ANESTHETIC EFFICACY OF AN UPRIGHT VERSUS A SUPINE POSITION FOR INFERIOR ALVEOLAR NERVE BLOCK

A Thesis

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Abstract

Introduction: Malamed (12) recommends positioning patients upright for anesthetic administration believing it will help improve pulpal anesthetic success. The purpose of this study was to compare anesthetic success in healthy subjects with vital, asymptomatic teeth when an inferior alveolar nerve (IAN) block was given in an upright and supine position.

Materials and Methods: One hundred-ten healthy subjects were given inferior alveolar nerve blocks (IANB) using 2% lidocaine with 1:100,000 epinephrine while in the upright and supine position, at two different appointments, spaced at least two weeks apart. Subjects used a Heft-Parker VAS to report pain of needle insertion, needle placement, and solution deposition. The molars, premolars, and incisors were tested with an electric pulp tester (EPT) every four minutes for fifty-five minutes post-injection. Pulpal anesthesia was considered successful when two consecutive 80/80 EPT readings were recorded within fifteen minutes of the injection, and the 80/80 readings were sustained for 55 minutes.

Results: Injection pain in both upright and supine groups, on average, was reported as mild, except for needle placement, which was reported as moderate. In the upright group, pulpal anesthetic success rates were 65.5% for second molars, 53.6% for first molars, 52.7% for second premolars, 57.3% for first premolars, 22.7% for lateral incisors, and
8.2% for central incisors. In the supine group, success rates were 72.7% in second molars, 59.1% in first molars, 62.7% in second premolars, 75.5% for first premolars, 28.2% for lateral incisors, and 10.9% for central incisors. Pulpal anesthesia was statistically more successful in the supine group (p=0.0009).

**Conclusions:** The supine position was found to be statistically more successful than the upright position. However, the difference may not be big enough to be significant clinically since a large percentage in each group was not numb.
Dedication

To my wife, Kortney-you carried me through school. Thank you for constantly supporting me and taking such good care of me.
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Hannah, Tommy, and Daniel- I will miss you guys so much! I don’t like to get all sappy, but you guys are the best co-residents and friends possible, and I love you all. I feel like we are brothers and sister.
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Introduction

The inferior alveolar nerve (IAN) block is the most frequently used injection technique for achieving local anesthesia for mandibular restorative and surgical procedures. However, the IAN block is not always successful in achieving pulpal anesthesia. Nusstein and coauthors (1) found that failure rates of pulpal anesthesia ranged from 10%-39% when given an IAN block. There have been many attempts to improve the success of the IAN block. For instance, studies have tried increasing the anesthetic volume given (1-6), increasing the amount of the vasoconstrictor epinephrine (7), buffering the anesthetic solution (8), adding hyaluronidase to the anesthetic (9), adding carbonation to the anesthetic (10), and adding a cartridge of 3% mepivacaine plain (11). None of these studies showed a statistical increase in pulpal anesthetic efficacy when compared to 2% lidocaine with 1:100,000 epinephrine.

Malamed (12) recommends placing the patient in an upright or semi-upright position following an inferior alveolar nerve block. Perhaps, the upright position allows more of the anesthetic to diffuse in an inferior direction and expose more nerve area resulting in better anesthesia. However, there has only been one study that has investigated whether or not the upright position is better for anesthetic success when compared to the supine position (97). Within the parameters of their study, they concluded that position of the patient did not have an effect on the success of the
Evidence shows that injecting with low pressures (slow injection rate) significantly reduces pain and anxiety for the patient. One way to give a controlled, slow injection is to use a computer controlled local anesthetic delivery system - Wand (CCLAD – Computer-Controlled Local Anesthetic Delivery system). The Wand can deliver 1.4 mL of anesthetic solution over a time period of 4 minutes and 45 seconds (slow rate). There are also faster rates of delivery available with the Wand (CCLAD). The majority of the literature on the computer delivery system has dealt with the pain of injection with the delivery system compared to standard injections using a syringe (13-38). There is very good evidence that the Wand (CCLAD) decreases the pain of injections and reduces disruptive behavior in children (13-33) - with four studies showing no difference (34-37) and one study showing higher pain ratings (38) with the computer-assisted injection system. The use of the Wand (CCLAD) in the current study standardized the rate of injection for the operator and attempted to decrease the pain of solution deposition overall.

Further studies are needed to objectively evaluate position for an inferior alveolar nerve block. Therefore, the purpose of this prospective, randomized study was to compare the degree of pulpal anesthesia obtained with placing the patient in an upright or supine position for an inferior alveolar nerve block, while additionally studying the injection pain of the IAN block using the Wand (CCL
Materials and Methods

Adult subjects who were in good health and not taking any medications that would alter their perception of pain participated in this study. The Ohio State University Human Subjects Review Committee approved the study and written informed consent was obtained from each subject.

In a crossover design, the blinded subjects randomly received either an IAN block using 3.2 mL of 2% lidocaine with 1:100,000 epinephrine (Xylocaine, Dentsply Pharmaceutical, York, PA) with the subject in a supine position or with the subject in an upright sitting position, at two separate appointments, spaced at least two weeks apart. With the crossover design, there were 220 IAN blocks administered and each subject served as his or her own control. An equal number of IAN blocks were administered on the right side and the left side. The same side randomly chosen for the first IAN block was used again for the second IAN block. The test teeth chosen for the experiment were the first and second molars, first and second premolars, and central and lateral incisors. The contralateral canine was used as the unanesthetized control to ensure that the pulp tester was operating properly and that the subject was responding appropriately during each experimental portion of the study. Clinical examinations indicated that all teeth were free of caries, large restorations, and periodontal disease. None of the teeth had histories of trauma or sensitivity.
Before the experiment, the two positions for the IAN blocks were randomly assigned six-digit numbers from a random number table (random.org). Each subject was randomly assigned to one of the two positions for the IAN blocks to determine which would be administered at each appointment. Only the random numbers were recorded on the data collection sheets to help blind the experiment.

At the beginning of each appointment and before any injections were given, the experimental teeth and control contralateral canine were tested three times with an electric pulp tester (Kerr, Analytic Technology Corp., Redmond, WA) to record baseline vitality. After the tooth to be tested was isolated with cotton rolls and dried with gauze, toothpaste was applied to the probe tip, which was placed midway between the gingival margin and the occlusal or incisal edge of the tooth. The current rate was set at 25 seconds to increase from no output (0) to the maximum output (80). The number associated with the initial sensation was recorded. Trained research personnel performed all pre-injection and post-injection tests.

Before the injection, each subject was informed of the pain rating for injection pain and shown the visual analog scale (VAS). A Heft-Parker VAS (39) was used in this study. Immediately after each IAN block, each subject rated the pain for needle insertion, needle placement and solution deposition on the VAS. The VAS is a 170 mm line with various descriptive terms. The subjects placed a mark on the scale where it best described their pain level. To interpret the data, the VAS was divided into the following four categories. No pain corresponded to 0 mm on the scale. Mild pain was defined as greater than 0 mm and less than or equal to 54 mm. Mild pain included the descriptors of
“faint”, “weak”, and “mild” pain. Moderate pain was defined as greater than 54 mm and less than 114 mm. The descriptor term was “moderate”. Severe pain was defined as equal to or greater than 114 mm. Severe pain included the descriptors of “strong”, “intense” and “maximum possible”.

The IAN block was administered with the subject in two positions – upright or supine. The upright position was defined as the position where the subjects’ mandibular occlusal plane was parallel to the floor when the mouth was in an open position. The back of the chair was set to about a 75° angle to the floor, as measured with a protractor with a weighted string hanging from it. The injection was administered by the operator standing up. The supine position was defined as the position where the subject was reclined so that their feet were slightly higher than their head and their body was parallel with the floor. The injection was administered by the operator sitting down. The operator (CC) practiced giving IAN block injections to patients sitting in an upright position for about four weeks previous to the commencement of this study, in order to get accustomed to both positions.

Before each injection, topical anesthetic gel (20% benzocaine, Patterson Dental Supply, Inc., St. Paul, MN) was passively placed with a cotton tip applicator for 60 seconds at the injection site. A standard IAN block injection (40) was administered with the Wand (CCLAD, Milestone Scientific, NJ) and a 27-gauge 1¼ inch needle (Sherwood Medical Co., St. Louis, MO). The needle was attached to the end of the sterile plastic Wand tubing. A cartridge of the anesthetic solution was placed into the unit’s handpiece assembly and this was placed into the cartridge holder with a quarter
turn in a counter clockwise direction. By depressing the foot pedal, the Wand automatically initiates a priming cycle, removing air from the tubing.

For the injection, the 27-gauge 1¼-inch needle was inserted through the mucosal tissue (needle insertion phase). The computer-assisted injection system was activated at a slow rate, by partially depressing the foot pedal, for 3 seconds. By removing the foot from the foot pedal, the computer-assisted injection system unit was activated to cruise control (continuous flow of anesthetic solution at the slow rate). One chime from the computer-assisted injection system corresponded to one second, allowing audible monitoring of the elapsed injection time. The primary investigator then slowly placed the needle to the target site over a 10-second time period (needle placement phase). The anesthetic solution was deposited over a one-minute time period on the slow setting and then the CCLAD was activated to the faster rate and the remaining solution was deposited (solution deposition phase) for a total deposition time of 1 minute and 52 seconds. The needle stayed in place while a research assistant changed the empty anesthetic cartridge for a new one by turning the cartridge holder a quarter turn clockwise, lifting the cartridge holder, replacing the spent anesthetic cartridge, engaging the new anesthetic cartridge, and relocking the cartridge holder onto the unit with a quarter turn counterclockwise. The Wand then went through the priming cycle again and deposited the remaining anesthetic solution from the first cartridge into the pterygomandibular space. The second cartridge (1.4 ml) was then delivered at the faster delivery rate over another 60 seconds of injection time. A total
of 3.2 mL of anesthetic solution was delivered. All injections were administered by one operator (CC).

Following the IAN block, the patient remained in either the supine or upright position until the end of the testing appointment. Each subject was asked if his or her lip/tongue was numb every five minutes for 55 minutes. If profound lip numbness was not recorded within 15 minutes, the block was considered unsuccessful. The subject was then reappointed. This happened once in the upright group and once in the supine group. The subject in the upright group withdrew from the study, while the subject in the supine group was reappointed, started the study over again, and was able to complete the study.

At 5 minutes after the initiation of the IAN block, the first and second molars were pulp tested. At 6 minutes, the first and second premolars were tested. At 7 minutes, the lateral and central incisors were tested. At 8 minutes, the control canine was tested. This cycle of testing was repeated every 4 minutes. At every third cycle the control tooth, the contralateral canine, was tested by a pulp tester with the ground separated from the hand piece to test the reliability of the subject. All testing was stopped at 60 minutes post-injection.

