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# Injection pain

## Comparison of three mandibular block techniques and modulation by nitrous oxide:oxygen

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**A B S T R A C T**

**Background.** The authors conducted this study to compare the pain on injection of the three mandibular block techniques and to determine the effect that the delivery of nitrous oxide:oxygen, or $N_2O:O_2$, had on this pain.

**Methods.** Based on sample size calculation, the authors randomly assigned 60 subjects to receive either local anesthetic alone or local anesthetic with $N_2O:O_2$ titrated to effect. Each subject received two mandibular block injections bilaterally from three possible pairings: Gow-Gates/standard block, standard block/Vazirani-Akinosi or Gow-Gates/Vazirani-Akinosi. Subjects scored their pain using a 100-millimeter visual analog scale immediately after each injection. The authors analyzed data using analysis of variance, Student $t$ tests and multiple regression analyses.

**Results.** There were no significant differences in pain on injection among the three injection techniques. The subjects in the group that received $N_2O:O_2$ and the local anesthetic demonstrated a statistically significant reduction in pain on injection compared with subjects in the group that received the local anesthetic only ($P < .05$). When $N_2O:O_2$ was used, there was a statistically significant decrease in pain with the first injection ($P < .0005$), an effect not seen with the second injection.

**Conclusions.** There was no significant difference in pain among the three mandibular block techniques. $N_2O:O_2$ can reduce pain on the first injection given, but this effect is not seen subsequently.

**Clinical Implications.** The decision to select one of the three mandibular block techniques should be based on factors other than pain on injection. $N_2O:O_2$ reduces pain on the first injection only.

L ocal anesthesia is essential for pain-free dentistry, yet intraoral injections often are considered painful and a source of anxiety for many patients. Any new information that will allow us to reduce the pain of injection will be beneficial. Anesthesia for mandibular procedures may be achieved by using the standard inferior alveolar nerve block, or SB; the Gow-Gates, or GG; or the Vazirani-Akinosi, or VA, techniques. The latter two techniques, which have unique insertion points and paths, are being used increasingly, as they have specific advantages over the traditional standard block, or Halsted, approach.[1-5]

Each of the three techniques has advantages and disadvantages. Potential differences in pain on injection could be a determining factor in their selection. The SB technique is the most widely known among dentists, but it has a significant failure rate. This often is because of its susceptibility to anatomical variation of the mandibular foramen and its inability to anesthetize a number of accessory innervation pathways. The GG technique uses extraoral and intraoral landmarks and requires patients to be able to open their mouths widely. Local anesthetic is deposited at a deeper site than in the SB technique, more proximally along the mandibular division of the trigeminal nerve before its separation into the distal branches. The GG technique, therefore, is more likely to anesthetize the lingual and

*A dentist's decision to select one of the three techniques should be based on factors other than pain on injection.*

BOX

## INCLUSION AND EXCLUSION CRITERIA FOR STUDY.

### INCLUSION CRITERIA

- Between the ages of 18 and 70 years.
- Weigh between 40 and 100 kilograms.
- In good health (American Society of Anesthesiology, or ASA, classification I or II).
- Possess at least one tooth distal to the central incisor in each mandibular quadrant that is vital, as assessed by electric pulp test.
- Informed written consent given before participation.

### EXCLUSION CRITERIA

- Allergy to lidocaine or sulfites.
- History of a significant medical problem (ASA classification III or greater).
- Have not taken any medications 48 hours before testing, which may influence the results. These are central nervous system depressants including alcohol or any analgesics such as opioids, nonsteriodal anti-inflammatory drugs or acetaminophen.
- Inability to breathe through nose.
- Inability to tolerate administration of nitrous oxide:oxygen through the nasal mask.
- Pregnancy.
- Lack of informed consent.



