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ORIGINAL RESEARCH ARTICLE

Clinical Impact of Local Anesthesia on Sedation Stability and Propofol Dosage in Pediatric Dental Sedation

Merve Hayriye Kocaoğlu [1], Çağıl Vural [2,*] and Betül Büşra Ursavaş [3]

[1]Ankara University, Faculty of Dentistry, Department of Pediatric Dentistry, Ankara, Türkiye and [2]Ankara University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, Ankara, Türkiye and [3]Private Clinic, Ankara, Türkiye

[*]Corresponding Author; cagilvural@hotmail.com

Abstract

Background: Local anesthesia (LA) is often preferred for stabilization of vital signs, depth of anesthesia and pain control in dental restorations but the efficacy of LA administration during deep sedation is controversial.
Aim: To retrospectively investigate the effects of LA on heart rate, blood pressure, oxygen saturation, depth of anesthesia and total dose of anesthetic drugs given in pediatric patients sedated for dental procedures.
Materials and Methods: Records of 50 healthy children were divided into two groups: Patients who received infiltration LA at the beginning of sedation (Early LA) or who received LA at the end of sedation after completion of restorations (Late LA). Demographic data, hemodynamic data, Bispectral Index (BIS) scores, Ramsey Sedation Scale scores, total propofol dose administered were compared. Since the difference between two quantitative dependent variables did not meet the assumptions of normal distribution, Wilcoxon Signed Rank test was used. Generalized Estimation Models were used to look at the effect of quantitative variables with repeated measures (BIS and Ramsey) on groups.
Results: There was no statistically significant difference between the groups in terms vital signs, depth of anesthesia (BIS (p=0.190) and Ramsey score (p=0.887)), and total propofol dose adjusted for BMI (p=0.59).
Conclusions: The presence of LA during deep dental sedation has no significant impact on vital signs, depth of anesthesia and total amount of propofol used compared to the absence of LA. LA does not contribute to stabilization of dental sedation, but close monitoring of deep sedation prevents drug overdose.

Keywords: Dental Sedation; Local Anesthesia; Monitoring; Pediatric Anesthesia; Propofol

Introduction

Anxiety and fear are challenging for dentists in the treatment of pediatric patients.[1] When cooperation with the child cannot be achieved with behavioral management methods, pharmacological methods such as oral sedatives, nitrous oxide inhalation, deep sedation and general anesthesia are used.[2–4] Intravenous anesthesia combined with local anesthesia is an preferable method during general anesthesia in terms of safety and effectiveness in controlling anxiety and pain in patients.[5] During dental restorations under general anesthesia, local anesthesia is often preferred for bleeding and postoperative pain control.[6] In addition, local anesthesia is effective for stabilization of vital signs and anesthesia depth during general anesthesia or sedation, control of pain and bleeding after the procedure, and enhancement of recovery.[5–10] Although some dentists believe that LA is ineffective for pain, delays wound healing and causes prolonged numbness, we acknowledge it is an integral part of procedural sedation for postoperative pain and bleeding control.[11,12]

The optimal timing of local anesthesia administration during pediatric dental sedation is still a controversial topic. Depending on personal preference, some dentists administer local anesthesia at the very beginning of the procedure, while others leave it until after the completion of restorative procedures, just before the extractions. We hypothesized that infiltration local anesthetic administration during the induction period of procedural sedation stabilize vital signs, enhances the depth of anesthesia, and reduces the need for sedative medication.

In this retrospective study, we aimed to compare the effects of the presence or absence of LA on hemodynamic parameters, depth of anesthesia, and total anesthetic dose used during deep dental sedation for restorative dental procedures.

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Material and Methods

Study Design and Setting

This retrospective cohort study evaluates the retrospective data of 50 patients who underwent dental treatment using deep sedation at Ankara University, Faculty of Dentistry, Department of Pediatric Dentistry between December 2021 and December 2022. All the patients in this study were anesthetized in the faculty of dentistry of a tertiary university hospital. The findings of this study are based on pre-recorded data on monitor readings and administered medications with patient characteristics during deep sedation procedures.

Ethical Approval and Clinical Trials Registration

After obtaining the institutional ethical committee approval (approval number: 36290600/55) records of the 50 patients who had dental treatments under sedation in the department of pediatric dentistry between 2021-2022 were included in this retrospective study. This study was performed in line with the principles of the Declaration of Helsinki and registered to ClinicalTrials.gov (NCT06218173). The parents of the patients whose records were used had previously provided written informed consent for deep sedation anesthesia for restorative dental procedures.

