Making Patients Safe and Comfortable for a Lifetime of Dentistry: Frontiers in Office-Based Sedation

John A. Yagiela, D.D.S., Ph.D.

Abstract: Conscious sedation administered in the office setting is one important method for helping people obtain necessary dental care. Patients who may benefit from sedation include the dentally fearful, young children, the behaviorally or medically challenged, and individuals who are undergoing invasive procedures or have problems with gagging or local anesthesia. In-office sedation is effective in reducing apprehension and can improve patient behavior without adversely affecting the patient’s physiological status. Mortality and serious morbidity are exceedingly rare in modern practice. Although behavioral strategies are clearly more cost-effective for the patient receiving routine dental care, in-office sedation is usually the least expensive alternative for patients requiring pharmacologic management. Future advances in conscious sedation may include agents and techniques currently thought to be dangerous for nongeneral anesthesia-trained dentists because of their ability to produce rapid changes in anesthetic depth. However, delivery devices such as infusion pumps for drugs like propofol, when coupled with computers to help regulate the infusion rate and monitor the sedative effect, may provide the necessary control for safe administration of propofol and similar drugs by these individuals. A final approach to drug delivery may involve patient-controlled sedation in which the patient self-infuses small boluses incrementally until the desired effect is achieved.

Dr. Yagiela is Professor and Chair of the Division of Diagnostic and Surgical Sciences, University of California, Los Angeles School of Dentistry. Direct correspondence and reprint requests to him at the UCLA School of Dentistry, Center for the Health Sciences, Los Angeles, CA 90095; 310-825-9300 phone; 310-825-3125 fax; johny@dent.ucla.edu.

Key words: bispectral analysis, dental fear, propofol, sedation

The dental profession has taken great strides in the past century to improve oral health care. If the presentations in this symposium are any indication, dentistry’s future will be marked by even greater advances rooted in such varied disciplines as molecular biology, bioengineering, and behavioral science. However, to receive the benefits of modern dentistry, prospective patients must seek out and participate in their dental care. Among the barriers that prevent individuals from doing so are fear of dentistry and an inability to cooperate with the dentist. Office-based sedation provides one important strategy for overcoming these barriers.

The Need for Office-Based Sedation

Over the past two decades, numerous studies using different survey instruments with different population samples have found that 7 percent to 15 percent of adults in the United States are very nervous or terrified about having to receive dental care.1-3 Individuals with high dental fear are more likely to delay scheduling appointments for needed treatment, to cancel or fail to attend scheduled appointments, and to require more extensive, invasive procedures as a result of self-neglect. Although behavioral strategies as described in this symposium by Professors Berggren and Feigal are generally preferred for “making patients safe and comfortable for a lifetime of dentistry,” sedative techniques may be necessary initially to facilitate treatment of the patients’ emergent needs and subsequently to permit those individuals who are unable or unwilling to learn the necessary coping skills to receive routine dental care. Patients with lesser degrees of anxiety, who tolerate conservative dentistry well, may desire pharmacosedation for more invasive procedures, such as the surgical extraction of impacted third molars. Other individuals who may benefit from anesthesia services include patients with a significant gag reflex or who cannot obtain satisfactory pain relief with local anesthetics alone. As determined by Dionne and colleagues using a stratified random national telephone survey, a significant disparity exists between the percentages of patients who prefer pharmacologic anxiety and pain relief for dentistry and who actually receive it (Figure 1).3

Young children constitute another important group of patients who have difficulty receiving regu-
lar dental care. According to United States census data, there are approximately 7.7 million children between the ages of eighteen and forty-two months of age. Using the adage that 80 percent of all caries in young children is found in 20 percent of the cohort, and the finding by Steelman that almost two-thirds of these patients require physical or pharmacologic restraint to receive care, we can estimate that approximately one million young children may need anesthetic management to facilitate their treatment.

Children with special needs (developmental, emotional, or behavioral problems), adult patients with severe/profound mental retardation or other disabling CNS disorders, and geriatric patients with acquired dementia may also be unable to cooperate with the dentist. These patients tend to have more caries, fewer restorations, and fewer teeth than do their counterparts in the general population.

A final set of patients who may benefit from perioperative sedation are those with significant cardiovascular disease or other medical conditions that reduce their physical ability to tolerate stress. Autonomic nervous system arousal because of inadequate pain or anxiety control may precipitate such immediate medical emergencies as stroke, myocardial infarction, and cardiac dysrhythmias.