**Figure 1.** The overall study design showing the 60 subjects randomly assigned to group 1 to receive local anesthetic only or group 2 to receive local anesthetic with nitrous oxide:oxygen. GG: Gow-Gates; SB: standard block; VA: Vazirani-Akinosi.

buccal nerves, as well as accessory innervation pathways. The VA technique uses a closed-mouth approach, which may be beneficial for patients with trismus or a significant gag reflex induced by intraoral palpation. Unlike the SB or GG approach, in the VA technique the needle is inserted to its predetermined depth without contacting a hard-tissue landmark. A number of sources have provided detailed descriptions of these techniques.[1-5]

A couple of studies in the literature have com-pared pain on injection for all three techniques[6,7]; however, to our knowledge neither of these was a randomized controlled trial. Although these three mandibular blocks are taught in dental schools and are used increasingly by dentists, there is little documentation regarding their relative degrees of pain. A significant difference in pain would imply that one of these methods has an advantage over the others, whereas "no difference" implies that the three blocks are equivalent with respect to pain. Either finding would be worth determining. Therefore, the primary purpose of our investigation was to evaluate the relative pain experienced on administration of local anesthetic using the SB, GG and VA techniques.

Dentists use several techniques to modify patients' pain response to injection, including the use of topical anesthetic. Unfortunately, when we reviewed the literature, we found that the effectiveness of topical anesthetic is equivocal at best and often is no better than placebo.[8-13] Another pharmacological approach used to minimize the pain on injection is the administration of nitrous oxide:oxygen, or $N_2O:O_2$. Therefore, our second reason for conducting this study was to evaluate the effect of the delivery of $N_2O:O_2$ on injection pain.

## METHODS

We designed this study as a randomized crossover investigation, in which the subjects were blinded to the type of injections they received and served as their own controls. As determined by a sample size calculation, which is described later, 60 of the 63 subjects screened satisfied the inclusion/exclusion criteria (Box). We randomly decided each subject's group assignment, as well as the mandibular injection type, side and order. Each subject received one of the following pairs of injections bilaterally: VA-SB, SB-GG or GG-VA. The study design is illustrated in Figure 1. Within each of the VA-SB, SB-GG and GG-VA pairs, we balanced the injection order. For example, of the 10 subjects in group 1 assigned to receive GG and SB injections, five received the GG injection first and five received the SB injection first. We similarly balanced the right
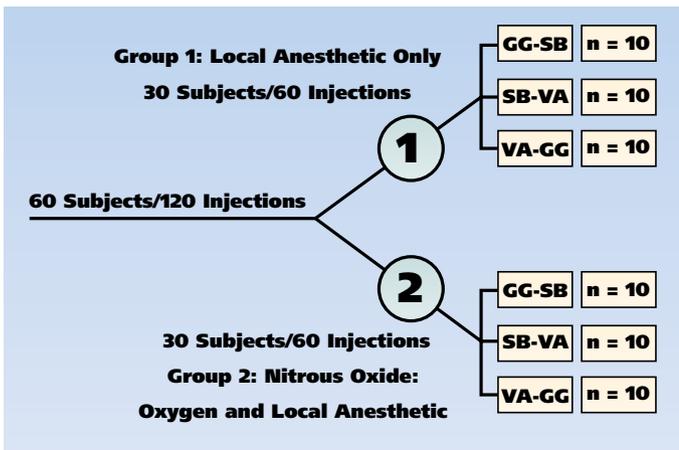
and left sides for each injection type.

At the screening visit, each prospective subject completed a medical history questionnaire and underwent an intraoral examination to verify the presence of bilateral nonheavily restored teeth distal to the mandibular lateral incisors and a non-heavily restored maxillary tooth. We used the mandibular teeth to verify anesthesia and as a control for the proper function of the electric pulp tester, or EPT. We recorded baseline EPT values at this screening visit and at the start of each testing session.

One investigator (S.J.) administered all of the injections to minimize variability in injection skill. He administered each local anesthetic injection using a standard self-aspirating dental syringe, a new 25-gauge, 36-millimeter long needle and 1.8 milliliters of 2 percent lidocaine with 1:100,000 epinephrine. He did not use topical anesthetic before inserting the needle, so as to avoid a potential confounding variable. He administered each injection over a 60-second period and recorded the occurrence or absence of a positive aspirate. He monitored the subjects with automatic, noninvasive blood pressure and continuous pulse oximetry.

Immediately after injection, each subject scored his or her pain level by placing a vertical mark on a 100-mm horizontal visual analog scale, or VAS, with the left-hand side of the scale being "no pain" and the right-hand side being the "most severe pain imaginable."

