anesthesia.

Active none cavitated lesions (ICDAS 1, 2) were found in 34 patients with permanent teeth, of whom 17.14% had more than 10 surfaces with non-cavitated lesions. Three patients had missing permanent teeth. In the primary dentition group, HC had significantly more new caries lesions on prior untreated surfaces than SNP ($p = 0.04$). In the permanent dentition group, SNP had significantly more filled surfaces than HC ($p < 0.01$) and a higher restorative index on the surface level ($p = 0.02$).

In the permanent dentition group, linear regression analysis revealed that time since the last GA and the presence of a health problem were significant predictors for filled surfaces. Health problems were also found to be a significant predictor for the RI in HC and SNP, while toothbrushing frequency was found to be significantly associated with HI. In the primary dentition group, regular dental visits could significantly predict the RI at the surface level (Table 4).

5. Discussion

This study investigated the long-term outcome of oral health and oral habits in young healthy children and patients with special needs who received dental rehabilitation under GA. The results showed that both groups had poor oral health parameters and oral health-related behavior. In addition, a longer time since GA was found to be associated with a higher risk of dental caries. Recalling patients after GA, especially in the long term, remains challenging [14, 18]. The reasons for failure to follow up were time restrictions, distance, lack of interest in the study and issues related to the Covid-19 pandemic, which seriously affected dental attendance, especially

during the first months of the outbreak [19, 20].

Dental rehabilitation under GA is often the treatment of choice for young uncooperative HC and SNP. The latter comprised two-thirds of our participants, while one-third were healthy young children. The small number of HC undergoing dental treatment under GA in Greece could be associated with existing behavior management techniques, low parental acceptance for the use of GA, financial issues and mainly legal restrictions

Although every dental treatment in HC and SNP always starts with an individualized preventive program, as expected, the results of this study indicated that oral health-related behaviors remained unmodified. These were similar to those reported in current literature, especially after long follow-ups [14, 21], which showed that 82% of their participants brushed their teeth twice daily on average. However, it should be noted that this data was based on a 15-month post-GA follow-up, shorter than that described in our present study. Further, compliance with dietary instructions was also reported to be poor in previous studies among patients receiving dental treatment under GA [21–23], which was similar to the findings of our study, where in both groups, half of the participants reported daily consumption of sweet snacks.

In this present study, 14% of the patients failed to attend the one-week post-GA scheduled follow-up visit, a fact that has also been previously reported [4, 21, 24]. However, the importance of the first follow-up visit should be emphasized as it seems to motivate parents and could help reduce the likelihood of recurrence of caries, particularly in patients with primary dentition [25]. Failure to attend the first follow-up visit could compromise the follow-up schedule of the patient, resulting

TABLE 3. Analysis of OHI, dmfs/DMFS and ri/RI indices and differences between the groups (mean \pm SD).

	HC	SNP	<i>p</i> value
	% or mean (SD)	% or mean (SD)	
OHI (%)	34.29 \pm 20.78	32.01 \pm 19.78	0.70
dmfs	34.75 \pm 14.91	22.10 \pm 17.18	0.08
d	5.58 \pm 4.54	2.30 \pm 2.31	0.05
m	13.00 \pm 11.82	7.70 \pm 11.86	0.1
f	16.17 \pm 9.46	12.10 \pm 12.92	0.4
ri (%)	76.89 \pm 29.43	67.11 \pm 29.43	0.87
Surfaces with new caries lesions in primary teeth	1.27 \pm 2.15	0.00 \pm 0.00	0.04*
DMFS	6.39 \pm 4.99	12.95 \pm 13.29	0.12
D	4.92 \pm 5.08	5.41 \pm 6.26	0.8
M	0.00 \pm 0.00	1.36 \pm 3.51	0.28
F	1.54 \pm 3.27	6.18 \pm 6.17	0.004*
RI (%)	26.23 \pm 40.46	62.00 \pm 40.46	0.02*
Surfaces with new caries lesions in primary teeth	2.46 \pm 2.84	2.88 \pm 2.37	0.7

*Statistically significant.

(OHI = Oral Hygiene Index, D/d decayed teeth, M/m missing teeth, F/f filled teeth, RI/ri Restorative Index). HC: healthy children; SNP: special needs patients, SD standard deviation.

TABLE 4. Linear regression analysis results for permanent and primary teeth.

	DMFS	D	M	F	OHI	RI (surf)
	dmfs	d	m	f		ri (surf)
Special needs	0.05	-0.03	0.03	0.13*	-0.03	0.16*
	0.10	0.14	0.004	-0.01		-0.02
Last GA >5 years ago	0.03	-0.03	-0.03	0.12*	0.003	0.00
	0.12	-0.01	0.05	-0.01		-0.05
Low educational level (mother)	0.00	-0.03	-0.03	0.07	0.01	0.03
	0.05	0.02	-0.05	0.10		-0.03
Working mother	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
	-0.10	0.10	-0.04	-0.04		-0.01
Regular dental visits of parents	-0.01	-0.02	-0.03	0.002	-0.03	-0.003
	-0.03	0.03	0.10	0.01		0.3*
Frequent toothbrushing	-0.02	-0.07	0.002	0.03	0.11*	0.02
	0.02	0.05	-0.04	-0.03		0.05
Frequent consumption of sweet snacks	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02
	0.06	0.1	-0.04	0.004		-0.04
Sweet snacks between meals	0.04	-0.02	0.01	0.07	-0.02	-0.01
	-0.01	-0.05	-0.05	0.07		-0.03

*Statistically significant.