Sample Size Determination and Patient Selection

A power analysis was performed to determine the appropriate sample size. According to the results of a preliminary study with 12 patients, the sample calculation was made based on the effect size. When the effect size of the relationship between the study variables was 0.2 a sample size of 44 was determined at an alpha of 0.05 and a power of 0.95. In this case, the records of 2 groups of patients were accessed: 28 patients who received LA at the time of anesthesia induction (EarlyLA) and 22 patients who received LA after the end of anesthesia (LateLA).

Pediatric dental patients who were previously sedated and fulfilled the following inclusion criteria were included in this investigation. Inclusion criteria were patients with American Society of Anesthesiologists (ASA) physical status classification I-II and aged between 2 and 8 years. Exclusion criteria were ASA status III-V, age older than 8 years, any history of allergy to anesthetic drugs, renal disease interfering with drug metabolism.

Anesthesia and Dental Interventions

Patient records were divided into two groups: patients undergoing infiltration anesthesia (4% articaine HCl with 1:100.000 epinephrine) at the beginning of sedation (Early LA Group, n:28) and administered infiltration anesthesia after the completion of restorative treatments and just before the extractions (Late LA Group, n:22). The utilization of local anesthesia in pediatric dental sedation was a discretionary decision made by individual practitioners. Within our clinic, some pediatric dentists choose to administer LA at the beginning of the sedation, while others choose to administer at the end, just before the extractions. Since bleeding blocks the exposure of the surgical site, teeth extractions are routinely performed as the last step of sedation protocol in our clinical practice. After induction of anesthesia in the early la group and stabilization of the sedation level to the target BIS level with maintenance anesthesia, the patient was prepared for dental restorations. At this stage, local anesthesia was administered by the dentist just before starting dental treatments. On the other side, in the Late LA group, local anesthesia was administered at the end of sedation, corresponding to the discontinuation of anesthetic drugs and just before extractions. Since the local anesthetic in the Late LA group was administered after the propofol infusion was discontinued, it was considered that it did not affect the total dose of sedative drug used. Infiltration anesthesia was performed with 4% articaine HCl with 1:100,000 epinephrine solution. Articaine is an amid type local anesthetic, which has a rapid onset and potency and widely used in dentistry.[13] Articaine was the local anesthetic utilized in this study and dosing never exceeded 7mg/kg in all patients.

Patients were monitored for oxygen saturation, respiratory rate, electrocardiography, heart rate, blood pressure (Dräger, Infinity Vista XL monitor, Germany), capnography (Microstream EtCO2; Medtronic Capnostream35, USA), and Bispectral Index (BIS) (Aspect XP Bispectral Index Monitor (Medtronic, Minneapolis, Minnesota, USA). Anesthesia induction was achieved by inhalation of 50% oxygen + 50% nitrous oxide + 1-8% sevoflurane gas mixture via mask ventilation. After intravenous access was established, sevoflurane and nitrous oxide were discontinued. A bolus dose of 0.1 mg/kg lidocaine and 1mg/kg propofol were administered. Depth of anesthesia was monitored by BIS, which is a technique that uses the electroencephalogram (EEG) to assess patients' levels of consciousness while under anesthesia. This system allows accurate adjustment of sedation levels by assigning a numerical value ranging from 0 to 100, with higher scores indicating higher levels of consciousness.[14,15] After induction of anesthesia, propofol infusion was started in all patients using a TCI system based on the Schneider model. (BBraun Perfusor SpaceTM TCI; BBraun, Melsungen, Germany). The primary plasma target concentration was 2 μg/ml, the expected brain propofol concentration was calculated and displayed on the TCI pump monitor. Propofol was titrated to the desired BIS value by the anesthesiologist. To reach the deep sedation level, the goal was to reach a BIS value of 50-60, characterized by unresponsiveness to painful stimuli and absence of reflex activity. The sedation score was also assessed and recorded according to the Ramsey sedation scale from 1 to 6, with a score of 1 meaning fully awake and a score of 6 meaning unresponsive to any stimulus.[16] After a stable depth of sedation was reached, patients were placed in the head and chin lift position and a nasal cannula was inserted for supplemental oxygen (2-4 L/min). The airway was not instrumented. According to BIS levels, deep sedation and spontaneous ventilation was also confirmed. Chin lift or chin thrust maneuvers were performed if any saturation drop occurred. The standard analgesia protocol applied in our clinic was paracetamol administration at a dose of 10 mg/kg. Once consciousness was restored after the dental procedure, patients were transferred to the post-anesthesia care unit (PACU), where they were closely monitored until they met the AAPD's established discharge criteria.