No response from the subject at the maximum output (80/80 reading) of the pulp tester was used as the criterion for pulpal anesthesia. Onset of anesthesia was defined as when a subject first achieved two consecutive 80/80 readings. Anesthesia was considered successful when two consecutive 80/80 readings were obtained within 15 minutes of the injection and the 80/80 reading was continuously sustained for 60 minutes. Anesthesia was also considered successful by a second definition of success; when a
subject achieved two consecutive 80/80 readings at any point during the appointment. Anesthesia was defined as slow onset if the subject achieved two consecutive 80/80 readings after 15 minutes. Anesthesia was considered as short duration if the subject achieved two consecutive 80/80 readings, but then the anesthesia was lost before the end of the testing time. Anesthesia was considered non-continuous if the subject achieved two consecutive 80/80 readings, and then the 80/80 readings discontinued, and then the patient re-achieved two more consecutive 80/80 readings. With a non-directional alpha risk of 0.05 and a power of 95%, a sample size of 110 subjects was required to demonstrate a difference of ± 15% in anesthetic success.

Comparisons between the supine and upright positions for anesthetic success were analyzed using the Cochran-Mantel-Haenszel statistical test. Onset and duration of anesthesia were analyzed using Wilcoxon matched pairs signed-ranks tests. Slow onset, short duration, and non-continuous anesthesia were analyzed non-parametrically using Exact McNemar tests. Incidence of pulpal anesthesia (percentage of 80/80 readings across time) between the two positions were analyzed using Exact McNemar tests which were adjusted using the Step-down Bonferroni method of Holm. Pain ratings for needle insertion, needle placement, and solution deposition were compared between the upright and supine positions using Wilcoxon matched-pairs signed ranks tests, and were adjusted using the Step-down Bonferroni method of Holm. The anesthetic phases of the injection were compared using a repeated-measures ANOVA with Post hoc testing using the Tukey-Kramer procedure. Comparisons were considered significant at p<0.05.
Results

One hundred-ten subjects participated in this study, including fifty-five males and fifty-five females. Their ages ranged from 20 to 36 years old, with a mean age of 25.8 years (Table 1). All subjects were classified as ASA I or II from their medical history.

Average VAS pain ratings for the injection phases are found in Table 2a. The average pain rating for needle insertion was 22.0±19.3 mm in the upright group and 25.1±18.7 mm in the supine group, with no significant difference between the two groups. This fell into the mild category for pain. For needle placement, the average pain rating was 67.5±29.3 mm for upright and 66.5±26.4 mm for the supine group, with no significant difference between the two groups. This fell into the moderate pain category.

For solution deposition, the subjects' average pain rating was 22.9±22.3 mm for upright and 21.7±20.8 mm for supine, landing it in the mild pain category. There was no significant difference between the two groups.

Although there was no difference between groups for injection phase (Table 2a), when comparing the injection phases within the groups, the needle placement phase of the injection was statistically more painful than both the needle insertion phase and solution deposition phase (p<.0001) (Table 2b).

Table 3 summarizes the injection pain ratings for all the subjects in each phase of the injection. Overall, the majority of subjects in both the upright and supine groups
rated pain of needle insertion to be none to mild. Similarly, the majority of subjects in both groups rated the pain of solution deposition to be none to mild. Needle placement, however, was rated as moderate pain by the majority of patients in both the upright and supine groups.

The first definition of anesthetic success in this study was the onset of pulpal anesthesia (two consecutive 80 EPT readings) within fifteen minutes of the injection, and sustained the 80/80 readings for the remainder of the 60-minute testing period. The summary of these findings is found in Table 4 and Figure 1. In the upright group, nine central incisors (8.2%), twenty-five lateral incisors (22.7%), sixty-three first premolars (57.3%), fifty-eight second premolars (52.7%), fifty-nine first molars (53.6%), and seventy-two second molars (65.5%) met this criteria and were classified as successful. In the supine group, twelve central incisors (10.9%), thirty-one lateral incisors (28.2%), eighty-three first premolars (75.5%), sixty-nine second premolars (62.7%), sixty-five first molars (59.1%), and eighty second molars (72.7%) met the criteria and were classified as successful. Using the Cochran-Mantel-Haenszel statistical analysis, there was a statistically significant difference found between the upright and supine groups, with supine being statistically more successful (p=.0009).

The second definition of success was defined as having two consecutive 80 readings with the electronic pulp tester at any time during the 60-minute testing period. The summary of these findings is found in Table 5 and Figure 2. In the upright group, thirty-two central incisors (29.1%), sixty-one lateral incisors (55.5%), one hundred-three first premolars (93.6%), ninety-six second premolars (87.3%), ninety-five first molars
(86.4%), and one hundred-four second molars (94.5%) met this criteria and were considered successful. In the supine group, thirty-three central incisors (30.0%), sixty-six lateral incisors (60.0%), one hundred-three first premolars (93.6%), ninety-six second premolars (87.3%), one hundred-two first molars (92.7%), and one hundred-six second molars (96.4%) met the criteria and were considered successful. This time using the Cochran-Mantel-Haenszel statistical analysis, there was no significant difference in anesthetic success found between the upright and supine positions (p=0.2468).

Figure 3 through Figure 8 show the percentage of teeth with 80/80 EPT readings at different time points during the 60-minute testing period. The premolars were anesthetized, on average, more than molars, and the molars more anesthetized than the incisors. The second molar was more numb than the first molar, the first premolar was more numb than the second premolar, and the lateral incisor was more numb than the central incisor.

The mean onset and duration of anesthesia for each tooth are found in Table 6 and Table 7, respectively. In general, anesthetic onset times were faster in molars and premolars, and slower in the incisors. The second molar had the fastest mean onset time in the upright group at 9.8 minutes, while the central incisor had the slowest mean onset time at 22.9 minutes. The second molar also had the fastest onset time in the supine group at 9.6 minutes, while the central incisor had a mean onset time of 19.1 minutes. However, all teeth had very large ranges and standard deviations.

Even though the lateral incisor had the second lowest rate of anesthetic onset, it had the longest mean duration of anesthesia with an average of 27.2 minutes in the
upright group, and 26.7 minutes in the supine group. However, the standard deviations were very large. The second premolar had on average the shortest anesthetic duration, with only 16.2 minutes in the upright and 13.9 minutes in the supine group; both having large standard deviations. The duration of anesthesia was longest in the incisors, then in the molars, and shortest in the premolars. There were no statistical differences found between the upright and supine groups.

Some teeth were classified into different categories, such as slow onset of anesthesia (two consecutive 80 readings with the EPT after the first fifteen minutes), short duration of anesthesia (pulpal anesthesia was obtained but wore off before the end of the testing period), and non-continuous anesthesia (pulpal anesthesia was obtained initially, then discontinued, and then re-continued before the end of the testing period). Summaries of the prevalence of slow onset, short duration, and non-continuous anesthesia can be found in Table 8 and Figure 11, Table 9 and Figure 12, and Table 10 and Figure 13, respectively. Teeth that fell into these three categories were not considered successful by the first definition of success. There was a higher incidence of slow onset of anesthesia in the incisors than in the premolars or molars, with the central incisor having the highest rate. The central incisor also showed a higher incidence of short duration of anesthesia than the other teeth. The rates for the other teeth were similar. The central incisor also had the highest rate of non-continuous anesthesia, while the other teeth showed similarly low rates. Although not statistically significant, there were lower rates of slow onset, short duration, and non-continuous anesthesia in the supine group than in the upright group.
Discussion

One hundred-ten subjects participated in this study. There were equal numbers of males (n=55) and females (n=55). Some studies have shown that men and women report pain differently (41-44). Perry et al (41) studied pain of injection in maxillary anterior infiltrations in men and women with male and female operators giving the injections. They found there were significantly higher pain ratings when a male operator was giving the injection to a female subject during the solution deposition phase of the injection. Fillingim and coauthors (42) tested pain thresholds in males and females by touching their forearms with a heated thermode. They reported that females had lower pain thresholds than males, and both females and males reported lower pain thresholds when males performed the experiment. Keogh and coauthors (43) found that females reported more pain and were less tolerant of pain than males when their hands were placed in an ice bath for up to two minutes. Liddell and Locker (44) experimented by sending out surveys inquiring about dental anxiety, pain, and feelings during past dental visits. They discovered that females reported higher anxiety than males. Females were also less accepting of and more likely to avoid pain. Since the above evidence shows that gender may have an effect on pain rating, it was decided that subjects should be equally balanced between males and females.

The subjects in the current study were between the ages of 18 and 65 years old
Subjects under 18 years of age cannot legally provide consent, and are considered minors. For this reason, they were excluded from the study. Also, infiltration injections are reportedly more successful in subjects over the age of 65 years, and have a quicker onset as reported by Nordenram (45). Even though the current study is focused on the IAN block and not an infiltration like Nordenram’s (45) study, it was decided that any subject above the age of 65 years was to be excluded.

Injection Pain

Patients rated their pain on a Heft-Parker 170 mm visual analogue scale (VAS). They were instructed before the injection was given on how to use it properly to report their pain. The VAS includes descriptive words such as “faint”, “weak”, “mild”, “moderate”, “strong”, and “intense” to assist in guiding the subjects in reporting their pain levels. The patient could mark his or her pain anywhere along the scale, allowing for a large number of rating possibilities. Heft and Parker (39) concluded that verbal descriptors of the pain are important, and should correspond to the right location on the visual analogue scale, and not necessarily be spaced evenly. Even though subjects' pain ratings tended to group near the verbal descriptors on the VAS (39), it has been shown to be a more accurate and sensitive way to rate subjective pain compared with other methods (46).

Needle Insertion

In this study, the average needle-insertion-phase pain rating was 22.0±19.3 mm for the upright group and 25.1±18.7 mm for the supine group, with no statistical difference between the two groups (Table 2a). It may be difficult to explain why there
would or would not be a difference in needle insertion pain while sitting upright versus lying down supine. Psychological factors may affect subjects in one way or another. Some subjects may psychologically associate lying down with getting a medical or dental procedure done which would increase their anxiety, and may cause them to rate their pain higher. Others, perhaps, are more comfortable lying down supine, and would rate their pain lower.

The overwhelming majority of the subjects reported none to mild pain (upright-90%, supine-88%) (Table 3). Many other studies have found similar results to the current study. Interestingly, close to half of them used 20% topical benzocaine (2, 11, 47-52), and the others did not (5, 8, 53-62). This suggests that topical most likely does not have an effect on decreasing the pain of needle insertion, since the pain ratings were very similar. Nusstein and Beck (63) performed a retrospective study of 1635 injections, 470 of which were given topical anesthetic before the injection, to see if there is a difference in injection pain. Fourteen to twenty-two percent of the patients rated their pain of needle insertion as moderate to severe. They concluded there was no difference between pain ratings with and without topical benzocaine. Even though evidence does not seem to support topical benzocaine decreasing pain of needle insertion for the inferior alveolar nerve block, psychological factors may play a role in decreasing a patient’s perceived pain when topical anesthetic is applied, showing the patient that the provider cares and is doing everything possible to make the patient comfortable (64).

A 27-gauge needle was used for the injections in the current study. This is the most commonly used gauge of needle in dentistry (65). With so many studies using the
27-gauge needle, it was decided that it was the appropriate size needle for this current study. Even though logically it seems that needle size would have an effect on the pain a patient feels, there is evidence showing that needle gauge has no effect on subjects’ perceived pain during dental injections (66-68).

