# Bispectral Index System (BIS) Monitoring Reduces Time to Extubation and Discharge in Children Requiring Oral Presedation and General Anesthesia for Outpatient Dental Rehabilitation

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## Abstract

**Purpose**: Pediatric oral rehabilitation patients who receive presedation with oral Versed and general anesthesia (GA) occasionally experience prolonged sedation and delayed discharge. The Bispectral Index System (BIS) is an EEG monitor that measures the anesthesia level. The purpose of this study was to compare the effects of monitoring the BIS to not monitoring the BIS on time from discontinuation of GA to extubation and to discharge.

**Methods**: Twenty-nine children were enrolled. BIS was monitored from admission until discharge. Each child received 0.7 mg/kg of oral Versed. In the operating room, GA with sevoflurane (IH), rocuronium 1 mg/kg (IV), fentanyl 1 μg/kg (IV), and ondansetron 0.15 mg/kg (IV) was administered. Randomly, in half the patients, the anesthesiologist maintained the level of anesthesia and BIS by adjusting sevoflurane. In the rest, the anesthesiologist did not know BIS. The time from turning off sevoflurane to discharge was compared.

**Results**: Group 1 patients were extubated 5±2 minutes sooner than group 2 patients ($P$=.04). The post-anesthesia care unit stay for group 1 patients was 47±17 minutes compared to 63±17 minutes in group 2. (p=0.02)

**Conclusions**: Monitoring anesthesia with BIS promotes earlier extubation and discharge for pediatric dental patients who receive oral Versed and sevoflurane GA. (Pediatr Dent 2005;27:500-504)


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Some children require general anesthesia (GA) for oral rehabilitation. Occasionally, these outpatients experience prolonged sedation and delayed discharge. Some children may also be transferred to the postanesthesia care unit (PACU) and intubated and may even require overnight admission because they were too sleepy to be discharged. This is a real hardship, as it adds the burden of more expense on families as well as delayed recovery of the child after this procedure. In addition, admission of the child is a complicated process, as most dentists and anesthesiologists do not have admitting privileges.

The Bispectral Index System (BIS) is a monitor (Aspect Medical Systems, Newton, Mass) which derives its data from the electroencephalogram (EEG) utilizing bispectral and time domain parameters.[1] It is used to monitor the anesthesia level in patients. A sensor is placed on the forehead and connected to the BIS monitor. The BIS processes the complex EEG wave form into a single number, from 100 to 0. At high values near 100, the patient is awake. At ranges from 60 to 70, about 95% of the patients are considered to be in deep sedation or light hypnotic state (ie, the range used to maintain sufficient GA and amnesia). At ranges from 40 to 60, the patient is unconscious and is said to be in a moderate hypnotic stated. Below 40, the patient is said to be in a very deep hypnotic state.[2] Based on previous studies, the ideal BIS range of 60 to 70 for maintaining sufficient GA in children is the same for adults. This range is neither gender nor age sensitive. To date, there is little

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information regarding monitoring the anesthesia level in pediatric patients who receive oral presedation and inhalation anesthesia.

The clinical validity and data derivation studies were conducted on healthy adults, suggesting the possible benefit for utilizing the BIS in optimizing the depth of anesthesia, assuring adequate anesthesia, and reducing the time to extubation and discharge.[4] Reports on BIS utilization in children have emerged in the past 4 years, indicating that the BIS could possibly be utilized in children with the same benefit that was found in the adult patient population.

In 1994, Sigl and Chamoun[1] published an article in the *Journal of Clinical Monitoring* describing the basic concept behind the utilization of the BIS monitor as a simplified method for the interpretation of the electroencephalogram. It was described as a possible tool in diagnosing neurological disorders, as well as for intraoperative monitoring of anesthetic efficacy and cerebral ischemia.

Since then, numerous articles were published on the adult uses of the BIS monitor in anesthesia monitoring and assessment of its clinical utilization. Glass et al[3] reported that, in adults, the BIS reduced the incidents of free recall and consciousness to 0. Gan et al[4] reported a 36% faster extubation time and a 16% faster PACU discharge time in adult patients undergoing propofol, alfentanil, and nitrous oxide anesthesia. Further studies by Guignard et al,[5] Silva et al,[6] and Song at al[7] have all reported a significant reduction of isoflurane[5,6] and desflurane[7] requirements when the inhalational anesthetic was titrated based on the BIS number. All the aforementioned studies were conducted on healthy adult patients or healthy adult volunteers.