We assessed the success of the anesthesia 10 minutes after the injection by means of an EPT and by clinical measures. We applied the probe of the EPT to the buccal surface of the tooth being tested midway between the incisal edge and the gingival margin, using conducting gel. We recorded the median value of three readings. Clinical measures to test for subjective signs of anesthesia included probing the mandibular canine gingival mucosa and asking the subjects if they had any lip numbness symptoms. This type of clinical assessment parallels that of a dentist assessing whether a local anesthetic injection is effective.

To assess the effect of $N_2O:O_2$, we randomly assigned the subjects to one of two groups (Figure 1). Group 1 received local anesthetic only and group 2 received $N_2O:O_2$ before the investigator administered local anesthetic. We used the same protocol for each group with
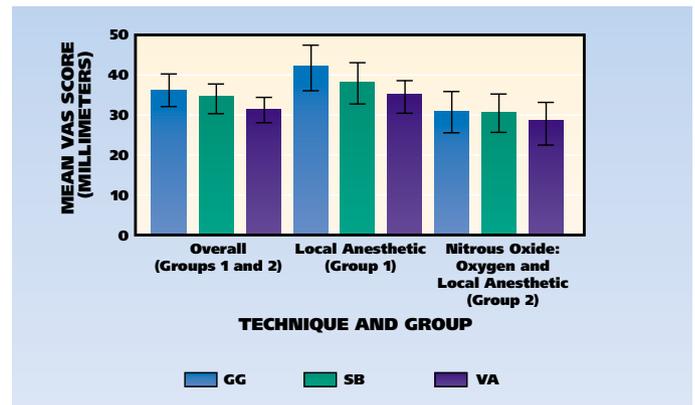


Figure 2. Mean and standard error of the visual analog scale, or VAS, scores by injection technique and group. GG: Gow-Gates; SB: standard block; VA: Vazirani-Akinosi.

respect to selection, timing, injection administration, pain scoring and outcome measures. We considered using group 1 as a control for group 2 by having subjects in group 1 breathe either 100 percent oxygen or room air through a nasal mask. We deemed, however, that this approach was questionable because the subjects would not be truly blinded, as they would know whether they were receiving the $N_2O:O_2$. Therefore, we decided that the subjects in group 1 would breathe room air without a nasal mask because this would allow us to assess globally the technique of administering the $N_2O:O_2$ by nasal mask and achieve our secondary objective.

*Immediately after injection, each subject scored his or her pain level using a visual analog scale.*

Using an established protocol,[14,15] we administered $N_2O:O_2$ to the subjects in group 2 by means of a standard scavenging nasal mask and at a concentration titrated for subject comfort using a portable $N_2O:O_2$ delivery system. We set the unit to deliver 20 percent $N_2O:O_2$ initially and then assessed the subjects for depth of sedation after two minutes. We continued to reassess the subjects every minute thereafter and adjusted the level upward in 5 percent increments until satisfactory signs and symptoms were achieved. The subjects' affirmative responses to the question "Are you relaxed enough to begin the study?" were the endpoint sedation level.

The investigator administered anesthetic to the subjects per the protocol, and they immediately scored their pain levels. We determined anesthesia success 10 minutes after this first injection. After one minute, the subjects verbally confirmed their comfort, and the investigator

**TABLE 1**

| SUMMARY OF POSTINJECTION VAS* SCORE MEAN VALUES. | | | | | |
|---|---|---|---|---|---|
| **GROUP** | **PAIRING†** | **TECHNIQUE** | **MEAN VAS SCORE** | **STANDARD ERROR** | **P VALUE** |
| All Subjects | GG-SB | GG | 30.70 | ± 5.64 | .96 |
| | | SB | 30.45 | ± 4.56 | |
| | GG-VA | GG | 42.45 | ± 5.51 | .05 |
| | | VA | 29.85 | ± 4.27 | |
| | SB-VA | SB | 38.70 | ± 5.49 | .39 |
| | | VA | 33.35 | ± 5.30 | |
| Local Anesthetic Only (Group 1) | GG-SB | GG | 33.10 | ± 9.60 | .79 |
| | | SB | 31.70 | ± 6.36 | |
| | GG-VA | GG | 51.60 | ± 5.19 | .03 |
| | | VA | 32.70 | ± 4.58 | |
| | SB-VA | SB | 45.10 | ± 8.09 | .23 |
| | | VA | 37.20 | ± 7.04 | |
| Nitrous Oxide: Oxygen and Local Anesthetic (Group 2) | GG-SB | GG | 28.30 | ± 6.38 | .92 |
| | | SB | 33.30 | ± 6.87 | |
| | GG-VA | GG | 33.30 | ± 9.08 | .53 |
| | | VA | 27.00 | ± 7.35 | |
| | SB-VA | SB | 32.30 | ± 7.25 | .80 |
| | | VA | 29.50 | ± 8.11 | |