Many studies have shown similar results to the current study, as far as pain on needle insertion. Whitcomb et al (8) had very similar pain ratings reported in their study on buffered and non-buffered lidocaine for inferior alveolar nerve blocks. They found that 40% of their subjects reported no pain, and 55% reported mild pain on needle insertion. In their study, they did not use topical. Similar to the current study, they used a 27-gauge needle. However, they used a different pain scale for the pain ratings. A four point scale was used instead of a 170 mm VAS ((0=no pain, 1=mild pain, 2=moderate pain, 3=severe pain).

In Dunbar et al’s study (53), similar pain-ratings were found amongst their subjects. They studied supplemental intraosseous injections. Forty subjects were given IAN blocks without topical anesthetic and using a 27-gauge needle. Using a 4-point scale (0=no pain, 1=mild pain, 2=moderate pain, 3=severe pain), they rated pain of needle insertion to be 43% no pain, 53% mild pain, and 5% moderate pain.

In Reitz's study (54) of supplemental intraosseous injections, thirty-eight subjects reported 32% no pain, 58% mild pain, and 10% moderate pain on needle insertion of the IAN block. No topical and a 27-gauge needle were used, as well as a 4-point pain scale.

In Willett's study (55) of diphenhydramine as an anesthetic for IAN blocks, thirty subjects rated their pain on a 4-point scale to be 29% no pain, 58% mild pain, 12%
moderate pain, and 1% severe pain upon insertion of the needle. No topical anesthetic and a 27-gauge needle were used. These percentages include the control and treatment groups, but there is no reason to expect a difference in pain ratings with needle insertion since the needle insertion technique was the same for both groups.

In Wolf's study (56) on adding mannitol to lidocaine for IAN blocks, forty subjects were given injections using no topical anesthesia and a 27-gauge needle. Using a 4-point pain scale, the subjects rated their pain to needle insertion to be 31% no pain, 55% mild pain, and 14% moderate pain. These percentages include the control and treatment groups since the needle insertion technique was the same for both groups, like Willett’s (55) study.

In Goodman's study (47) of lidocaine and meperidine for IAN blocks, fifty-two subjects were given 20% topical benzocaine for sixty seconds before getting an IAN block with a 27-gauge needle. The subjects rated their pain of needle insertion using a 170 mm Heft-Parker visual analog scale. Four percent of subjects reported no pain, 84% reported mild pain, 11% reported moderate pain, and 1% of subjects reported severe pain. The mean pain rating on the pain scale was 37.5 mm, which falls into the mild category, similar to this current study, but slightly higher.

In Steinkruger's study (48) on needle bevel orientation in IAN blocks, fifty-one subjects were given 20% topical benzocaine for sixty seconds before getting an injection with a 27-gauge needle. The subjects rated their pain of needle insertion on a 170 mm Heft-Parker visual analog scale. The subjects reported no pain 7.8%, mild pain 84.3%, and moderate pain 7.8%. The mean pain rating on the pain scale was 34 mm, which falls
into the mild category - slightly higher than this current study, but within the same pain category.

Hinkley (57) compared 4% prilocaine with 1:200,000 epinephrine, 2% mepivacaine with 1:20,000 levonordephrin, and 2% lidocaine with 1:100,000 epinephrine. Thirty subjects were given IAN blocks using a 27-gauge needle and no topical anesthetic. A 4-point pain scale was used, and there was no distinction made between needle insertion and placement of the needle. Twenty-one percent of subjects reported no pain, 67% reported mild pain, 11% reported moderate pain, and 1% reported severe pain. These results were similar to our findings (Table 3).

Other studies found slightly higher pain ratings than the current study. Since topical benzocaine and needle-size may not have an effect on needle insertion pain, this could possibly be explained by operator differences. It is also possible that the Wand (CCLAD) is responsible for the lower pain ratings. The Wand will be discussed more later on in this section, but the Wand is different than the traditional syringe. The Wand looks different, and may not be psychologically associated with pain like the traditional syringe for many people.

Other authors have reported pain ratings that were slightly higher than the current study. In Vreeland et al.’s study (2) of different volumes and concentrations of lidocaine, thirty subjects rated 63.3% none to mild pain, 31.1% moderate pain, and 5.5% severe pain. Twenty percent topical benzocaine was placed for thirty seconds, and a 27-gauge needle was used. A 3-point pain scale (1= none to mild pain, 2= moderate pain, 3= severe pain) was implemented, and the needle insertion and needle placement phases
were not distinguished.

In Yonchak et al.’s study (5) of unilateral and bilateral IAN blocks, forty subjects rated pain of insertion as no pain 6%, mild pain 49%, moderate pain 40%, and severe pain 5%. No topical anesthetic and a 27-gauge needle was used. A 4-point scale (0=no pain, 1=mild pain, 2=moderate pain, 3=severe pain) was implemented, and no distinction between insertion and placement of the needle was made.

Lammers et al (11) looked at combining mepivacaine and lidocaine in the IANB. One hundred subjects were given injections with a 27-gauge needle after having 20% topical benzocaine applied for sixty seconds. The subjects rated their pain of insertion using a 170 mm Heft-Parker visual analog scale. One percent of subjects reported no pain, 79% reported mild pain, 18% reported moderate pain, and 2% reported severe pain.

In Guglielmo and co-authors’ work (58) about supplemental intraosseous injections, forty subjects rated pain of needle insertion for the IAN block as 7% no pain, 67% mild pain, and 26% moderate pain on a 4-point scale (0=no pain, 1=mild pain, 2=moderate pain, 3=severe pain). No topical anesthetic and a 27-gauge needle were used.

In Childers et al (59) studied the use of supplemental PDL injections. Forty subjects were given IAN blocks with no topical anesthetic and a 27-gauge needle. They rated their pain for the IANB on a 4-point scale (0=no pain, 1=mild pain, 2=moderate pain, 3=severe pain) and reported 25% no pain, 58.75% mild pain, 13.75% moderate pain, and 2.5% severe pain.

In Clark's study (60) of the mylohyoid block in conjunction with the IAN block,
thirty subjects rated their pain on needle insertion to be 28.8% no pain, 53.1% mild pain, 14.4% moderate pain, and 3.8% severe pain on a 4-point scale. No topical anesthetic and a 27-gauge needle were used.

In Simon and co-authors (61) worked on giving the IAN block with a peripheral nerve stimulator, forty-six subjects received IAN blocks using no topical and a 22-gauge needle. Using a 4-point pain scale, the subjects rated the pain of insertion to be 16% no pain, 53% mild, 29% moderate, and 3% severe.

In Mikesell's study (49) comparing articaine and lidocaine in IAN blocks, fifty-seven subjects were given injections after applying 20% topical benzocaine for sixty seconds. A 27-gauge needle was used, and the patients rated their pain of insertion on a 170 mm Heft-Parker visual analog scale. The subjects reported 6% no pain, 65% mild pain, and 29% moderate pain. The mean pain rating on the pain scale was 38.7 mm, which falls into the mild category, similar to this study (Table-3).

In Elmore's study (50) on Oraverse®, ninety subjects were administered IAN blocks after having 20% topical benzocaine applied for 60 seconds. A 27-gauge needle was used and the subjects reported their pain on insertion using a 170 mm Heft-Parker visual analog scale. Sixty-four percent of subjects reported none-to-mild pain, and 36% reported moderate-to-severe pain; the mean pain rating being 44 mm, which still fell into the mild category.

McLean (62) compared 4% prilocaine, 3% mepivacaine, 2% lidocaine for IAN blocks. Thirty subjects were given injections using no topical and a 27-gauge needle. A 4-point scale was used for pain rating, and there was no distinction made between
insertion and placement of the needle. Nine percent of subjects reported no pain, 50% reported mild pain, 34% reported moderate pain, and 7% reported severe pain.

Goldberg et al (51) compared the traditional IANB, the Gow-Gates, and the Vazirani-Akinosi techniques. Forty subjects were given IANB injections using a 27-gauge needle after first applying 20% topical benzocaine for sixty seconds. A 4-point scale was used for pain rating, and there was no distinction made between insertion and placement of the needle. Seventy-seven percent of patients reported none-to-mild pain, and 22% reported moderate pain.

Droll et al (52) studied injection pain of the inferior alveolar nerve block in red-haired versus dark-haired females. Pain ratings were recorded on a 170 mm Heft-Parker VAS. The women with red hair reported mild pain 48% of the time, and moderate pain 52% of the time. The women with dark hair reported 5% no pain, 66% mild pain, and 29% moderate pain. A significant difference was found, with red-haired subjects reporting higher pain than dark-haired subjects (p=0.048). The injection was given following 20% topical benzocaine application for one minute, and using a 27-gauge needle.

Overall, the literature reports a majority of subjects reporting none-to-mild pain for needle insertion. The current study supports this same finding.

**Needle Placement**

The needle placement phase of the injection was statistically more painful than the other phases of the injection (Table 2b). This seems to be a common finding among other studies performed with more pain ratings in the moderate to severe category during
needle placement than during the other phases of the injection (8, 11, 47, 49, 50, 52-56, 58-61, 69). The upright group reported a mean pain rating of 67.5±29.3 mm, and the supine group a mean of 66.5±26.4 mm, with no statistical difference between the two groups. As discussed with needle insertion, needle placement pain may be rated higher or lower while in the upright or supine position because of psychological factors. It could also be affected by the ease or difficulty of access. This makes it difficult to predict whether there would be a difference in pain between the two positions.

The majority of subjects reported moderate pain (upright-68%, supine-70%). The next most common pain rating was mild (upright-22%, supine-24%) (Table 3). This is similar to what other studies have reported, in that they reported mostly mild-to-moderate pain. However, most of the following studies had more pain ratings in the mild category than the current study, and fewer pain ratings in the moderate category. One difference in the current study compared to others is the use of the Wand (CCLAD). Also, the variability in pain ratings could possibly be due to operator differences. It could also be due to the different sample sizes in each study.

The Wand (CCLAD) was used in the current study which expresses a small amount of anesthetic while the needle is advanced. Some other authors injected a small amount of anesthetic while advancing the needle, hoping that it would have an immediate effect on the tissue being penetrated and would decrease the pain of needle advancement (8, 47, 49, 56). However, evidence does not seem to show that this technique helps in decreasing pain of needle placement. Nusstein et al (69) introduced a two-stage IAN block injection in an attempt to decrease the pain of needle placement. Fifty-one subjects
participated in the study, and were given 2.2 ml of 2% lidocaine with 1:100,000 epinephrine. The traditional one-stage IAN block injection was given with 0.4 ml of the solution expressed over a ten-second needle advancement. The rest of the 1.8 ml was expressed over a one-minute period. The two-stage injection was given in the following manner: initial insertion of the needle was to a depth of 2-3 mm and then 0.4 ml of solution was deposited over a one-minute period. After five minutes, the needle was reinserted and fully advanced to the target (IAN). The remaining 1.8 ml of solution was deposited over one minute. The subjects rated their pain using a 170 mm Heft-Parker visual analog scale. The subjects rated their pain of the traditional one-stage injection to be 64.7% mild pain, 33.3% moderate pain, and 2% severe pain for placement of the needle. The mean pain rating for the one-stage injection was 53 mm, which just falls into the mild category. The subjects rated the pain for the two-stage injection to be 27.5% no pain, 51% mild pain, and 21.6% moderate pain for needle placement. The mean pain rating for the two-stage injection was 33 mm, which fell into the mild category. There was no significant difference found between the one-stage and two-stage injection, except for the female subjects, in whom the needle placement with the two-stage injection was statistically less painful.