Although there has been earlier work done on the correlation between the EEG variations in children under anesthesia,[8] the utilization of BIS in anesthesia monitoring was first published in 1998. These clinical studies were in a variety of surgical and critical care settings. The question remains whether BIS could be useful in the reduction of time from the end of GA to extubation and PACU discharge time in children undergoing ambulatory surgery. Berkenbosch et al[9] studied 24 mechanically ventilated children in the intensive care unit and found that the BIS number correlated with the clinically assessed sedation levels and was useful in differentiating between adequate and inadequate sedation levels.

Choudhry and Brenn[10] compared 21 neurologically healthy children to 20 children with cerebral palsy and mental retardation (CPMR) undergoing sevoflurane anesthesia. They reported that BIS changes in both groups showed similar patterns of change when correlated with the sevoflurane concentration administered. They found, however, that CPMR children had a lower BIS baseline value when compared to healthy children.

Bannister et al[11] evaluated 202 sevolflurane/nitrous oxide anesthetics, which were randomized between standard practice and BIS utilization. Children ages 0 to 3 were having inguinal hernia surgery, which also involved a caudal block for postoperative analgesia, and children ages 3 to 18 were undergoing tonsillectomy and/or adenoidectomy. They reported that titrating sevoflurane, while utilizing the BIS value as a part of the monitoring criteria, significantly reduced the use of anesthesia and recovery time. This was consistent with earlier data published by Denman et al[12] showing that BIS monitoring can significantly reduce the end tidal sevoflurane and the recovery time in children. He reaffirmed the fact that the baseline MAC (mean alveolar concentration) requirement by children less than 1 year of age is generally higher than for older children.

Morse et al[13] assessed the use of BIS monitoring in 22 patients undergoing conscious sedation for dental surgery and found that the BIS values remained close to baseline and did not lend further value to the standard monitoring methods. Religa and others[14] reached the same conclusion when they assessed the use of BIS in 21 pediatric patients ages 3 to 6 undergoing oral conscious sedation for dental treatment.

Some studies have suggested that ketamine anesthesia increases brain electrical activity, as evident by EEG monitoring. Kurehara et al[15] reported that the spectral edge frequency 90 of the BIS increased significantly in relation to the beta power. This, however, did not change the parameters in a dose-related fashion.

A recent article by Matsuzaki and Tanaka[16] measured the feasibility of using the BIS for IV sedation during dental treatments in a relatively small population. The study compared 7 patients undergoing dental treatment while receiving GA to 7 patients undergoing dental procedures receiving intravenous sedation. This article suggested that BIS monitoring helped maintain anesthesia and reduce the amount of anesthesia utilized. They described, however, that artifactual data such as eye movement affected the BIS score due to position of the BIS sensor strip during oral surgery.

This study's authors recently evaluated the use of BIS monitoring in reducing extubation and discharge time after intramuscular (IM) ketamine/Versed presedation and sevoflurane GA.[17] Although it was reduced in the BIS-aware group, time to extubation was not a statistically significant reduction. The authors found that time to PACU discharge was reduced among the BIS-aware group in a statistically significant fashion. In this study, the presedation regimen was replaced by oral Versed in an attempt to understand if that would influence the outcome of extubation and discharge time in the BIS-aware group as it compares to the BIS-unaware group.

The purpose of this study was to evaluate the use of BIS monitoring in reducing time to extubation and PACU discharge in children who received presedation with oral Versed and general anesthesia for their dental rehabilitation procedure.

## Methods

The study protocol was reviewed and approved by the Institutional Review Board Office of Protection of Research Subjects, University of Illinois at Chicago, and received full approval prior to any data collection. This was a prospective, randomized, and observer-blinded study. Twenty-nine children ages 2 to 18 years old, who were scheduled to undergo complete dental rehabilitation under GA, were recruited to participate in this study. Patients with mild cerebral palsy who did not have significant neurological deficit were also enrolled in this study. Previous studies have shown that the baseline BIS value in cerebral palsy patients is low. It was found, however, that BIS is still valuable in predicting the anesthesia level in this population. The study protocol was explained to the parents or guardian and to the children. Written informed consent was obtained. Assent was obtained for children (ages 7 years and older).