**Evidenced-Based Assessment of In-Office Sedation**

For in-office sedation to be a viable solution for the needs just described, it must be clinically effective in providing both immediate and long-term benefits, be cost-effective for both patient and dentist, and be safe.

**Clinical Effectiveness**

Although individual antianxiety/sedative drugs (at least those marketed since 1938) are known to have therapeutic value because of the approval and review processes required by the U.S. Food and Drug Administration, their actual use singly or in combination for in-office sedation has not been well tested. Recently, the first large-scale controlled investigation of the efficacy of prototypic sedative regimens for outpatient oral surgery was published. This double-blind, multicenter trial examined the effectiveness of five different regimens in healthy adult patients (approximately 200/regimen) undergoing surgical extraction of impacted third molars. The five regimens were: placebo, the benzodiazepine midazolam (Versed) titrated to a clinical end point of conscious sedation (defined by the American Dental Association as “a minimally depressed level of consciousness that retains the patient’s ability to independently and continuously maintain an airway and respond appropriately to physical stimulation or verbal command and that is produced by a pharmacological or non-pharmacological method or a combination thereof”); midazolam plus additional midazolam titrated as needed during the procedure to maintain adequate conscious sedation; the opioid analgesic fentanyl (Sublimaze, 1.4 µg/kg) plus midazolam titrated to conscious sedation; and fentanyl plus midazolam plus the ultrashort-acting barbiturate methohexital (Brevital) given as needed to maintain adequate conscious sedation. Local anesthesia (2 percent lidocaine plus 1:100,000 epinephrine) was administered immediately after the sedative medications.

Figure 2 illustrates the overall effectiveness of the regimens as evaluated after surgery by both patients and surgeons. All active treatments were more effective than the placebo in providing conscious sedation. Whereas patients preferred the two regi-
mens in which the level of sedation was maintained throughout surgery by the administration of an additional drug, surgeons preferred the two regimens in which fentanyl was administered. Other measures of efficacy included interfering movements of the patient, verbalizations of discomfort, nonverbal signs of discomfort, anxiety and pain ratings during surgery, and the patient’s recall of intraoperative events. Correlating the data from these measures with those shown in Figure 2 suggests that patients prefer regimens that cause amnesia to aversive stimuli and surgeons prefer regimens that minimize interfering movements and evidence of patient discomfort.

Physiologic measures of drug activity were minimally altered. The only statistically significant disturbances, observed after fentanyl, reflected transient respiratory depression lasting from the time the patients reached the desired level of conscious sedation through the first few minutes of surgery (Figure 3). The following conclusions can be drawn from this study:

- the techniques as tested were therapeutically effective and without significant adverse effects;
- standard doses of midazolam may worsen patients’ behavior even as they improve patients’ surgical experience;

![Figure 2](image1.png)

Figure 2. Patients’ and surgeons’ (gray and black bars, respectively) global evaluations of sedation efficacy after the administration of placebo (P), midazolam (M), midazolam plus midazolam (M+M), midazolam plus fentanyl (M+F), or midazolam plus fentanyl and methohexital (M+F+Me). * = \( P < .01 \) versus placebo; † = \( P < .01 \) versus M and M+F; ‡ = \( P < .01 \) versus M and M+M. (Data from Dionne RA, et al. Comparing efficacy and safety of four intravenous sedative regimens in dental outpatients. J Am Dent Assoc 2001;132:740-51.)

![Figure 3](image2.png)

Figure 3. Influence of placebo (P), midazolam (M), midazolam plus midazolam (M+M), midazolam plus fentanyl (M+F), or midazolam plus fentanyl and methohexital (M+F+Me) on arterial oxygen saturation. Pre-op = baseline; 1 = fentanyl or placebo; 2 = midazolam or placebo; 3 = methohexital or placebo; * = \( P < .01 \) versus P, M, and M+M. (Reproduced with permission from Dionne RA, et al. Comparing efficacy and safety of four intravenous sedative regimens in dental outpatients. J Am Dent Assoc 2001;132:740-51.) Copyright © 2001 American Dental Association. Reprinted by permission of ADA Publishing, a Division of ADA Business Enterprises, Inc.
• the partial substitution of an antianxiety drug (midazolam) with an opioid (fentanyl) improves patients’ behavior but reduces respiratory drive; and
• maintenance of the sedative level throughout surgery improves patients’ assessment of treatment.