\* VAS: Visual analog scale.
† GG: Gow-Gates; SB: standard block; VA: Vazirani-Akinosi.

administered the second injection one minute later. Again, the subjects immediately scored their pain levels, and we assessed the effectiveness of the second block 10 minutes later. The $N_2O:O_2$ was then discontinued, followed by 100 percent oxygen for three minutes.

**Sample size calculation.** The sample size calculation consisted of an α level (type I error) rate of 0.01 for a two-tailed test and a β level (type II error) rate of 0.05. In both cases, we selected values at a more rigorous level than the standard α level of 0.05 and β level of 0.20.

For the calculation, we used the standard deviations from topical anesthetic studies that also measured pain on injection using a VAS, which equaled 20.[9,10] We estimated that δ—a difference of 20 mm on a 100-mm VAS—would be considered clinically significant when comparing one group with another. The formula for the sample size calculation is

$$ n = \frac{(Z_\alpha + Z_\beta)^2 \times \sigma^2}{\delta^2} = \frac{(2.58 + 1.64)^2 \times 20^2}{20^2} = 17.8 $$

$Z_\alpha$ and $Z_\beta$ are values taken from standard statistical tables.[16]

Assuming a dropout rate approximating 10

percent, we enrolled 20 subjects per injection pairing, for a total of 60.

**Statistical analysis.** We analyzed the results using analysis of variance and Student $t$ tests, followed by multiple linear regression, which began with a stepwise regression to search for significant predictive independent factors that comprised the dependent variable, the VAS score. We determined potential interactions of predictive factors selected from the stepwise analysis and used them to confirm or reject results observed with the other statistical tests.

*The Gow-Gates injection tended to have the highest pain scores, and the Vazirani-Akinosi injection tended to have the lowest.*

## RESULTS

Thirty-six women and 24 men, with an age range of 18 to 61 years, enrolled in the study. There was no significant difference between the two groups in terms of age, weight or sex. The success rate of mandibular nerve blocks using a combination of EPT and at least a partially numb sensation was GG, 87.5 percent; SB, 97.5 percent; and VA, 95 percent. The incidence of positive aspiration for each injection technique was GG, four of 40; SB, one of 40; and VA, none of 40. The mean concentration of $N_2O$ titrated to effect for the subjects in group 2 was 35 percent, with a standard error of 1 percent and a range of 25 to 50 percent.

The mean VAS scores of the three injection

**TABLE 2**

## REGRESSION ANALYSES: TECHNIQUE AND NITROUS OXIDE:OXYGEN.

| FACTOR | VAS VERSUS GG, SB AND VA TECHNIQUES*†‡ | | | | VAS VERSUS GG, SB, VA AND NITROUS OXIDE: OXYGEN TECHNIQUES§ | | | |
|---|---|---|---|---|---|---|---|---|
| **Multiple Regression Analysis** | | | | | | | | |
| **Predictor** | **Coefficient** | **Standard Error Coefficient** | **t** | **P Value** | **Coefficient** | **Standard Error Coefficient** | **t** | **P Value** |
| Constant | 31.6 | 3.661 | 8.63 | < .001 | 44.55 | 7.22 | 6.17 | < .001 |
| GG | 4.975 | 5.177 | 0.96 | .339 | 4.975 | 5.106 | 0.97 | .332 |
| SB | 2.975 | 5.177 | 0.57 | .567 | 2.975 | 5.106 | 0.58 | .561 |
| Nitrous Oxide:Oxygen | NA¶ | NA | NA | NA | −8.633 | 4.169 | −2.07 | .041# |
| **Analysis of Variance** | | | | | | | | |
| **Source** | **Degrees of Freedom** | **Sum of Squares** | **Mean Square** | **F Ratio** | **P Value** | **Degrees of Freedom** | **Sum of Squares** | **Mean Square** | **F Ratio** | **P Value** |
| Regression | 2 | 501.3 | 250.7 | 0.47 | .628 | 3 | 2,737.4 | 912.5 | 1.75 | .161 |
| Residual error | 117 | 62,713.2 | 536 | NA | NA | 116 | 60,477.1 | 521.4 | NA | NA |
| **TOTAL** | **119** | **63,214.5** | **NA** | **NA** | **NA** | **119** | **63,214.5** | **NA** | **NA** | **NA** |