The children were randomized into 2 groups. In group 1, the anesthesiologist knew the BIS and titrated sevoflurane delivery to maintain a BIS level of 55 to 65 (since previous studies showed that 5% of the patients can have awareness at BIS levels of 60 to 70, the number was lowered). Additionally, other parameters such as blood pressure, heart rate, and surgical stimulation were used. In group 2, the anesthesiologist was blinded to the BIS and titrated the sevoflurane to heart rate, blood pressure, and surgical stimulation, as is customarily done when no brain monitor is in place. The BIS level in both the groups was recorded by an independent observer. In addition, the end tidal carbon dioxide in all patients was maintained at the standard operating room level of 30 to 35.

**Table 1. Demographic Data**

| | Group 1 (N=15) | Group 2 (N=14) |
|---|---|---|
| Age (ys) | 4±2 | 4±2 |
| Weight (kg) | 17±5 | 18±5 |
| ASAPS* | I-II | I-II |
| Gender (male:female) | 4:10 | 2:3 |

*ASAPS=American Society of Anesthesiology Physical Status.

Both groups received a standard anesthetic of Versed 0.7 mg/kg by mouth and were transferred to the operating room 15 to 20 minutes after the administration of the oral sedative. Both groups were then given titrated sevoflurane (IH), fentanyl 1 μg/g (IV; administered at the start of the case), rocuronium 1 mg/kg (IV; a single dose administered at the beginning of the case), and ondansetron 0.15 mg/kg (IV). All patients were weaned of sevoflurane as the surgery neared conclusion. Hence, when the surgery ended, it coincided with the sevoflurane being turned off. Once the patients were extubated, all patients were transferred immediately to the PACU. In the PACU, the criteria for discharge—which included consciousness, normal vital signs, no pain, no nausea or vomiting, and ability to pass urine—was the same for all patients.

The BIS number was recorded at key points: (1) baseline or presedation; (2) induction of GA; (3) end of GA and extubation; (4) PACU admission; and (5) PACU discharge. The duration of the surgical procedure, the time between the end of GA or the turning off the sevoflurane and extubation, and the time between anesthesia termination and discharge from PACU were noted. The time from administration of the presedation to the start of the surgical procedure was noted, but it had no bearing on the assessed data.

Data are presented as mean±standard deviation or median and range. Statistical analysis was performed using the student's *t* test and the Mann-Whitney rank sum test, with a significance level of $P<.05$.

## Results

Group 1 and 2 patients were comparable demographically (age, ASAPS, weight, and gender). The mean age of group 1 children was 4±2. The mean age of group 2 children was 4±2 (Table 1). The duration of surgery was not statistically significant between the 2 groups. The level of the surgical care and the procedure were similar in all patients. Group 1 patients were extubated 5±2 minutes after the end of GA, which was significantly sooner than for group 2 patients, who were extubated 10±7 minutes after the end of GA ($P=.04$). Likewise, there was a considerable reduction in PACU stay to 47±17 minutes for group 1 patients, compared to 63±17 minutes PACU stay for group 2 patients ($P=.02$; Table 2). The BIS numbers, which were recorded at key points before, during, and after the surgical and anesthetic procedure in both groups, showed no statistical significance. The independent recorder, however, noticed a lower BIS value throughout most of the case duration in the BIS-unaware group compared to the BIS-aware group (Table 3).

**Table 2. Time (in Minutes) of Surgery and Recovery in Patients With BIS-known vs BIS-unknown During Anesthesia***

| | BIS-known (group 1) | BIS-unknown (group 2) | *P*† |
|---|---|---|---|
| Duration of surgery | 133±31 | 143±33 | .4 |
| End of GA extubation | 5±2* | 10±7 | .04 |
| PACU stay | 47±17* | 63±17 | .02 |

*BIS=Bispectral Index System; GA=general anesthesia; PACU=post-anesthesia care unit.
†Data are mean±standard deviation. *P* value was determined by student *t* test between groups. Significance was <0.05.

## Discussion

Pediatric patients admitted to the hospital for outpatient dental rehabilitation under GA are usually highly anxious and sometimes combative children with complex dental and anesthetic needs. Their dental conditions often require prolonged and multiple sessions to perform their dental procedures safely without GA. In most cases, these children need presedation prior to the induction of GA. Adding another sedative regimen of anesthesia above the anesthetic agents used during the actual procedure can lead to prolonged postoperative sedation. Presedation is much needed for a smooth transfer to the operating room and safe induction of GA. The level of postoperative home care varies, depending on the level of involvement of parents, family members, and caretakers. BIS use reduces time to discharge for pediatric patients who required oral presedation and GA for total oral rehabilitation.