(OHI = Oral Hygiene Index, D/d decayed teeth, M/m missing teeth, F/f filled teeth, RI/ri Restorative Index). GA: general anesthesia.

in unfavorable long-term oral conditions. Additionally, we found that only half of the participants had regular dentist visits, while 38% re-visited only after suffering dental-related pains. Similarly, Peerbhay *et al.* [21] reported that 37% of their investigated children did not return for follow-up after dental treatment under GA.

In the published literature, the number of repeated GA dental treatments varies between 4%–24% for a second intervention and between 1.5%–2% for a third intervention [10, 14, 26–32]. We found that the follow-up period, sample size and medical history of patients of these studies could justify this large range variation. In this present study, 6% and 1.5% of participants that had a second and third GA intervention were SNP. Although many of the participants' dental caries recurred after GA, all HC and most of the SNP were treated in the dental chair. An interesting finding was that almost all participants who underwent GA in the past due to being uncooperative during dental treatment answered positively to the facial image scale at the time of this study, indicating an improved attitude toward dentists.

Both groups showed similar visible plaque accumulation and tooth brushing habits, while only 3 participants were caries-free. Additionally, the fact that numerous non-cavitated lesions were identified in most patients indicated that caries remains an active unresolved issue that urges more attention. The SNP group had more filled surfaces on permanent teeth, which is expected because, at the time of GA, these patients were older and had more permanent teeth than HC. The first permanent molars were the teeth with the most caries lesions in both groups. These data are similar to the study of Lin *et al.* [13], who reported that 71.1% of children previously treated under GA at the age of 3–5 years developed carious lesions involving the first permanent molars five years later. The authors of the above study also reported that carries in the second primary molar could be a reliable predictor for future caries development in the first permanent molar [13].

The results of this present study were in accordance with the finding that children's dental health practices are influenced mostly by parental attitudes and guidance as well as parental dental health practices [33]. Frequent attendance of parents to the dentist was found to be a predictor of a high restorative index of primary teeth. Taking these into account, it can be assumed that a positive change in parental behaviors could lead to improved dental attitudes in children as the parents would be more compliant towards preventive oral health practices for their children. However, the conventional approach of providing preventive oral health information to parents of children treated under GA was shown to not effectively change their oral hygiene behavior or dentist attendance, suggesting the need for more effective approaches [34].

Oral healthcare in Greece is mostly provided by private practitioners, with patients paying the total cost of the treatment. There are three national public pediatric hospitals in Athens that provide only preventive dental care and emergency dental treatment to non-hospitalized patients free of charge. In the private sector, the legislation does not easily allow a child to undergo dental treatment under GA, and only a relatively limited number of families can afford the high cost of treatment. This situation results in very long waiting lists

in public hospitals where extractions are often the most commonly offered treatment, which was worsened by the Covid-19 pandemic. Thus, there is an obvious need for new legislation to facilitate children's dental treatment under GA.

The nature and design of this present study led to some limitations that should be clarified. The sample size and subsequent group allocations were relatively small, mainly because only a small number of patients had undergone dental rehabilitation under GA for the above-described reasons. Furthermore, restrictions due to the Covid-19 pandemic and fear of transportation, especially for SNP, had decreased the number of patients willing to return for examination. In addition, caries lesions were registered based on visual examination and not radiographically, which might have led to an underestimation of the condition. Moreover, oral health-related behaviors were registered based on a questionnaire answered by the parents, which might have mirrored the desired answers rather than the actual ones. Nevertheless, the strengths of our study were the long follow-up time and the inclusion of patients with special needs. To our knowledge, only one study performed on patients treated under GA contained long-term follow-up data, but it was conducted on only healthy individuals rather than on those with special needs [14]. Furthermore, our present study is the first to report such issues in the indicated population in Greece. Future studies could focus on whether alternative preventive strategies [34] would result in a significantly reduced incidence of new caries following dental rehabilitation under GA.

6. Conclusions

In conclusion, this cross-sectional study with long-term follow-ups found that very young uncooperative children with ECC and SNP treated under GA had poor oral health-related behaviors and new caries lesions. In addition, a longer time since GA was associated with a higher risk of developing new caries in patients with primary or permanent dentition.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

LA—worked on Methodology, Data collection, Writing-Original Draft. AA—worked on Methodology, Data analysis, Writing-Review & Editing. BGM—analyzed the data and worked on Writing-Review & Editing. TA—collected Data. GS—worked on Conceptualization, project administration, Methodology, Supervision, Writing-Review & Editing.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol was approved by the Ethics Committee of the School of Dentistry, NKUA (404/18.04.2019). A signed written informed consent was obtained from the participants

and/or legal guardians.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Gizani Sotiria is serving as one of the Editorial Board members of this journal. We declare that Gizani Sotiria had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to RA.

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