\* VAS: Visual analog scale; GG: Gow-Gates; SB: standard block; VA: Vazirani-Akinosi.
† The VA technique is highly correlated with other independent variables and was removed from the equation because the coefficient was not statistically different from zero.
‡ The regression equation was VAS = 31.6 + 4.975 GG + 2.975 SB. There was no statistical significance among the techniques using this analysis.
§ The regression equation was VAS = 44.55 + 4.975 GG + 2.975 SB − 8.633 nitrous oxide:oxygen.
¶ NA: Not applicable.
# Multiple regression analysis showed that nitrous oxide:oxygen had a significant effect on predicting the VAS score ($P < .05$). These data predict that the use of nitrous oxide:oxygen will reduce the VAS score.

techniques are shown in Figure 2 (page 871). We found no significant differences in pain among the techniques, whether we assessed them overall or subdivided them into the groups that did or did not receive $N_2O:O_2$. Table 1 shows the means and standard errors of the VAS scores for each injection pairing. There were no differences if $P < .01$ was judged as significant due to repeated measurements; however, the GG-VA pairing in group 1 did show a trend favoring VA as less painful ($P < .03$). We then analyzed these data using multiple regression analysis to determine the relationship between mean VAS scores and the three injection techniques. We found no statistically significant difference among the techniques using this analysis (Table 2).

We performed a stepwise regression analysis to determine which variables would significantly predict the VAS score (Table 3). This showed that among the factors analyzed, only $N_2O:O_2$ and injection order had a significant predictive effect. The

> **There were no significant differences in pain among the techniques.**

use of injection order as a predictive variable was highly significant ($P < .005$). Other factors, such as GG, SB, VA, sex and side of injection (left or right), were not significantly predictive.

The effect of $N_2O:O_2$ on injection pain is shown in Figure 3 (page 875). When we analyzed all of the techniques together, we found that $N_2O:O_2$ had a significant effect on reducing pain on injection ($P < .05$).

As we stated earlier, the first injection was significantly less painful than the second ($P < .005$). Figure 4 (page 875) shows that the mean VAS score for the first injection was significantly less than that for the second injection only when the subject received $N_2O:O_2$.

## DISCUSSION

There have been few studies reported in the literature comparing pain from anesthetic injection using the SB, GG and VA techniques. One report was an uncontrolled pilot study of 90 subjects who underwent tooth extraction after

**TABLE 3**

## REGRESSION ANALYSES: ADDITIONAL VARIABLES.

| FACTOR | ADDITIONAL VARIABLES | | |
|---|---|---|---|
| **Stepwise Regression: VAS Versus GG, SB, VA, Sex, $N_2O:O_2$, Side of Injection (Left/Right), Injection Order.*†‡** | | | |
| **Step** | **1** | **2** | **3** |
| Injection order | 12.5 | 12.5 | 12.5 |
| $t$ | 3.08 | 3.13 | 3.15 |
| $P$ value | .003§ | .002 | .002 |
| $N_2O:O_2$ | −8.6 | −9.1 | NA¶ |
| $t$ | −2.16 | −2.28 | NA |
| $P$ value | .033§ | .025 | NA |
| Sex | 6.6 | NA | NA |
| $t$ | 1.61 | NA | NA |
| $P$ value | .109 | NA | NA |