The two studies with findings most similar to the current study were performed by Elmore et al (50) and Droll et al (52). Elmore's (50) subjects reported 51% none to mild pain and 49% moderate-to-severe pain in the study on Oraverse®. They used a 170 mm Heft-Parker visual analog scale to rate their pain. The mean pain rating was 54.3 mm, which falls into the moderate pain category, similar to this study. No anesthetic was
expressed during advancement of the 27-gauge needle.

Droll et al (52) found that red-haired female patients reported no pain 3% of the time, mild pain 44%, moderate pain 50%, and severe pain 3% of the time, while dark-haired female patients reported no pain 5% of the time, mild pain 53%, and moderate pain 42% of the time. These percentages were lower than this study’s groups (Table 3). The pain ratings were recorded on a 170 mm Heft-Parker VAS. There was no significant difference found between the two groups for this phase of the injection.

As previously mentioned, most other studies have found lower pain ratings than the current study when in the needle placement phase of the IAN block injection. However, it was still the most painful phase of the injection in these other studies. Here is what other authors reported:

Whitcomb et al (8) reported 28% no pain, 50% mild pain, 20% moderate pain, and 2% severe pain on needle placement when subjects were given IAN blocks in the study of buffered and non-buffered lidocaine. One-fifth ml of solution was expressed during advancement of the 27-gauge needle, and a 4-point scale was used for pain rating.

Lammers et al (11) reported 62% none-to-mild pain, 36% moderate pain, and 2% severe pain on needle placement in the study of mepivacaine and lidocaine for IAN blocks. A 170 mm Heft-Parker visual analog scale was used for pain rating, and no solution was expressed during advancement. The mean pain rating was 57.1 mm, which falls into the moderate category, similar to this study.

Dunbar and co-authors (53) reported 14% no pain, 63% mild pain, 23% moderate pain, and 1% severe pain on needle placement in the study on supplemental intraosseous
injections in conjunction with the IAN block. A 4-point pain scale was used, and no anesthetic was expressed during advancement of the 27-gauge needle.

Guglielmo et al (58) studied supplemental intraosseous injections, and reported 27% no pain, 51% mild pain, and 22% moderate pain on needle placement for the IAN block. A 4-point pain scale was used, and no anesthetic was expressed during advancement of the 27-gauge needle.

Childers et al (59) studied supplemental periodontal ligament injections in conjunction with the IAN block, and reported no pain 17.5%, mild pain 47.5%, and moderate pain 35% during placement of the needle. The subjects reported pain using a 4-point scale, and no anesthetic was expressed during needle advancement.

Reitz et al (54) reported 40% no pain, 45% mild pain, and 15% moderate pain with needle placement in a study on supplemental intraosseous injections in conjunction with the IAN block. A 4-point scale was used, and no anesthetic was expressed during advancement of the 27-gauge needle.

Clark (60) studied the mylohyoid nerve block in conjunction with the IAN block, and reported 26% no pain, 36% mild pain, 27% moderate pain, and 11% severe pain on placement of the needle. A 4-point pain scale was used, and no anesthetic was expressed during needle advancement.

Willett (55) reported pain ratings of 12.9% for no pain, 42.6% mild pain, 38.6% moderate pain, 5.9% severe pain of needle placement in the study on diphenhydramine in IAN blocks. The subjects used a 4-point scale to rate their pain, and no anesthetic was expressed during advancement of the 27-gauge needle.
Simon et al (61) reported no pain in 11% of subjects, mild pain in 58%, and moderate pain in 32% of subjects on needle placement during a conventional IAN block injection in the study on peripheral nerve stimulators. A 4-point pain scale was used for pain rating, and no anesthetic was expressed during advancement of the needle.

Wolf (56) reported no pain in 30% of subjects, mild pain in 52.5%, and moderate pain in 17.5% of subjects during needle placement of the IAN block injection in the study on mannitol in IAN blocks. One-fifth ml of 2% lidocaine with 1:100,000 epinephrine was expressed during needle advancement, and a 4-point pain scale was implemented.

Mikesell (49) reported mild pain in 40.4%, moderate pain in 54.4%, and severe pain in 5.3% of subjects upon needle placement in the study of articaine and lidocaine for IAN blocks. Subjects rated their pain using a 170 mm Heft-Parker visual analog scale. The mean pain rating was 60.6 mm, which falls into the moderate category, similar to our results (Table 2a). One-fifth ml of 2% lidocaine with 1:100,000 epinephrine was deposited during needle advancement.

Goodman (47) reported 7% no pain, 64% mild pain, 24% moderate pain, and 5% severe pain with needle placement in the study on meperidine and lidocaine for IAN blocks. Subjects rated their pain using a 170 mm Heft-Parker visual analog scale. The mean pain rating was 47.5 mm, which falls into the mild category. One-fifth ml of 2% lidocaine with 1:100,000 epinephrine was deposited during advancement of the needle.

Overall, needle placement pain in the current study was rated slightly higher than most of the other literature. However, the results were similar in that the needle placement phase was the most painful phase of the injection.
Solution Deposition

In the current study, the mean pain rating for solution deposition was 22.9±22.3 mm in the upright group and 21.7±20.8 mm in the supine group, with no difference being found between the groups (Table 2a). As mentioned with needle insertion and needle placement, psychological factors could influence a subject’s pain ratings in different ways between the upright and supine positions, which would make it difficult to predict a difference in pain between the two positions.

The majority of subjects reported the pain ratings as none-to-mild (upright-91%, supine-92%) (Table 3). This is similar to what other studies have found, although, in some studies there were slightly higher pain ratings than the current one.

Several studies have reported results similar to the current study. In Yonchak et al.’s study (5) of unilateral and bilateral IAN blocks, subjects were given injections with 3.6 ml of 2% lidocaine with 1:100,000 epinephrine over two minutes. The subjects rated their pain of solution deposition using a 4-point pain scale; 39.2% of subjects reported no pain, 54.2% reported mild pain, and 7.5% reported moderate pain.

Whitcomb et al (8) gave their subjects IAN blocks with 3.6 ml of 2% lidocaine with 1:100,000 epinephrine, and then gave them the same solution with 0.17 mEq/mL sodium bicarbonate buffering. Both solutions were injected over two minutes, and the subjects rated their pain of solution deposition using a 4-point scale. When subjects were given non-buffered lidocaine, they reported 58% no pain, 35% mild pain, and 8% moderate pain. When given the buffered solution, 72% reported no pain, 25% reported mild pain, and 2% reported moderate pain. No statistical difference was found between
the buffered and non-buffered solutions.

Guglielmo et al.’s (58) subjects reported 58% no pain, 35% mild pain, 6% moderate pain, and 2% severe pain to solution deposition when given IAN blocks. 1.8 ml of 2% lidocaine with 1:100,000 epinephrine was injected over one minute, and a 4-point scale was used for the subjects to rate their pain.

Reitz (54) reported no pain in 82% of subjects, mild pain in 17% of subjects, and moderate pain in 1% of subjects when given IAN blocks. Subjects were administered 1.8 ml of 2% lidocaine with 1:100,000 epinephrine over one minute, and they used a 4-point scale to rate their pain of solution deposition.

When Hinkley's (57) subjects were given 1.8 ml of 2% lidocaine with 1:100,000 epinephrine for the IAN block at a rate of 1.0 ml per minute, they reported their pain of solution deposition to be 56.7% no pain, 33.3% mild pain, and 10% moderate pain. They used a 4-point scale to rate their pain (0= no pain, 1= mild pain, 2= moderate pain, 3= severe pain).

As mentioned previously, other authors have reported higher pain ratings than the current study. Vreeland et al (2) studied three different volumes and concentrations of lidocaine with epinephrine. The subjects were given IAN blocks with each solution at three different appointments, and each injection was given over two minutes, regardless of the volume. The patients rated their pain of solution deposition using a three-point scale (1= none-to-mild pain, 2= moderate pain, 3= severe pain). For the first solution (1.8 ml of 2% lidocaine with 1:100,000 epinephrine), subjects reported 66.7% none to mild pain, 26.7% moderate pain, and 6.7% severe pain. For the second solution (3.6 ml
of 2% lidocaine with 1:200,000 epinephrine), subjects reported 63.3% none to mild pain, 30% moderate pain, and 6.7% severe pain. For the third solution (1.8 ml of 4% lidocaine with 1:100,000 epinephrine), subjects reported 60% none to mild pain, 33.3% moderate pain, and 6.7% severe pain. No statistical difference was found between the deposition of any of the three formulations.

When Lammers et al. (11) administered IAN blocks with 2% lidocaine with 1:100,000 epinephrine, subjects reported 3% no pain, 81% mild pain, and 16% moderate pain. Each subject was given 3.6 ml of the solution in 1.8 ml increments, each over one and a half minutes. The subjects rated their pain of solution deposition using a 170 mm Heft-Parker visual analog scale.

Dunbar and co-authors’ (53) subjects reported their pain of solution deposition to be 34% no pain, 45% mild pain, and 21% moderate pain when given IAN blocks with 1.8 ml of 2% lidocaine with 1:100,000 epinephrine. The solution was injected over two minutes, and the patients used a 4-point scale to rate their pain.

In Childers et al.’s (59) study of supplemental injections, subjects were given IAN blocks with 1.8 ml of 2% lidocaine with 1:100,000 epinephrine over two minutes. Using a 4-point pain scale, subjects reported 35% no pain, 47.5% mild pain, and 17.5% moderate pain to solution deposition.

In Clark's study (60) on mylohyoid nerve blocks in conjunction with the IAN block, subjects were given IAN blocks with 3.6 ml of 2% lidocaine with 1:100,000 epinephrine over two minutes, and asked to report their pain of solution deposition. Using a 4-point pain scale, the subjects reported no pain in 17% of injections, mild pain
in 41%, moderate pain in 27%, and severe pain in 15% of injections.

Willett (55) gave IAN blocks with 1.8 ml of 2% lidocaine with 1:100,000 epinephrine, 1.8 ml of 1% diphenhydramine with 1:100,000 epinephrine, and 3.6 ml of a combination of 1.8 ml of 2% lidocaine with 1:100,000 epinephrine and 1.8 ml of 1% diphenhydramine with 1:100,000 epinephrine. Subjects were asked to rate their pain of solution deposition using a 4-point pain scale. Subjects reported, for the lidocaine solution, 24% no pain, 40% mild pain, 32% moderate pain, and 4% severe pain. For the diphenhydramine solution, subjects reported mild pain 10%, moderate pain 40%, and severe pain 50% of the time. For the combination of lidocaine and diphenhydramine, subjects reported 16% no pain, 28% mild pain, 40% moderate pain, and 16% severe pain. The diphenhydramine solution was found to be significantly more painful than the other two solutions. However, there was no significant difference between the pain of solution deposition of the lidocaine solution and the combination solution of lidocaine and diphenhydramine.