All anesthesia interventions, follow-up and recovery were performed in accordance with the guidelines of AAP/AAPD.[3] All interventions during the procedure were performed by an experienced anesthesiologist. Patients were observed by an independent observing anesthesiologist for hemodynamic parameters, complications, and medical record. Restorative procedures (fissure sealants, glass ionomer restorations, compomer and composite resin restorations, pulpotomy and pulpectomy, stainless steel crowns, strip crowns and extractions) were performed by the pediatric dentists in all patients.

Hemodynamic data including systolic and diastolic blood pressure, heart rate and blood oxygen saturation were retrieved form the files. The total amount of anesthetic drug administered, recovery time, complications were also recorded.

Patient demographics, blood pressure, heart rate, oxygen saturation, BIS values and sedation depth scores according to Ramsey Sedation Scale were compared between the two groups. The total amount of general anesthetic drug (propofol) given was compared according to body mass index (BMI).

Table 1. Identifiers by Groups

Variables		Group		
		EarlyLA:28	LateLA:22	p value
Age (years)	Mean.±SD	5.11±0.85	4.55±1.10	0.095[b]
	Median (Min.-Max.)	5.00 (4.00-7.00)	5 (2-6)	
Sex, n(%)	Male	16 (59.3)	10 (45.5)	0.336[c]
	Female	12 (40.7)	12 (54.5)	
BMI	Mean±SD	16.04±1.64	17.87±3.38	0.016[a]
	Median (Min.-Max.)	15.70 (13.61-22.16)	17.57 (12.46-24.41)	
Total Propofol (mg)	Mean SD	217.44±72.50	215±75.95	0.597[b]
	Median (Min.-Max.)	201 (140-380)	202.5 (131-392)	

SD: Standard Deviation, Min.: Minimum, Max.: Maximum, a: Student-t test, b: Mann-Whitney U test, c: Chi-square test

Statistical Analysis

SPSS 11.5 program was used in the analysis of the data. Mean ± standard deviation and median (minimum-maximum) were used as descriptors for quantitative variables, and the number of patients (percentage) for qualitative variables. The difference between the categories of the qualitative variable, which has two categories in terms of quantitative variables, was examined using the Mann-Whitney U test, since the assumptions of normal distribution were not met. Chi-square test was used to examine the relationship between two qualitative variables. When the difference between two quantitative dependent variables was wanted to be examined, the Wilcoxon Signed Rank test was used because the assumptions of normal distribution were not met. Generalized Estimation Equation (GEE) Models were used to look at the effect of the LA application timing of groups on the quantitative variable with repeated measurements. The statistical significance level was taken as 0.05.

Results

The 28 patients included in the study received local anesthesia just after the induction of anesthesia for restorative procedures (Early LA group), while 22 patients received local anesthesia only immediately prior to tooth extraction following restorations (Late LA group). Patients were aged between 2 and 7 years and 52% were male. There was no significant difference between the two groups in terms of age and gender. Table 1. shows the relationship between age, gender, body mass index (BMI) and the total amount of propofol used between the groups. There were no significant differences between the two groups in terms of the total amount of propofol used (p=0.59). The total amount of general anesthetic drug given was compared adjusting to body mass index.

Table 2. shows the differences between the BIS values according to the groups and the times (minutes) when the measurements were made. Generalized Estimating Equation (GEE) models were used to examine the effect LA application timing on the BIS variable with repeated measurements, and no statistically significant differences were found between the two groups in terms of BIS measurements (p=0.190). The difference between the mean BIS values of the Early LA group and Late LA group was 1.25.

GEE models were used to examine the effect of LA application timing of groups on the Ramsey scores variable with repeated measurements, and no statistically significant differences were found between the two groups in terms of Ramsey score measurements (p=0.887). The difference between the mean Ramsey Scores of Early LA and Late LA groups was 0.02. The descriptors of the Early LA and Late LA groups and the differences between these groups before the procedure, at other times, and between the groups are given in Table 3. There was no significant difference between the groups in these measurements. No complications were observed in the recordings. The lowest oxygen saturation was 99% in the EarlyLA group and 98.2% in the LateLA group. All non-severe oxygen saturation drops were corrected by chin elevation or airway repositioning.