Cost-Effectiveness

The burgeoning growth of ambulatory anesthesia services in medicine is a response, in part, to cost-containment efforts by third-party payers. Although the monetary savings behind this trend are obvious for medicine, the same cannot be said for dentistry. Most invasive medical procedures are not repeated in the same patient, and there is often no alternative to involving a separate anesthesia provider in the care of the patient. In contrast, many dental procedures such as tooth scaling and operative restorations are performed on multiple occasions for the same patient. The primary choice here is between providing conscious sedation (or other forms of anesthetic management) repeatedly over the anxious patient’s lifetime or equipping the patient with the coping skills necessary to manage fear and apprehension. Clearly for the patient, the most cost-effective strategy is to overcome the mental barriers preventing routine dental care. Current procedure-based economics for the dentist strongly favors pharmacosedation. It remains a challenge for our profession to promote competitive reimbursement for dentists seeking behavioral management solutions for their patients.

Management alternatives for children who are too young to cooperate with the dentist are often limited to in-office oral or inhalation conscious sedation versus general anesthesia in the hospital. Although the direct costs of office sedation are much lower than those of hospital anesthesia, a recent study including societal costs incurred by the child’s family found that oral sedation is preferred only when the number of appointments to complete the treatment plan is less than four. It was assumed for this analysis that all necessary care was performed during a single general anesthetic, whereas conscious sedation appointments were aborted in 5.6 percent of cases and otherwise limited to sixty to ninety minutes each. The option of in-office general anesthesia administered by a second practitioner was not included in this study; however, the assumptions and cost information used indicate that this mode of anesthesia delivery would be favored for treatment plans requiring more than one conscious sedation to complete. Also not considered in this investigation was the quality of restorative care. Presumably because of better operating conditions, restorations placed under general anesthesia in children tend to have better marginal adaptation and a lower incidence of secondary caries.

Safety

Little accurate information exists regarding the safety of contemporary in-office conscious sedation in the United States. Mortality and serious morbidity events are quite rare and can only be studied by capturing data from thousands of practitioners over a multiyear period. Because there is no national mandatory reporting requirement, investigators have relied for information on voluntary surveys and reports to malpractice insurance carriers. Limitations to these studies include the inability to collect mortality/morbidity data from all practitioners who use conscious sedation and accurate information about the number of patients receiving this service.

Perhaps the most reliable statistics on the safety of parenteral conscious sedation are those of the British National Health Service compiled by Coplans and Curson. As shown in Table 1, there were no deaths in

<table>
<thead>
<tr>
<th>Anesthetic technique</th>
<th>1970-79* Deaths</th>
<th>1980-89† Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>General anesthesia</td>
<td>100</td>
<td>42</td>
</tr>
<tr>
<td>Conscious sedation</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Local anesthesia</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Other‡</td>
<td>10</td>
<td>24</td>
</tr>
</tbody>
</table>

na = not available

‡ Includes cases in which the anesthetic management was unknown or not related to the outcome.
over two million sedations from 1970 to 1979. Two fatalities were associated with conscious sedation in the next decade (1980-89). One case probably resulted from an overdose of midazolam; the other was caused by an accidental injection of concentrated epinephrine. But because of advances in monitoring over the last two decades and other variables, these data are not fully applicable to contemporary American practice.

Many state dental boards require that they be informed of any death or serious injury occurring in the dental office or linked to dental care. In California, for example, there have been nineteen deaths associated with dentistry in the decade following adoption of its conscious sedation permit process in January 1991 (personal communication, California Dental Board). Twelve deaths were attributed to general anesthesia permit holders; three were in children given oral sedation by dentists without a parenteral sedation or general anesthesia permit; and four were caused by hematologic/vascular problems (three bleeding, one stroke). None of the deaths resulted from sedation administered by a parenteral sedation permit holder (266 holders as of January 2001). It would be highly desirable if states like California would develop standardized reporting methods and pool their data to provide a clear view of the safety of conscious sedation techniques and other anesthetic methods used in dentistry. Even the limited findings from a single state can sometimes improve safety. For example, the aforementioned pediatric deaths in California recently prompted legislation to regulate oral sedation in children under the age of thirteen. It is expected that mandatory facility and performance standards, coupled with obligatory continuing education in oral sedation, will significantly reduce risk.