Wolf's study (56) showed 17% no pain, 50% mild pain, 30% moderate pain, and 3% severe pain to solution deposition when his subjects were administered IAN blocks with 1.8 ml of 2% lidocaine with 1:100,000 epinephrine. The solution was deposited over the course of one minute, and the patients rated their pain on a 4-point scale.

In Mikesell's study (49) comparing articaine and lidocaine for the IAN block, subjects were given blocks using 1.8 ml of 2% lidocaine with 1:100,000 epinephrine over one minute. Using a 170 mm Heft-Parker visual analog scale to rate their pain of solution deposition, subjects reported no pain in 9% of injections, mild pain in 72%,
moderate pain in 18%, and severe pain in 2% of injections. The mean pain rating with lidocaine was 31.5 mm, which falls into the mild category, similar to our study.

Goodman's (47) subjects were given IAN blocks with 1.8 ml of 2% lidocaine with 1:100,000 epinephrine or 3.6 ml of 2% lidocaine with 1:100,000 epinephrine plus 36 mg of meperidine. The injections were given over a two-minute period regardless of volume. A 170 mm Heft-Parker visual analog scale was used for the patients to rate their pain of solution deposition. What they found with the lidocaine solution was no pain in 8% of subjects, mild pain in 75%, moderate pain in 12%, and severe pain in 6% of subjects. The mean pain rating with the lidocaine solution was 40.3 mm, which falls into the mild category, similar to this study. With the lidocaine/meperidine solution, no pain was 4%, mild pain was 60%, moderate pain was 25%, and severe pain was 12% . The mean pain rating with this solution was 55.4 mm, which falls into the moderate category. The lidocaine alone was significantly less painful.

Elmore (50) reported none-to-mild pain in 48% of subjects, and moderate-to-severe pain in 52% of subjects when they were given IAN blocks with 1.8 ml of 2% lidocaine with 1:100,000 epinephrine over one minute. Subjects rated their pain of deposition using a 170 mm Heft-Parker visual analog scale. The mean pain rating was 55.9 mm, which fell into the moderate category, and was higher than the current study’s results.

In McLean's study (62), subjects were given IAN blocks using prilocaine, mepivacaine, and lidocaine solutions. When they were administered 1.8 ml of 2% lidocaine with 1:100,000 epinephrine at a rate of 1.0 ml per minute, they reported their
pain of solution deposition to be 33.3% no pain, 36.7% mild pain, 20% moderate pain, and 10% severe pain. A 4-point scale was used for pain rating.

When Goldberg et al.’s (51) subjects were given IAN blocks with 3.6 ml of 2% lidocaine with 1:100,000 epinephrine, they reported no pain 38%, mild pain 48%, and moderate pain 15%. The solution was deposited over two minutes, and a 4-point scale was used.

In Nist et al.’s study (72), subjects used a 4-point scale to rate their pain of solution deposition when administered IAN blocks using 3.5 ml of 2% lidocaine with 1:100,000 epinephrine, and reported no pain 19%, mild pain 56%, moderate pain 23%, and severe pain 2%. The solution was injected over two minutes.

Kashyap et al (74) reported on subjects who were given IAN blocks with 2.5 ml of 2% lidocaine with 1:80,000 epinephrine, they reported 22% no pain, 62% mild pain, and 16% moderate pain. They used a 4-point scale to rate their pain of solution deposition.

Kramp et al.’s (75) subjects were given IAN blocks with 2% mepivacaine with 1:20,000 levonordefrin, 2% lidocaine with 1:100,000 epinephrine, and 4% prilocaine plain for IAN block. They rated their pain of the injection using a 10-point visual analog scale without the different phases of the injection being distinguished. Their mean pain rating was 2.6 out of 10 for the lidocaine solution, which equated to mild pain.

Wahl, Schmitt, and Overton (76) studied the injection pain of 4% prilocaine plain, 3% mepivacaine plain, 4% articaine with 1:100,000 epinephrine, and 2% lidocaine with 1:100,000 epinephrine. The subjects were clinic patients who were getting routine dental
treatment performed. A 10-point scale was used for patients to rate their pain of injection (1=no pain, 10= unbearable pain), with no distinguishing between phases of the injection. Six-hundred-nine subjects reported a mean pain rating of 3.14 out of 10 for the lidocaine solution, which equated to mild pain.

Wahl et al (77) also studied pain of injection between 4% prilocaine plain and 2% lidocaine with 1:100,000 epinephrine. Patients getting routine dental treatment used a 6-point scale (0= no pain, 1= mild, 2= moderate, 3= distressing, 4= horrible, 5= unbearable) to rate their pain of solution deposition, without distinguishing between phases of the injection. The mean pain rating for the IAN block injections was 0.72 for the lidocaine solution, which equates to none or mild pain.

Kanaa and co-authors (78) administered IAN blocks with 2 ml of 2% lidocaine with 1:80,000 epinephrine injected over one minute. The subjects rated their pain of the injection, without distinguishing between the different phases of the injection. Pain rating on the visual analog scale ranged between 7 mm and 81 mm, with the mean being 34.7 mm.

Droll et al (52) compared injection pain between red-haired and dark-haired female subjects. Subjects were given IAN blocks with two full cartridges of 2% lidocaine with 1:100,000 epinephrine. Pain ratings were recorded on a 170 mm Heft-Parker VAS. They found that 37% of red-haired subjects reported mild pain, 48% reported moderate pain, and 15% reported severe pain upon solution deposition. For dark-haired subjects, 47% reported mild pain, 50% reported moderate, and 3% reported severe pain. No significant difference was found between the two groups for this
injection phase.

As mentioned earlier, the current study had lower pain ratings for solution deposition than many other studies. This could potentially be explained by giving a slow injection. Kanaa (71) studied different speeds of injection of the IANB. Subjects were injected with 2 ml of 2% lidocaine with 1:80,000 epinephrine at rates of fifteen seconds and one minute. Subjects used a 100 mm visual analog scale to rate their pain of solution deposition, and reported a range of 0-65 mm for the slower injection; the mean being 20.9 mm. For the faster injection, subjects reported a pain range of 3-73 mm; the mean being 30.5 mm. The faster injection was significantly more painful. The Wand (CCLAD-Computer-Controlled Local Anesthetic Delivery system) was used in the current study in place of the traditional syringe, to help give a slow injection. The Wand (CCLAD) delivers anesthetic at a constant rate. At the slow setting, it delivers 1.4 ml of anesthetic over four minutes and forty-five seconds, and at a faster rate, 1.4 ml over one minute. Solution deposition at a slow rate has shown to reduce pain and anxiety (70, 71), and most research on the Wand (CCLAD) has shown that it can reduce pain compared to a traditional syringe and help with disruptive behavior in children (13-33). The studies that used the Wand to administer inferior alveolar nerve blocks are discussed below:

Nicholson and coauthors (16) studied maxillary infiltrations as well as inferior alveolar nerve blocks using the Wand and a traditional syringe. Each of the thirty subjects was given the injections with both techniques. The subjects rated their pain of injection as well as post-operative pain of the injection site, and then stated their preference between the Wand and traditional syringe. The pain of injection was rated
lower with the Wand, however, it was not statistically lower. The post-operative pain, on the other hand, was significantly lower with the Wand. In general, the subjects’ preference was the Wand. Palm and coauthors (24) studied the Wand and the traditional syringe in children ages 7-18 years of age. Each of the thirty-three young patients needed restorative work on both sides of the mandible, and was given an IAN block on either side. One side of each mandible was anesthetized using the Wand while the other side was anesthetized using a traditional syringe. The sound of the Wand was turned on during both injections and the patients were blindfolded. The patients rated their pain of injection on a ten-point scale, and the Wand was found to be statistically less painful than the syringe. Sumer and coauthors (28) studied the Wand in patients needing extractions. Patients filled out an anxiety scale, and those with an anxiety score higher than 12 would be given IAN blocks with the Wand, while those with less than a 12 on the anxiety scale were given IAN blocks using a traditional syringe. There were twenty-six subjects who received injections with the Wand and twenty-six who were anesthetized using the traditional syringe. The patients receiving the Wand injection reported statistically significantly lower pain rating of needle insertion and pain of injection, even though their anxiety was higher. In both groups, however, the mean pain ratings were in the none-to-mild pain category. Yesilyurt and coauthors (31) compared the Wand to the traditional syringe in forty patients needing mandibular restorative treatment. Each patient had two appointments; one on either side of the mandible, and were randomly given IAN blocks with the syringe or the Wand at the two separate appointments. They found that the Wand was rated statistically significantly lower in pain ratings of the needle insertion and
The question that must be answered is whether the slow injection from the Wand was less painful than the traditional syringe. The average VAS pain ratings in the current study for needle insertion, needle placement, and solution deposition were 22.0 mm in the upright group and 25.1 mm in the supine group, 67.5 mm in the upright group and 66.5 mm in the supine group, and 22.9 mm in the upright group and 21.7 mm in the supine group, respectively. The following studies used a traditional syringe, and their study subjects were asymptomatic and rated their pain using a 170 mm Heft-Parker VAS, similar to the current study:

Lammers et al.’s (11) pain ratings for needle insertion, needle placement, and solution deposition were 43.5 mm, 57.1 mm, and 39.1 mm, respectively, giving a 90-second injection. Goodman (47) gave a two-minute injection, and had pain ratings for needle insertion, needle placement, and solution deposition reported as 37.5 mm, 47.5 mm, and 40.3 mm, respectively. Mikesell (49) gave a 60-second injection, and had reported pain ratings for needle insertion, needle placement, and solution deposition as 38.7 mm, 60.6 mm, and 31.5 mm, respectively. Elmore (50) gave a 60-second injection, and had pain ratings for needle insertion, needle placement, and solution deposition reported as 44 mm, 54.3 mm, and 55.9, respectively. Droll et al (52) gave a 60-second injection, and had pain ratings for needle insertion, needle placement, and solution deposition reported as 59.3 mm in red-haired women and 44.2 mm in dark-haired women, 60.3 mm in red-haired women and 52.5 mm in dark-haired women, and 72.9 mm in red-haired women and 63.7 mm in dark-haired women.
Schellenberg and coauthors (98) studied the pain of injection using the Wand. Different from the current study, their subjects had lower posterior teeth with symptomatic irreversible pulpitis. They compared their pain ratings of needle insertion, needle placement, and solution deposition to other studies similar to theirs that used the traditional syringe. They concluded that the Wand gave a less painful injection.

Using the Wand, the current study showed much lower pain ratings in the needle insertion phase and in the solution deposition phase than any of these other studies. The needle placement phase, on the other hand, was rated higher in the current study than these other comparable studies using the traditional syringe. However, it was not as large of a difference as in the needle insertion and solution deposition phases. Giving an inferior alveolar nerve block with the Wand appears to be less painful overall in the current study when compared with other studies using the traditional syringe since it was superior in two out of the three injection phases.