Discussion

This study aimed to examine the effects of timing of local anesthesia administration for restorative procedures during dental treatments under sedation on hemodynamic data, depth of anesthesia and total anesthetic drug dose. Findings of this retrospective study revealed that there was no difference between the groups that received LA at the beginning of the sedation and received LA following the sedation in terms of hemodynamic parameters, depth of sedation and total propofol requirements.

The effect of local anesthesia on hemodynamic data in children undergoing dental treatment under general anesthesia has been investigated in many studies.[5–9,17] Most of these studies show that local anesthesia application under general anesthesia reduces the fluctuations in vital signs by blocking pain pathways. However, our study may contribute to the literature in terms of both focusing on pediatric patients under deep sedation and showing that the effect of local anesthesia does not strengthen sedation contrary to the information in the literature. For instance, a study by El Batawi et al.[8] and reported that the use of local anesthesia in painful dental treatments under general anesthesia helped stabilize heart and respiratory rates. In the same study, it was stated that tooth extraction and pulp treatments had the most impact on hemodynamic data.[8] According to a study by Watts et al.[9] during traumatic interventions under general anesthesia such as closure treatment, pulpotomy, and pulpectomy, the depth of anesthesia decreases due to pain, and the need for additional sedative drugs or LA emerges. They concluded that patients who were not given intraoperative local anesthesia were more likely to have vital sign fluctuations requiring anesthetist intervention. However, in this study, unlike our study, the depth of anesthesia was provided by anesthesia interventions including intermittent bolus propofol administration when needed.[9] The difference in vital signs between patients with and without LA may also be due to a fluctuating anesthetic course maintained by bolus drug administration which are likely to alter heart rate and blood pressure as well. According to the Wilson at al.[10] exclusive administration of anesthetic agents does not sufficiently restrain physiological responses such as changes in blood pressure, heart rate, or irregular heartbeats triggered by painful surgical stimuli. Research has demonstrated that employing bupivacaine alongside general anesthesia during the perioperative period can diminish these reactions to surgical stimuli.[10] In our study, hemodynamic parameters such as heart rate, SpO2, systolic and diastolic blood pressure measurements remained constant and there was no statistically significant difference between the two groups when compared Figures:1-4. The reason why there were no difference in hemodynamic parameters in our study may be the continuous monitoring of the depth of anesthesia with BIS monitoring and prevention of fluctuations in vital signs with deep and stable sedation throughout the procedures. This is because anesthetic maintenance in this study was adjusted to consistently achieve the targeted BIS

Table 2. Identifiers for the EarlyLA and LateLA groups for the BIS

Variables		EarlyLA:28			LateLA:22		
minute	**Mean.±SD**	**Median (Min.-Max.)**	**P value[a]**	**Mean.±SD**	**Median (Min.-Max.)**	**P value[a]**	**P value[b]**
3.	58.15±6.76	61 (36-65)	–	56,41±8,08	58 (44-68)	–	0.449e
5.	57.93±8.20	60 (31-69)	0.664c	55.73±10.11	56 (35-72)	0.832c	0.586e
10.	55.96±8.14	58 (38-66)	**0.034c**	55.41±8.97	55 (30-68)	0.757c	0.793e
15.	53.03±8.15	52 (35-65)	**0.007c**	53.64±9.67	55 (25-64)	0.156c	0.672e
20.	52.11±10.59	52 (30-66)	**0.008c**	54.18±7.93	54 (40-71)	0.389c	0.451 d
30.	50.59±9.80	46 (38-65)	**0.006c**	47.05±8.90	48 (30-62)	**0.001c**	0.432e
40.	51.78±10.44	56 (32-65)	**0.013c**	44.60±7.35	44 (32-59)	**<0.001c**	0.021e
50.	50.88±11.98	45.50 (36-75)	**0.041c**	49.71±8.19	52 (40-65)	0.035c	0.747d
60.	51.92±9.16	50 (41-65)	0.130c	54.00±12.09	52 (37-69)	0.255c	0.658d
70.	50±11.21	51 (36-62)	**0.026c**	-	-	-	-
80.	45±4.62	45 (41-49)	0.063c	-	-	-	-

a: Comparison between 3 and other times, b: Comparison between EarlyLA and LateLA groups, c: Wilcoxon Signed Rank test, d: Student-t test, e: Mann-Whitney U test