**Biotechnologic Advances in Pharmacosedation**

The most important advances in conscious sedation for dentistry during the past thirty years have come from new monitoring devices such as the pulse oximeter and from national guidelines and state legislation that have recommended or even mandated standards of professional training and patient care for the delivery of pharmacosedation in the office setting. These advances occurred once there was general acceptance that sedation carries substantial health risks but that these risks can be minimized. Although new anesthetic drugs and delivery devices with potential applications in conscious sedation have also been marketed in recent years, most dentists providing parenteral sedation continue to use drugs and techniques that are decades old. In order to embrace these new developments and expand the frontiers of office-based sedation in the twenty-first century, we may again need to revise certain assumptions pertaining to risk.

**“Prohibited Agents” and Infusion Pumps**

According to the American Dental Association (and many other entities interested in dental anesthesia), “the drugs and/or techniques used [for conscious sedation] should carry a margin of safety wide enough to render unintended loss of conscious unlikely.” Some states actually list “prohibited agents” whose pharmacologic characteristics are assumed to violate this proviso. Prohibited agents typically include the inhalation anesthetics (e.g., sevoflurane [Ultane]), ultrashort-acting barbiturates (e.g., methohexital [Brevital]), ketamine (Ketalar), propofol (Diprivan), and remifentanil (Ultiva). As a group, these drugs have a fast onset of action and a short duration of effect, which often necessitates that they be administered by specialized equipment (anesthetic machines, infusion pumps) to control and maintain drug effect. General opinion holds that these agents are not compatible with the typical office situation in which the dentist, without extensive anesthesia training, is responsible for both the sedation and the procedure. Not only would the dentist have to pay increased attention to the patient’s sedative depth and the administration devices, there would be a strong inclination to increase drug delivery in response to acute noxious stimuli. Removal of the stimulus or administration of too great a dosage could then lead to general anesthesia and such risks as airway obstruction and respiratory arrest. Of these CNS depressants, only the opioid remifentanil can be reversed by a specific drug antagonist if the practitioner recognizes the need.

These concerns notwithstanding, a case can be made that a drug such as propofol could be a significant boon to conscious sedation in dentistry. The inherent safety margin of propofol, that is, the ratio between the doses that produce general anesthesia
and conscious sedation, is similar to that of pentobarbital (Nembutal) used successfully in the conscious sedation technique first introduced in the 1940s by Niels Jorgensen. A great advantage of propofol over pentobarbital and all other sedatives currently used for parenteral conscious sedation in dentistry is the rapid dissipation of drug effect that occurs once administration is stopped, regardless of whether the case was thirty minutes long or three hours. Recovery to discharge is likewise hastened, and the chances of becoming oversedated at home are greatly reduced. Propofol also has specific antinauseant effects. Continuous infusion of propofol with the use of a battery-powered pump gives the control and flexibility required to meet a broad range of clinical situations.

Widely employed in deep sedation and general anesthesia in dentistry, propofol is increasingly being studied for conscious sedation. As described by Ruiz and colleagues, propofol administered with an infusion pump for conservative dentistry was positively rated by all 100 patients who received it and caused no patient to remain in the office for purposes of recovery. These authors also noted, however, that the need to monitor the patient’s response and adjust the propofol infusion rate during the procedure argued against administration by a single operator/anesthetist. Likewise the FDA-approved package labeling warns against propofol being administered by the same individual also involved in the procedure.

Computer-Assisted Sedation

In recent years, computers have been used to assist anesthesiologists in the delivery of general anesthesia. This technology, in the form of target-controlled infusion (TCI) systems, has now been adapted for the administration of propofol sedation. TCI devices seek to quickly achieve and then maintain a therapeutic concentration of drug in the blood or brain based on pharmacokinetic modeling of the distribution and metabolism of the drug. The ability of this system to elicit the desired sedation depends on the appropriateness of the pharmacokinetic model used, the accuracy of the data upon which the model is based, and the applicability of the model to the individual patient. It is also based on how closely linked the drug’s effect is to its plasma or brain concentration.

Oei-Lim et al. examined TCI for anxious patients undergoing dental procedures in which a target venous serum concentration of propofol was set initially at 1.4 µg/mL. From zero to three adjustments in the target concentration were required per patient to achieve the desired level of conscious sedation, resulting in a mean final target concentration of 1.6 ± 0.1 µg/mL (mean ± standard deviation). Plasma concentrations of propofol actually achieved were 1.4 ± 0.3 µg/mL. The duration of sedation varied from one to three hours.