**Anesthetic Success**

The current study provided two different definitions of success to allow for different interpretations of what anesthetic success means. The first definition of successful anesthesia was having an 80/80 EPT reading within the first fifteen minutes of the injection, and having sustained 80/80 readings for the remainder of the sixty-minute testing period. This is important clinically because dentists want anesthetic onset to occur in a reasonable amount of time, and have duration long enough to complete their procedure. The success rates for each individual tooth are found in Table 4 and Figure 1, and the percentages of each tooth that were numb at different time points during the
appointments are found in Figure 3 through Figure 8. The individual anesthetic success rates for each tooth are as follows: central incisor: upright-8.2%, supine-10.9%, lateral incisor: upright-22.7%, supine-28.2%, first premolar: upright-57.3%, supine-75.5%, second premolar: upright-52.7%, supine-62.7%, first molar: upright-53.6%, supine-59.1%, second molar: upright-65.5%, supine-72.7%. Using the Cochrain-Mantel-Haenszel statistical test, a statistically significant difference was found with supine having a higher anesthetic success rate (p=0.0009). The teeth that were anesthetized the most were the first premolars and the second molars. When one considers the Central Core Theory (79), it makes sense that the second molar would be the most anesthetized. This theory basically says that the external nerve fibers of the nerve bundle running through the mandibular canal split off to innervate the first teeth that it reaches, which would be the molars, and the more internal fibers will proceed forward to innervate the teeth further away. Hence, when anesthetic is given, it would have a shorter distance to diffuse through the bundle in order to anesthetize the molars, and the second molar would be the first tooth innervated by the bundle. This theory would also support why the incisors in the current study had a much lower pulpal anesthetic success rate than the other teeth. Interestingly, the first premolar was more successfully anesthetized than the first molar and second premolar. A reason for this could be that a molar, having three to four root canals on average, requires more nerve fibers to innervate it, and could therefore respond more easily to the EPT if even a small amount of those fibers fail to become anesthetized. A mandibular premolar, on the other hand, usually has only one canal, sometimes two, and would be anesthetized more easily because of the smaller amount of
nerve fibers innervating it. This could explain why the first premolar was more anesthetized than the first molar. This does not explain, however, why the first premolar would be more anesthetized on average than the second premolar. Perhaps, the first premolar does not follow the Central Core Theory. Many other authors, as discussed below, have also reported that the first premolar had a higher anesthetic success rate than the second premolar and/or the first molar (6-8, 10, 11, 47-49, 51, 52, 55, 62, 72, 80).

McLean (62) studied 4% prilocaine, 3% mepivacaine, 2% lidocaine with 1:100,000 epinephrine administered for IAN block. Thirty subjects participated, and success was defined as two consecutive 80 readings with the EPT, and 80 readings sustained throughout the testing period of the fifty minutes. When the patients were given 2% lidocaine with 1:100,000 epinephrine, they found 63% success in first molars, 67% in first premolars, and 30% in lateral incisors. There was no statistical difference between the two groups.

Goldberg et al (51) experimented with the conventional IAN block, Gow-Gates, and Vazirani-Akinosi to compare pulpal anesthesia. Forty subjects participated. When given a conventional IAN block with 3.6 ml 2% lidocaine with 1:100,000 epinephrine, 53% success was found in the first molar, 62% in the first premolar, and 25% in the lateral incisor. Success was defined by two consecutive 80 readings within the first fifteen minutes, and 80 readings sustained for rest of the sixty minutes.

Yared and Dagher (6) performed a study comparing different concentrations of epinephrine and larger amounts of anesthetic for IAN block. Thirty subjects were included in the study and were given 3.6 ml of 2% lidocaine with 1:50,000, 1:80,000, and
1:100,000 epinephrine. Success was defined by two consecutive 80 readings within sixteen minutes of the injection and 80 readings sustained for the rest of the fifty minutes. Seventy-seven percent success was found for the first molar, 80% for the first premolar, and 67% for the lateral incisor. No significant difference was found between the three different concentrations of epinephrine.

Whitcomb et al (8) studied buffered and non-buffered lidocaine for IAN block. Forty subjects were included. Success was defined by two consecutive 80 readings within fifteen minutes of the injection and sustained for sixty minutes. When given 3.6 ml of 2% lidocaine with 1:100,000 epinephrine, 65% of second molars, 58% of first molars, 68% of second premolars, 71% of first premolars, 35% of lateral incisors, and 10% of central incisors were successfully anesthetized.

Lammers et al (11) studied the combination of mepivacaine and lidocaine compared to lidocaine alone in the IAN block. One hundred subjects participated, and success was defined as two consecutive 80 readings with the EPT and sustained for sixty minutes. When given 3.6 ml 2% lidocaine with 1:100,000 epinephrine, patients experienced 56.6% success in second molars, 40.0% in first molars, 40.4% in second premolars, 49.5% in first premolars, 27.0% in lateral incisors, and 10.0% in central incisors.

Chaney et al (10) compared 1.8 ml of 2.2% lidocaine hydrocarbonate with 1:100,000 epinephrine, 2.2% lidocaine hydrocarbonate plain, and 2% lidocaine with 1:100,000 epinephrine in the IAN block. Thirty subjects participated and success was defined as two consecutive 80 readings with the EPT within sixty minutes of the injection.
and sustained for sixty minutes. When 1.8 ml 2% lidocaine with 1:100,000 epinephrine was administered, 57% of first molars, 63% of first premolars, and 43% of lateral incisors were successfully anesthetized.

Nist et al (72) combined the IAN block with incisive nerve blocks and compared it to the IANB alone. Forty subjects were given 3.6 ml 2% lidocaine with 1:100,000 epinephrine, and success was defined as two consecutive 80 readings within fifteen minutes of the injection that were sustained for sixty minutes. There was anesthetic success in 15% of the central incisors, 35% of the lateral incisors, 70% of the first premolars, 52% of the second premolars, 43% of the first molars, and 50% of the second molars.

Mikesell (49) administered IAN blocks with articaine and lidocaine and compared the two. Fifty-seven subjects participated. When given 1.8 ml of 2% lidocaine with 1:100,000 epinephrine, success was found in 48% of the second molars, 32% of the first molars, 29% of the second premolars, 42% of the first premolars, 14% of the lateral incisors, and 2% of the central incisors. Success was defined as two consecutive 80 readings with the EPT and sustained for the rest of the sixty minute appointment time.

Steinkruger (48) studied whether needle bevel orientation in an IAN block was important in achieving pulpal anesthesia. Fifty subjects were given 2.2 ml of 2% lidocaine with 1:100,000 epinephrine with the needle bevel toward the ramus and away from the ramus. Success was defined as two consecutive 80 readings with the EPT within fifteen minutes of the injection and sustained for sixty minutes. Anesthetic success was found to be 90% in second molars, 76% in first molars, 78% in second
premolars, 80% in first premolars, 43% in lateral incisors, and 24% in central incisors when the bevel was oriented away from the ramus, compared with 92% in second molars, 73% in first molars, 78% in second premolars, 73% in first premolars, 33% in lateral incisors, and 14% in central incisors when the bevel was turned towards the ramus.

Fernandez et al (80) compared bupivacaine and lidocaine for the IAN block. Thirty-nine subjects joined the study, and success was defined as two consecutive 80 readings with the EPT within fifteen minutes and sustained for sixty minutes. When given 1.8 ml 2% lidocaine with 1:100,000 epinephrine, 77% of second molars, 54% of first molars, 74% of second premolars, 84% of first premolars, and 54% of lateral incisors were successfully anesthetized.

Goodman (47) added meperidine to lidocaine and compared it to lidocaine alone for the IAN block. Fifty-two subjects were given an IAN block with 1.8 ml 2% lidocaine with 1:100,000 epinephrine. Success was defined as two consecutive 80 readings within fifteen minutes of the injection that were sustained for sixty minutes. The anesthetic success was 58% in second molars, 44% in first molars, 48% in second premolars, 51% in first premolars, 23% in lateral incisors, and 8% in central incisors.

Willett (55) gave diphenhydramine for an IAN block and compared it to lidocaine. Thirty subjects were given 1.8 ml 2% lidocaine with 1:100,000 epinephrine, and success was defined as two consecutive 80 readings within fifteen minutes of the injection that were sustained for sixty minutes. Success was found to be 84% in second molars, 52% in first molars, 52% in second premolars, 68% in first premolars, 36% in lateral incisors, and 12% in central incisor.
Wali et al (7) compared 1.8 ml and 3.6 ml of 2% lidocaine with 1:50,000 to the conventional 1.8 ml of 2% lidocaine with 1:100,000 epinephrine. Thirty subjects were given each of the three anesthetics at different appointments. Anesthetic success was found to be 43% in first molars, 60% in first premolars, and 40% in lateral incisors, and was defined as two consecutive 80 readings within fifteen minutes of the injection and sustained for sixty minutes.

Droll et al (52) compared red-haired female subjects to dark-haired female subjects. Sixty two subjects in each category participated, and each was given an IAN block with 3.6 ml of 2% lidocaine with 1:100,000 epinephrine. Anesthetic success for the red-haired subjects was reported as 39% in the second molar, 25% in the first molar, 21% in the second premolar, 34% in the first premolar, 5% in the lateral incisor, and 0% in the central incisor. Success for the dark-haired females was reported to be 42% for the second molar, 32% for the first molar, 25% for the second premolar, 34% for the first premolar, 7% for the lateral incisor, and 2% for the central incisor. Success was defined as pulpal anesthetic onset within fifteen minutes, and sustained anesthesia for the remainder of the hour-long appointment.

Other studies did not show that the first premolar was more anesthetized than the second premolar or first molar. These studies showed slightly different results than the current study. Hinkley (57) found pulpal anesthetic success in 54% of first molars, 50% of first premolar, and 36% of lateral incisors when administered 1.8 ml 2% lidocaine with 1:100,000 epinephrine. Thirty subjects participated and success was defined as two consecutive 80 readings with the EPT within sixteen minutes, and 80 readings sustained
for the remainder of the fifty minute appointment time.

Dunbar et al (53) studied the supplemental intraosseous injection in conjunction with the IAN block. 1.8 ml 2% lidocaine with 1:100,000 epinephrine was administered to forty subjects. Success was defined as two consecutive 80 readings within fifteen minutes of the injection and sustained for sixty minutes. The anesthetic success of the IANB alone was 42% in the first molar, 45% in the second molar, and 38% in the second premolar.

Childers et al (59) studied the supplemental PDL injection in conjunction with the IAN block. Forty subjects participated, and success was defined as two consecutive 80 readings with the EPT within fifteen minutes and sustained for sixty minutes. One-point-eight ml of 2% lidocaine with 1:100,000 epinephrine was given for the IAN block, and the anesthetic success was found to be 63% in the first molar, 73% in the second molar, and 60% in the second premolar.