Table 3. EarlyLA and LateLA group descriptors for Ramsey Sedation Score

Variables		EarlyLA:28			LateLA:22		
(time-minute)	**Mean.±SD**	**Median (Min.-Max.)**	**P value[a]**	**Mean.±SD**	**Median (Min.-Max.)**	**P value[a]**	**P value[b] /**
Preoperative	1±.0	1 (1.0-1.0)		1.0±0.0	1 (1.0-1.0)		1.000d
3.	5.59±0.50	6 (5-6)	**<0.001c**	5.86±0.35	6 (5-6)	**<0.001c**	**0.039d**
5.	5.81±0.40	6 (5-6)	**<0.001c**	5.64±0.49	6 (5-6)	**<0.001c**	0.164d
10.	5.78±0.42	6 (5-6)	**<0.001c**	5.82±0.39	6 (5-6)	**<0.001c**	0.730d
15.	5.93±0.27	6 (5-6)	**<0.001c**	5.82±0.39	6 (5-6)	**<0.001c**	0.257d
20.	5.93±0.27	6 (5-6)	**<0.001c**	5.64±0,49	6 (5-6)	**<0.001c**	**0.013d**
30.	5.78±0.42	6 (5-6)	**<0.001c**	6±0.00	6 (5-6)	**<0.001c**	**0.019d**
40.	5.48±0.66	6 (5-6)	**<0.001c**	5.80±0.41	6 (5-6)	**<0.001c**	0.085d
50.	5.50±0.52	6 (5-6)	**<0.001c**	5.83±0.38	6 (5-6)	**<0.001c**	**0.041d**
60.	5.58±0.51	6 (5-6)	**<0.001c**	5.44±0.53	6 (5-6)	**<0.001c**	0.538d
70.	6±0.0	6	**<0.001c**				-
80.	6±0,0	(5-6)	**<0.001c**				-

a: Comparison between 3 and other times, b: Comparison between EarlyLA and LateLA groups, c: Wilcoxon Signed Rank test, d: Mann-Whitney U test

value using target-controlled propofol infusion. A stable anesthesia as in this present study, will not require any additional drug administration and will not lead to vital sign fluctuations due to anesthetic agents. This may have also masked the effect of painful procedures in reducing the depth of anesthesia. In this study, no difference was found between the groups in BIS values and Ramsey Scores, which are parameters indicating the depth of sedation. (p=0.190 for BIS; 0.887 for Ramsay). However, what is noteworthy here is that the total dose of sedative agents used for BIS values providing similar depth of anesthesia was not different between the two groups.

In a survey study conducted in 2014, 92% of the dentists participating in the study reported that they preferred the use of local anesthesia to stabilize vital signs and maintain the depth of anesthesia while performing treatments under general anesthesia.[6] The use, drug choice, application method and time of LA may be according to the clinical habits of most dentists. In our clinic, some pediatric dentists apply LA at the beginning of sedation just before starting intraoral procedures, while others use it at the end of sedation, just before the tooth extraction. However, our study shows that vital signs were similar the other group in the absence of LA during sedation. In this case, consolidation of anesthesia and stabilization of vital signs are not related to the presence of local anesthesia, but rather can be attributed to close BIS monitoring and target-controlled propofol titration.

There are limited studies in the literature investigating the effect of LA application on anesthetic requirement during dental sedation. However, the findings of a study investigating the effect of infiltrative local anesthesia and abdominal wall nerve blockade on the need for anesthetic drugs in pediatric patients undergoing inguinal hernia repair are remarkable. Infiltration anesthesia did not reduce the need for intravenous anesthesia at the level of abdominal nerve blockade, but BIS values were similar throughout the surgery.[18] Likewise, in our study, infiltration anesthesia did not decrease the need for propofol. Although dental infiltration anesthesia is different from the infiltration anesthesia mentioned in abdominal surgery, it is significant that these findings demonstrate the difference in analgesic potency between direct nerve block and infiltration anesthesia. On the other hand, intraligamental LA injection provides more effective postoperative analgesia than infiltration anesthesia as shown in the results of a study by Leong et al.[19] This finding may also be much related to the fact that infiltration anesthesia did not contribute to the depth of anesthesia or reduced the need for propofol under sedation in this study. In this respect, these findings of above studies may support the findings of our study.