Computers are also being used to monitor directly the CNS depressant effect of anesthetic drugs. Two promising measures of anesthetic action are the bispectral index (BIS) and auditory evoked potentials. The BIS has generated more interest because of the commercial availability of a BIS monitor that is easy to use.

The BIS is derived from a complex analysis of the electroencephalogram. It is a dimensionless number from 0 (no brain activity) to 100 (wide awake) that is directly related to level of consciousness. With rare exceptions, a BIS less than sixty ensures that the patient will be unaware of intraoperative events. The use of BIS monitoring for conscious sedation is based on the hypothesis that the BIS accurately predicts whether a patient can respond to verbal command with propofol given alone or in combination with other agents. A BIS of seventy-five ensured that the patient was consciously sedated as defined by the American Dental Association (sedation score ⊕ 2). The BIS was also a better discriminator of consciousness than either the plasma propofol concentration or the predicted propofol concentration at the theoretical active brain site as produced by TCI. The ability of the BIS monitor to indicate consciousness has also been demonstrated in patients receiving intravenous sedation for third molar extractions.

Using the BIS to modify propofol TCI is a logical marriage of the two computer-based technologies. Potential advantages include a lower incidence of over- or underdosage and a more stable drug effect. Of course the ultimate union would be to have the BIS directly drive the TCI system. Preliminary tests indicate that an automated delivery system of this nature has promise both for general anesthesia and conscious sedation.
Clearly, the computer is revolutionizing anesthesia care in medicine and has the potential for allowing the safe use of propofol and other "prohibited" drugs for conscious sedation in dentistry. With modifications to prevent bolus administration and restrictions on the maximum target concentration or minimum BIS allowed, delivery systems could provide both increased control and safety using drugs like propofol whose pharmacokinetic characteristics are currently considered to be problematic for in-office sedation by the non-general anesthesia trained dentist. Indeed, we may see a time when the operator-anesthetist trained for conscious sedation only will be able administer intravenous sedation in which the desired effect is rapidly established, maintained for as long as necessary, and then terminated within a matter of minutes.

**Patient-Controlled Sedation**

A final approach that holds promise for conscious sedation in the dental office is to use the patient as the servo-controller for drug infusion. Patient-controlled sedation (PCS) is not a new concept. Many years ago, general anesthetics such as methoxyflurane were self-administered by women during childbirth using hand-held inhalers. More recently, patient-controlled analgesia in which the patient presses a button to infuse an intravenous bolus of morphine (or other opioid) has become commonplace.

Girdler and colleagues recently compared the benefits of patient- versus clinician-controlled propofol sedation in phobic dental patients.24 A randomized cross-over design was used. In one appoint-
ment, a clinician experienced in propofol sedation administered the drug using an infusion pump, adjusting the infusion rate to meet the apparent need of the patient; in the other, the patient performed the same task by pushing a button that delivered a single 5-mg bolus of propofol over 7.5 seconds with each activation. No limitation was placed on the number or frequency of pump activations.

As shown in Figure 5, there was a trend with PCS toward lower maximum sedation scores (reflecting a 38 percent absolute and 30 percent time-weighted reduction in propofol dosage with PCS) and better operating conditions as judged by the dentist. Significantly, 56 percent of the subjects preferred PCS, whereas only 17 percent preferred clinician control.

Giving patients some command over their own drug therapy may offer several advantages. It may allow them to select their own desired level of sedation; it may engage patients in ensuring a successful treatment outcome; and it may improve safety by interrupting drug administration once the patient is too sedated to function. Lastly, PCS provides an interesting fusion of pharmacology and psychology in the treatment of dental fear. Too often have these approaches to patient management been considered mutually exclusive, when in fact they can provide complementary benefits for both the patient and treating dentist.

**REFERENCES**


![Figure 5. Comparison of (A) maximum sedation scores and (B) operating conditions after clinician-controlled sedation (CCS) and patient-controlled sedation (PCS). The sedation scale ranged from 1 (awake/anxious) to 6 (unresponsive); operating conditions were graded from 1 (poor) to 5 (excellent). (Reproduced with permission from Girdler NM, Rynn D, Lyne JP, Wilson KE. A prospective randomised controlled study of patient-controlled propofol sedation in phobic dental patients. Anaesthesia 2000;55:327-3.)](image)