Foster et al (81) experimented with buccal and lingual infiltrations of lidocaine as a supplement to the IAN block. Forty-nine subjects were given 3.6 ml 2% lidocaine with 1:100,000 epinephrine, plus real or mock infiltrations. Success was defined as two consecutive 80 readings with an EPT within fifteen minutes and sustained for sixty minutes. The IAN block alone produced 74% success in the second molar, 53% in the first molar, 66% in the second premolar, and 56% in the first premolar.

Simon et al (61) used a peripheral nerve stimulator in an attempt to improve anesthetic success of the IAN block. Forty-six subjects were included in the study, and each were given 1.8 ml of 2% lidocaine with 1:100,000 epinephrine. Success was
defined as two consecutive 80 readings within fifteen minutes of the injection and sustained for sixty minutes. The conventional IAN block produced 45% pulpal anesthetic success in the first molars, 42% in the first premolars, and 32% in the lateral incisors. The peripheral nerve stimulator did not increase the anesthetic success significantly.

Dagher et al (82) compared the difference between 1.8 ml 2% lidocaine with 1:50,000 epinephrine, 1:80,000 epinephrine, and 1:100,000 epinephrine in IAN block injections. Thirty subjects were given each of the three anesthetics, and success was defined as two consecutive 80 readings within sixteen minutes and sustained for fifty minutes. Forty seven percent of the first molars, 43% of the first premolars, and 50% of the lateral incisors were successfully anesthetized with the 1:100,000 epinephrine formulation. No significant difference was found between the three solutions.

Hutchison et al (83) performed an experiment studying frequency-dependent conduction blockade in an attempt to increase anesthetic success in the IAN block. Eighty subjects participated and were administered 1.8 ml of 2% lidocaine with 1:100,000 epinephrine. Success was defined as two consecutive 80 readings with the EPT within fifteen minutes of the injection and sustained for the rest of the sixty-four minute testing period. When electrically stimulated, anesthetic success was 35% in lateral incisors and 48% in first molars. When mock-stimulation was performed, anesthetic success was 18% in lateral incisors and 62% in first molars. There was no significant difference in pulpal anesthesia.

As mentioned previously, there was a statistically significant difference between
the upright and supine groups in the current study, with the supine group having a significantly greater pulpal anesthetic success rate ($p=0.0009$) (Table 4). The greatest differences were found in the premolars, especially the first premolar. This is an interesting finding considering the Central Core Theory previously discussed.

All the injections were given by one operator. There was one missed IAN block in each group. The one subject in whom the block was missed in the upright group exited the study, while the subject in the supine group in whom the block was missed returned and completed the study. Fowler and coauthors (99) studied the incidence of missed IAN blocks in asymptomatic subjects and in subjects with irreversible pulpitis. From 37 different studies, there were 3169 subjects/patients who were analyzed for missed IAN blocks. A missed block was defined as not achieving lip numbness within 15-20 minutes of the administration of the block. Of the subjects, 2450 were asymptomatic and 719 were diagnosed with irreversible pulpitis. Each subject/patient was given a block using either a 1-cartridge volume or 2-cartridge volume of 2% lidocaine with 1:100,000 epinephrine. For the asymptomatic patients, the failure rate for the 1-cartridge volume of anesthetic was 6.3% while the failure rate for the 2-cartridge volume was 3.8%. For the symptomatic irreversible patients, the failure rate for the 1-cartridge volume was 7.7% while the failure rate for the 2-cartridge volume was 2.3%. For both the asymptomatic and symptomatic subjects, the 2-cartridge volume of anesthetic had a statistically lower failure rate.

Perhaps, the statistical difference found between the upright and supine groups can be explained by the operator being more accustomed to giving inferior alveolar nerve
blocks in the supine position. This would likely allow for a more accurate injection with each supine subject, and provide better pulpal anesthesia to the patient. However, lip numbness within fifteen minutes of the injection was a requirement for subjects in both groups, and showed that the injection was given accurately. Also, as mentioned before, there were equal numbers of missed blocks in each group. Either way, the statistical difference between the supine and upright positions found in the current study most likely is not large enough to make a difference, clinically. Both positions achieved comparable pulpal anesthetic success rates to those found by other authors previously mentioned (2,5-7, 10, 11, 48, 49, 51, 53, 54, 56, 57, 59, 60, 62, 72, 71, 78, 80-84). In other words, this study supports the use of the supine position for IAN blocks, but does not have enough support to indicate switching from the upright position if a clinician is more comfortable anesthetizing his or her patients with that technique.

It is also important to point out that even though there was a significant difference in pulpal anesthetic success between the upright and supine positions, there was no difference in the anesthetic failure rate between the two groups. Anesthetic failure was defined in this study as having no two consecutive 80/80 EPT readings during the hour-long appointment. This is in opposition to the second definition of success (Table 5 and Figure 2) with which there was no statistical difference found between the upright and supine groups. The possible reasons why a tooth would meet the criteria for the second definition of success, but not the first, would be if the tooth experienced late onset of anesthesia (onset after 15 minutes post-injection), short duration anesthesia (pulpal anesthesia was discontinued before the end of the appointment), or non-
continuous anesthesia (the tooth came in and out of anesthesia during the appointment). The teeth that fell into these categories were not considered successful by the first definition of success. Statistically, there was no difference found between the upright and supine groups in these three categories. However, considering each tooth individually, the first premolar showed a higher rate of these three behaviors in the upright position. This seems to be a large contributing factor to having a statistical difference in pulpal anesthetic success rates of the upright and supine position, when considering the first definition of success.

Malamed (12) recommends placing the patient in an upright or semi-upright position following an inferior alveolar nerve block in an attempt to improve anesthesia. Perhaps, the upright position allows more of the anesthetic to diffuse in an inferior direction resulting in better pulpal anesthesia. Takasugi and coauthors (97) also investigated whether there is a difference in anesthetic success between sitting a patient upright or laying them down supine. In their study, they investigated a new technique to administer the inferior alveolar nerve block. One-hundred patients needing mandibular molar extractions participated. In order to “estimate the postural effects during the anesthetic procedure”, 53 of the patients were sat upright, and the other 47 patients were laid down. After giving an IAN block with the new technique using 1.8 ml of 2% lidocaine with 1:80,000 epinephrine, the success of the block was confirmed by lip numbness. The new method was an “anterior technique”, where the operator placed the injection in the pterygomandibular space anterior to the mandibular foramen. The authors felt there would be a decrease in the incidence of neural or vascular damage when
compared to the traditional technique. The needle placement was at a steeper angle than the traditional block (approximately 60°) with the syringe end resting over the contralateral first molar, and the needle depth of penetration was 10 mm. After lip numbness was confirmed, a buccal infiltration with the same anesthetic was administered, most likely for soft tissue anesthesia. The authors did not report how much anesthetic was given for the buccal infiltration. The tooth extraction procedure was then commenced. The authors did not report what position the patients stayed in during the extraction procedures. Pain during the extraction was analyzed, and patients were placed into three groups based on their level of anesthesia during the procedure. Grade A patients had complete anesthesia during the procedure. Grade B patients felt slight pain but did not need more anesthesia. Grade C patients had poor anesthesia, and required additional anesthetic. The authors did not report what supplemental anesthesia was given. They also did not report whether the patients rated their pain on a scale to determine what grade they were in, or if the operators decided what grade the patients qualified for. They reported 62% of sitting patients and 66% of supine patients were grade A. For grade B, there was 15% in the sitting group and 9% in the supine group. For grade C, there was 21% in the sitting group and 26% in the supine group. There was no statistical difference found between the two positions.

Even though the patients were given the new technique for the IAN block, both the new technique and traditional technique were given in the pterygomandibular space. It is sensible that both injection techniques could potentially provide similar anesthetic success. The subjects were given buccal infiltrations, most likely for soft tissue
anesthesia for the extraction of the teeth. Foster (81) showed that a buccal or lingual infiltration with 2% lidocaine with 1:100,000 epinephrine did not statistically increase the pulpal anesthetic success rate in the first molar over the IANB alone. Takasugi and coauthors (97) did not take into account important confounding factors, such as the patients’ age, sex, diagnosis of each tooth, or the initial pain of the patient. In addition, no pain during tooth extraction does not prove anesthesia of the pulp. Some of these teeth may have been necrotic and not had vital pulps. The study had 100 subjects; 53 in the sitting group and 47 in the supine group. Even though the population size is not terribly small, the authors did not do a power analysis.

There have been other studies in different areas of medicine on this subject. Nishimura and Ogura (85) studied the effect of gravity on epidural anesthesia in obstetric patients. Twenty patients were split up into four groups and were placed in either a supine position, right decubitus, left decubitus, or sitting position and were given an epidural injection with radionuclide. The position of each patient was maintained for thirty minutes after the initial injection. In order to determine the distribution in the epidural space, a gamma camera was used. The patients in the left decubitus position had a somewhat even distribution of the injected substance. For the patients who were in the right decubitus and supine positions, a right-sided distribution was discovered. For those in the sitting position, there was a caudal pattern in the distribution of the radionuclide, and cephalic spread was limited compared to the other positions. In the study, it appeared that gravity did have an effect on the spread of the injected substance, although the authors did not mention the statistical tests used to analyze their data. Considering
the structure of the epidural space, and knowing it is filled with fluid, it makes sense that gravity might have an effect. The space where anesthetic is deposited for the inferior alveolar nerve block is different than the epidural space. It consists of different tissues that the anesthetic has to diffuse through. Due to this, we can expect gravity to have a different effect on different tissues and areas of the body. Perhaps, gravity did have an effect on the inferior alveolar nerve block in the current study and that is why the supine position had better success. However, the needed effect of gravity would have been different than what was previously thought by Malamed (12) and other practitioners, in that the anesthetic needed to diffuse posteriorly to enter the mandibular foramen in order to cause anesthesia, instead of in the inferior direction.

Some other things to consider are the densities and specific gravities of the injected substances. Density is defined as the ratio of the weight of a substance compared to its volume. The specific gravity is defined as the ratio of the density of a substance compared to the density of water (water has a specific gravity of 1.00). The density and specific gravity of the anesthetic would have to be greater than the fluid in the tissues (mostly water, or in the spinal cord, cerebral spinal fluid) in order to flow downward. If the specific gravity of lidocaine is less than that of water, the anesthetic would most likely show an upward diffusion trend, because the heavier water molecules would “sink” lower while pushing the anesthetic particles upward. We see this effect when a cup of water and oil are mixed; the oil floats to the top and the water sinks to the bottom. Horlocker and Wedel (86), in their study on density, specific gravity, and boracity of different spinal anesthetics, reported that with increasing temperature, there is a decrease
in density of both local anesthetics and cerebral spinal fluid in a “curvilinear” fashion. 
Unless warmed, local anesthetics in dentistry are injected at room temperature, and 
experience a slight decrease in density as their temperature is raised to body temperature. 
Horlocker and Wedel (86) reported that, at body temperature (about 37º C), 2% lidocaine 
has a specific gravity of $1.0056 \pm 0.0001$, while water has a specific gravity of $1.0000$. 
This would allow gravity to have a downward pull on the lidocaine molecules.