In general, the goal after procedural sedation is to avoid any possibility of re-sedation and safely discharge the patient directly home in the same condition as before the sedation. In this context, the concern in pediatric anesthesia is to provide effective anesthesia with the minimal dose of medication possible without residual effects. One of the aims of this study was to investigate the total doses of propofol required for both groups. In this study LA presence resulted in no difference in the requirement of propofol in groups. As Lin et al.[20] demonstrated, BIS-guided TCI propofol sedation technique provides the targeted depth of sedation with less drug consumption.[20] Another conclusion of this study that is consistent with literature that deep sedation can be achieved effectively with TCI propofol under BIS monitoring.[14] On the other hand, it is known that the pharmacodynamics of propofol may be different in underweight and overweight children; therefore, TCI mediated propofol anesthesia is recommended to eliminate this effect.[21] Rogerson et al.[22] showed that overweight and obese children require lower doses of propofol for deep sedation than children of normal body weight.[22] In our study, BMI was found to be higher in Late LA group. To reveal the effect of BMI, the total amount of propofol used was calculated by eliminating BMI and there was no statistically significant difference between the two groups (0.597). This study also demonstrated that deep sedation can be achieved with a similar dose of propofol under the BIS monitor and through target control propofol infusion, regardless of local anesthetic contribution.

Local anesthesia at the beginning of sedation did not contribute to stabilization of vital signs, depth of anesthesia and total dose of propofol administered compared to LA at the end of sedation.

Pediatric deep dental sedation via target-controlled propofol infusion using BIS monitoring resulted in similar amounts of propofol consumption regardless of the presence of local anesthesia. It is concluded that close Bispectral Index monitoring and target controlled propofol infusion rather than timing of local anesthetic administration are the parameters that influence the quality of pediatric deep dental sedation and total drug consumption.

Readers of this study should not conclude that there is no need for local anesthesia under sedation. Local anesthesia has been shown to have many benefits in terms of pain and bleeding control in dental restorations. In this context, the type of drug and drug combinations, dose titration and analgesic potency for postoperative pain management of local anesthesia under sedation may be the subject of future studies.

This study had a couple of limitations. Contrary to the findings in the existing literature, our results showed that the application of local anesthesia at the beginning of sedation did not provide any benefit in terms of stability of vital signs, depth of anesthesia and drug requirement. This may be due to the limited sample size of this retrospective study. In addition, the number of restorative procedures and the total amount of local anesthetic used for each patient in both groups are not known. The lack of standardization in this regard is another limitation of this study. Therefore, our study design aims to provide a randomized controlled trial to fully conclude that local anesthetic application does not affect the depth of hypnosis during propofol anesthesia for pediatric dentistry.

Conclusion

Overall, this retrospective study on 50 healthy subjects showed that local anesthesia during sedation is not effective in strengthening the depth of sedation and stabilizing vital signs. Furthermore, the application of local anesthesia at the induction of deep sedation did not reduce the total dose of propofol needed. In contrast, target-controlled propofol infusion and bispectral index monitoring allow titrating the minimal dose of propofol required to achieve effective depth of sedation rather than supplementing sedation with local anesthesia.

Clinical Implication

The presence of LA during deep dental sedation does not contribute to the depth of sedation, hemodynamic stabilization, and the total dose of propofol required. Pediatric dentists using local anesthesia to enhance sedation may inadvertently increase unnecessary doses and associated complications. According to the results of this retrospective study LA has no benefits to deepen sedation. This study also emphasizes that TCI-propofol and BIS monitoring are essential for ensuring sedation depth and stability.

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Author Contributions

Design : All Authors
Data Collection : C.V. , B.B.U.
Data Analysis and Led the Writing: M.H.K. , B.B.U.

Conflict of Interest

The authors have no conflicts of interest to declare.

Ethics Approval

After obtaining the institutional ethical committee approval (approval number: 36290600/55) records of the 50 patients who had dental treatments under sedation in the department of pediatric dentistry between 2021-2022 were included in this retrospective study. This study was performed in line with the principles of the Declaration of Helsinki and registered to ClinicalTrials.gov (NCT06218173).

Authors' ORCID(s)

M.H.K. 0000-0002-2259-0131
C.V. 0000-0002-9736-3996
B.B.U. 0000-0001-7690-168X

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