| **Multiple Regression Analysis** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Predictor** | **VAS Versus GG, SB, VA, $N_2O:O_2$, Injection Order#** | | | | **VAS Versus GG, SB, VA, Injection Order for Group 2 Only**** | | | |
| | **Coefficient** | **Standard Error Coefficient** | **$t$** | **$P$ Value** | **Coefficient** | **Standard Error Coefficient** | **$t$** | **$P$ Value** |
| Constant | 25.75 | 9.212 | 2.8 | .006 | 18.15 | 5.447 | 3.33 | .002 |
| GG | 4.975 | 4.924 | 1.01 | .314 | 2.55 | 6.671 | .38 | .704 |
| SB | 2.975 | 4.924 | 0.6 | .547 | 2.5 | 6.671 | 0.37 | .709 |
| $N_2O:O_2$ | −8.633 | 4.02 | −2.15 | .034 | NA | NA | NA | NA |
| Injection order | 12.533 | 4.02 | 3.12 | .002 | 20.2 | 5.447 | 3.71 | < .001 |

| **Analysis of Variance** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Source** | **Degrees of Freedom** | **Sum of Squares** | **Mean Square** | **$F$ Ratio** | **$P$ Value** | **Degrees of Freedom** | **Sum of Squares** | **Mean Square** | **$F$ Ratio** | **$P$ Value** |
| Regression | 4 | 7,449.9 | 1,862.5 | 3.84 | .006 | 3 | 6,205.6 | 2,068.5 | 4.65 | .006 |
| Residual error | 115 | 55,764 | 484.9 | NA | NA | 56 | 24,924.1 | 445.1 | NA | NA |
| **TOTAL** | **119** | **63,214.5** | **NA** | **NA** | **NA** | **59** | **31,129.7** | **NA** | **NA** | **NA** |

\* VAS: Visual analog scale; GG: Gow-Gates; SB: standard block; VA: Vazirani-Akinosi; $N_2O:O_2$: nitrous oxide:oxygen.
† The VA technique is highly correlated with other independent variables and was removed from the equation because the coefficient was not statistically different from zero.
‡ α-to-enter: 0.15; α-to-remove: 0.15; response is VAS on seven predictors, n = 120.
§ $N_2O:O_2$ and injection order both had a significant predictive effect.
¶ NA: Not applicable.
\# VAS = 25.75 + 4.975 GG + 2.975 SB − 8.633 $N_2O:O_2$ + 12.533 injection order.
** VAS = 18.15 + 2.55 GG + 2.5 SB + 20.2 injection order.

receiving anesthetic by one of the three techniques.[6] In that study, subjects filled out a questionnaire at least 15 minutes after surgery and recorded pain on a four-point ordinal scale. The study found no difference in pain associated with the injection among the three techniques. Another study compared the pain experienced from the GG and SB techniques in 10 subjects by observing the subjects' physical responses and oral comments.[7] The authors reported that the GG technique was less painful than the SB technique. To our knowledge, there have been no previously randomized controlled trials in the literature comparing pain experienced with

these three approaches to anesthetic injection.

Our study did not demonstrate any significant differences in pain on injection among the three mandibular block techniques. The GG injection tended to have the highest pain scores, and the VA injection tended to have the lowest; however, these differences were not statistically significant. This study benefited from the use of the VAS, which is widely used in pain studies,[17,18] to assess pain, thus allowing for parametric analysis of the data. The multiple regression analyses showed that none of GG, SB and VA techniques was a predictor for VAS scores, which was consistent with the finding that there was no difference among these techniques (Table 2 and Table 3). Therefore, pain on injection should not be a criterion when selecting a technique to use to bring about mandibular anesthesia.

Our second objective in conducting this study was to assess the effect of $N_2O:O_2$ delivery. Overall, this approach reduced pain experienced on injection. We expected this effect, as $N_2O:O_2$ is used clinically to provide sedation and it is known to have analgesic effects. In this study, we did not assess the pharmacological effect of $N_2O:O_2$ on pain on injection, as that would have required additional control groups. Instead, we assessed the actions of applying a nasal mask and delivering $N_2O:O_2$ to the subjects. Based on this study, however, how much of this pain reduction was because of a placebo effect cannot be known with certainty. Nevertheless, this action did reduce pain caused by a first injection significantly.