The ideal objective is to provide the anesthesia level necessary to carry out the treatment needed while minimizing postoperative drowsiness and the recovery and discharge time. To make the anesthetics comparable, standard doses of commonly used oral presedative were used in this study. Likewise, a standardized general anesthetic was also given. The GA was based on what is routinely used with children needing this kind of procedure, regardless of the study enrollment. In addition, fentanly was given intraoperatively for pain at the beginning of the case. None of the patients experienced postoperative pain. Ketrolac would have been administered, however, if they experienced any pain. Reversal for the muscle relaxant rocuronium was administered at the end of the case. This did not, however, produce any postoperative nausea and vomiting in any of the patients.

This study's data revealed a statistically significant reduction in the time between turning off sevoflurane anesthesia or the end of GA and extubation and PACU discharge, as well as the time between PACU admission and discharge. It was observed that patients in which the BIS was known required less time prior to the removal of the endotracheal breathing tube as well as less time to recover in the PACU compared to patients in which BIS was not known. In an earlier study,[17] the investigating group found similar results regarding PACU discharge time after IM ketamine/Versed presedation and sevoflurane GA was administered. A trend towards faster extubation was also noted; however, it was not statistically significant.

It is reasonable to speculate that, as noted in this study, the statistically significant reduction in time to extubation compared to the previous one, could be attributed to the shorter half-life of the oral Versed presedation vs the IM ketamine/Versed administered in the earlier study. This is important in terms of OR utilization, as well as time spent in the PACU. Measuring the BIS during the surgical procedure did not show a difference at the critical points between both groups. This appears to be inconsistent with the variation in anesthetic depth between the groups producing a longer time to recover in the BIS-unknown group. BIS observations during surgery indicated that the BIS-unknown group showed more variation in the rise and fall of the BIS number throughout the surgery. It is likely that this variation was related to using other signs of anesthetic depth (ie, adjustments of sevoflurane were reactions to changing vital signs, not the depth of anesthesia).

Though the authors did not analyze the sevoflurane level in both groups, it is reasonable to speculate that the sevoflurane level in the BIS-unknown group was higher than in the BIS-known group. While Table 3 does not demonstrate great variability between groups 1 and 2 during induction and the end of GA, the independent observer who recorded the BIS values in both cases noticed those variations during the intraoperative course of the anesthetic procedure. Thus, attempts to control depth of anesthesia based on cardiovascular and other physiological parameters would periodically require greater anesthetic doses. This may have resulted in higher tissue anesthetic levels at the end of the surgical periods.

In summary, children having oral rehabilitation under GA are extubated faster, recover more quickly, and are able to be discharged sooner if BIS is used to guide their anesthetic. A common occurrence in these cases is that the anesthesia practitioner fails to consider the cumulative effect of the oral Versed, inhalational anesthetics, and intravenous agents. According to this study's data, use of the BIS to guide the general anesthetic will prevent excessive levels of anesthesia and, thus, allow for speedier recovery. This is good not only for the facility, but for the patient and family. The child's level of anesthesia will return to baseline sooner so that the child and care provider will have a better perioperative experience. Patients are also billed for the duration of their PACU stay. Since this study showed that children will be discharged 20 minutes sooner, this could prove to be cost effective for the family.

**Table 3. BIS Values During Anesthesia and Recovery***

| | BIS-known | BIS-unknown | *P*† |
|---|---|---|---|
| Baseline | 90±9 | 94±9 | .3 |
| Induction GA | 51±22 | 59±18 | .06 |
| End GA | 69±11 | 70±19 | .5 |
| Extubation | 89±8 | 86±8 | .3 |
| PACU admission | 93±7 | 92±5 | .6 |
| PACU d/c | 95±4 | 93±5 | .9 |

*BIS=Bispectral Index System; GA=general anesthesia; PACU=postanesthesia care unit.
†Data are mean±standard deviation. *P* value was determined by Student *t* test between groups.

## Conclusions

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

1. The use of the BIS reduced the time to extubation and the postanesthesia care unit stay compared to traditional anesthesia performed while using clinical measures.
2. The faster discharge from the postanesthesia care unit may prove cost effective to families, as well as the hospital or surgical facility.
3. Further studies are needed in the pediatric patient population, including studies that evaluate other sedative and anesthetic techniques.

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