The benefit of $N_2O:O_2$ was not seen in the second injection. Linear regression revealed that the injection order showed a strong predictive value on the VAS scores. The first regression equation in Table 3 (VAS versus GG, SB, VA, $N_2O:O_2$, injection order) shows that when the second injection was administered, the predictive variable order would raise the VAS score by 12.533. In group 1, the effect of injection order was not found to be significant, whereas in group 2 this effect was found to be highly significant ($P < .0005$). Figure 4 shows that the large difference between the first and second injections in group 2 is attributed to the lack of pain experienced by subjects in group 2 during the first injection, whereas the other three groups had similar mean scores. These findings also confirm previous reports demonstrating that a second injection can lead to significantly more pain than a first injection.[19,20] One of the speculative reasons for this is that the recent first injection may have heightened the baseline
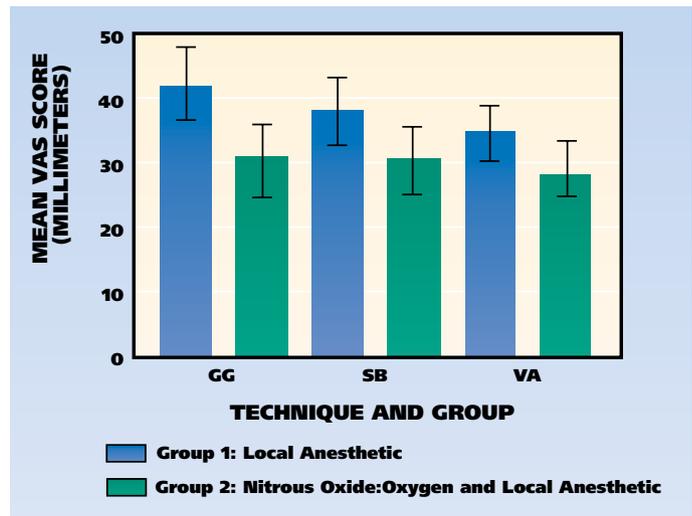


Figure 3. The effect of the administration of nitrous oxide:oxygen, or $N_2O:O_2$, on the mean and standard error of the visual analog scale, or VAS, scores for each injection technique. Overall, administration of $N_2O:O_2$ decreased pain on injection ($P < .05$). GG: Gow-Gates; SB: standard block; VA: Vazirani-Akinosi.
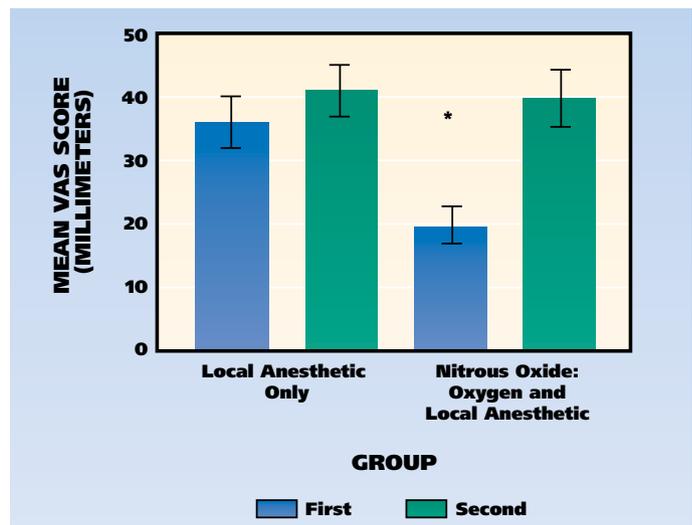


Figure 4. The effect of the injection order on the mean and standard error of the visual analog scale, or VAS, scores. Nitrous oxide:oxygen, or $N_2O:O_2$, administration reduced the pain on the first injection only ($P < .0005$). *$P < .0005$, unpaired Student $t$ test.

anxiety being experienced by the subject. This supports the notion that the best chance of delivering a pain-free injection is at the first administration.[20]

## CONCLUSIONS

We found no difference in pain on injection from the SB, GG or VA mandibular block techniques. A dentist's decision to select one of these techniques should be based on factors other than pain on injection. These factors may include the ability to

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determine the techniques' respective anatomical landmarks, the presence of accessory innervation, the need to anesthetize the buccal nerve, trismus or a marked gag reflex. The administration of $N_2O:O_2$ via a nasal mask reduces the pain associated with these mandibular block techniques when they are the first injection administered. ■

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