Norris and Dewan (87) studied extradural anesthesia in pregnant patients 
undergoing elective caesarean section procedures. Fifty ASA Class I and II patients 
participated; twenty-five of the patients were anesthetized in a supine position, and the 
other twenty-five patients at a thirty-to-forty degree “head-up” position. The age, weight, 
and height of the patients did not differ statistically between the two groups. Twenty-three 
ml of 3% 2-chloroprocaine was given between the L2-3 or L3-4 lumbar vertebrae for 
anesthesia using a standard technique. The patients were pin-pricked at five-minute 
intervals to assure sacral blockade, and more anesthetic was administered at twenty 
minutes if needed. At the thirty minute mark, fifteen of the supine patients and nineteen 
of the upright patients had reached sufficient anesthesia to pinprick at the S4-S5 
dermatome. By forty minutes, all patients achieved sufficient anesthesia for skin incision 
at the level of the S4-S5 dermatome. At twenty minutes, the cephalic spread of 
anesthesia was significantly greater in the supine group, but by thirty minutes the two 
groups had similar cephalic spread. In each group, five patients required the additional 
anesthetic to achieve successful blockade. There were no statistically significant 
differences found between the two groups.
Tamura and coauthors (88) studied intrahepatic perfusion in patients with metastatic carcinoma of the liver when placed in the decubitus positions or in the upright position in order to determine the effect of gravity. Twenty-seven patients were enrolled in the study, and had port-catheter systems implanted for hepatic arterial infusion chemotherapy. Technitium-99m-labeled macroaggregated albumin (Tc-99m-MAA) was injected into the liver through the port-catheter system on the third post-implantation day with the patients in an upright position. The injections were then repeated on the seventh post-implantation day with the patients in the decubitus positions. Using fused images from single-photon-emission computed tomography and computed tomography, the anteroposterior perfusion ratios as well as superoinferior perfusion ratios were measured and compared. The images were also observed visually. There was no statistical difference found in the anteroposterior or superoinferior perfusion ratios between the decubitus and upright positions. When analyzed visually, there was a difference in intrahepatic perfusion between the upright and decubitus positions in thirteen of the twenty-seven patients. However, there seemed to be a correlation between having a difference in intrahepatic perfusion between the two positions and the location of the implanted port-catheter system. Overall, they concluded that gravity did not make a difference in perfusion.

The second definition of success in the current study was having two consecutive 80/80 EPT readings at any time during the testing period. Clinically, this definition is not very relevant, because it is not known if anesthesia occurs at other times over the 60 minutes. However, technically, pulpal anesthesia was obtained, albeit, for a short period
of time. The success rates for this definition of pulpal anesthesia are found in Table 5 and Figure 2, and are as follows: central incisor: upright-29.1%, supine-30.0%, lateral incisor: upright-55.5%, supine-60.0%, first premolar: upright-93.6%, supine-93.6%, second premolar: upright-87.3%, supine-87.3%, first molar: upright-86.4%, supine-92.7%, second molar: upright-94.5%, supine-96.4%. Using the same Cochran-Mantel-Haenszel statistical test, there was no difference found between the upright and supine groups for pulpal anesthetic success. Every subject obtained lip numbness, confirming that the inferior alveolar nerve was blocked with the anesthetic for soft tissue anesthesia. Otherwise, they were dismissed. It can be assumed that the subjects would obtain some degree of pulpal anesthesia if the inferior alveolar nerve was in fact anesthetized. In addition, as discussed earlier, the space where the IAN block is given is not like the epidural space where fluids can flow freely. It makes more sense that gravity would not have the same effect in the inferior alveolar nerve space as it does in the epidural space. It has also been shown by Hannan and coauthors (84) that using ultrasound to locate the inferior alveolar nerve does not increase the success of the IAN block. There is additional evidence that even when placed accurately near the mandibular foramen, the IANB may not be successful (100-102). Galbreath and coauthors (100) used Renografin-60 to trace the path of anesthetic when it was given as an IANB. Renografin-60 was a radiopaque solution used in urography and angiography. They gave a total of 55 IANB injections using 0.9 cc of 2% lidocaine with 1:100,000 epinephrine and 0.9 cc of the radiopaque solution to oral surgery patients who needed mandibular extractions. The patients were in an upright sitting position. Patients needing molar extractions were also
given long buccal anesthesia for soft tissue without the radiopaque solution. To assure accurate injection, they took lateral and anteroposterior cephalograms with the anesthetic syringe and needle held in place with a stabilizer. After the cephalograms were taken, tracings were made of the mandible and of the radiopaque solution to observe the path of the anesthetic. They found that in 46% of the injections, the Renografin-60 had a posterior migration pattern, even though the patients were sitting upright. They also found an anterior migration pattern in 15% of patients. They discovered that the solution migrated in every direction, and was different in each patient. They reported a 5.5% rate of missed IAN blocks. A missed block was defined as no lip or tongue symptoms of anesthesia. Their success rate, being defined by no pain during the extraction procedure, was 52.7%. They concluded that, even with an accurate injection confirmed by radiography, the injected solution most likely followed the path of least resistance. This may have been influenced by the fascial planes and anatomic structures in the pterygomandibular space. Berns and Sadove (101) performed a very similar study to Galbreath (100). They used a similar radiopaque solution called Hypaque, and mixed it with 2% lidocaine with 1:50,000 epinephrine. They gave a total of 66 IANB injections using 2 cc of the mixed solution to patients needing mandibular tooth extractions. There was no mention of the patients’ position during the injection. However, after the injection was given, patients were asked to lay on their side for the lateral cephalogram. Long buccal anesthesia without the radiopaque solutions was administered if it was a molar extraction. They took lateral and anteroposterior cephalograms to confirm accurate placement of the needle. If the needle was not within 1 cm of the mandibular foramen, it
was repositioned. The needle was held in place with a stabilizer. Sixty-one cephalograms were analyzed in total. They found that 33 of the 61 cephalograms (54%) showed a “sigmoid distribution” of the radiopaque solution, where a tail of the solution travelled away from the main body of the deposited solution. They concluded that the tail of solution was most likely escaping out of the pterygomandibular space through certain anatomical structures. The majority of subjects showing this pattern of solution distribution still obtained some degree of anesthesia, but some did not. They also found no correlation between the sigmoid distribution and the placement of the needle (distance from the mandibular foramen) or speed of the injection. They reported an anesthetic failure rate of 4.7% (no lip or tongue numbness) and a success rate of 66.2% (no pain during tooth extraction). They concluded that solution distribution was unpredictable and most likely followed the path of least resistance. As we can see from these studies, evidence suggests that obtaining anesthesia from the IANB is not necessarily dependent on an accurate injection and may be different in each subject.

In general, other authors who used a similar definition of anesthetic success found lower success rates than the current study. This could be attributed to the different subject populations and the number of subjects. As mentioned earlier, the n-value of this study was much larger than the other similar studies. Hannan and co-authors (84) were the only group with comparable success rates. They studied ultrasound-guided needle placement for IAN blocks. Forty subjects were given 1.8 ml of 2% lidocaine with 1:100,000 epinephrine. Success was defined as two consecutive 80 readings in 60 minutes. Anesthetic success for the conventional IAN block was 92% for second molars,
85% for first molars, 90% for second premolars, 90% for first premolars, 65% for lateral incisors, and 38% for central incisors. Anesthetic success using the ultrasound was 92% for second molars, 78% for first molars, 92% for second premolars, 88% for first premolars, 65% for lateral incisors, and 38% for central incisors. They concluded there was no statistical difference. Here are some other studies who reported lower pulpal anesthetic success rates than the current study, with a similar definition of success:

Yonchak et al (5) found pulpal anesthetic success in 39% of central incisors, 50% of lateral incisors, and 68% of canines when given a unilateral IAN block with 3.6 ml of 2% lidocaine with 1:100,000 epinephrine. Forty subjects participated, and success was defined as two consecutive 80 readings during the testing period.

Reitz (54) studied repeated intraosseous injections along with the IAN block. One-point-eight ml of 2% lidocaine with 1:100,000 epinephrine was administered to thirty eight subjects. Success was defined as two consecutive 80 readings anytime during the 120 minute appointment time. The anesthetic success of the IAN block alone was 60% in the second premolars, 71% in the first molars, and 74% in the second molars.

Clark (60) performed a study comparing the IAN block in conjunction with the mylohyoid nerve block to the IAN block alone. Success was defined in this study as two consecutive 80 readings in sixty minutes of testing with the EPT. Three-point-six ml 2% lidocaine with 1:100,000 epinephrine was given for the IAN block. The anesthetic success rate was 87% in the second molar, 73% in the first molar, 90% in the second premolar, 87% in the first premolar, 50% in the lateral incisor, and 33% in the central incisor.
Kanaa et al (78) also studied buccal infiltration with articaine in conjunction with the IAN block. Thirty-six subjects participated and were given 2 ml of 2% lidocaine with 1:80,000 epinephrine. When administered mock infiltrations, anesthetic success was 55.6% in the first molar, 66.7% in the premolars, and 19.4% in the lateral incisors. Success was defined as at least two consecutive 80 readings.

**Anesthetic Onset and Duration**

The onset times for pulpal anesthesia are found in Table 6 and Figure 9. There was no difference in anesthetic onset between the upright and supine groups. Generally, the tooth closest to mandibular foramen was anesthetized first, and then each successive tooth was then anesthetized after its predecessor. The second molar was anesthetized first and the anesthesia continued forward until finally the central incisor obtained pulpal anesthesia. This finding is consistent with the Central Core Theory (79) previously discussed; the anesthetic diffuses through the outer-most neurons in the bundle first, and those neurons split off of the bundle to innervate the closest tooth (the second molar). The successive teeth are later anesthetized when the anesthesia has had proper time to diffuse through to the inner parts of the nerve bundle. The only disruption in this trend was the first molar. On average, it took slightly longer to obtain pulpal anesthesia than the second premolar. Similar to what was discussed earlier, this may be explained by the first molar having a much larger volume of innervation than the smaller premolars, and it may have simply taken longer for the diffusing anesthetic to reach all the nerve fibers innervating the molar. A study performed by Fernandez and coauthors (80) found a similar trend of anesthetic onset, where the onset moved in a forward direction with
exception of the first molar. They reported 6.4 ± 1.09 minutes for anesthetic onset of second molars, 10.7 ± 2.17 for first molars, 8.1 ± 1.12 for second premolars, 7.7 ± 1.16 for first premolars, and 12.0 ± 1.75 minutes for lateral incisors.

The majority of the literature shows a trend of forward-progressing anesthetic onset starting with the second molar and reaching the incisors last. Whitcomb et al (8) reported average anesthetic onset times (in minutes) of 5±6.6 for second molars, 5 ± 6.0 for first molars, 7 ± 7.3 for second premolars, 7 ± 6.7 for first premolars, 11 ± 6.3 for lateral incisors, and 12 ± 9.3 minutes for central incisors. Lammers et al (11) reported (in minutes) 6.0 ± 8.2 for onset of second molars, 7.6 ± 10.0 for first molars, 10.8 ± 11.2 for second premolars, 9.4 ± 8.6 for first premolars, 12.2 ± 10.7 for lateral incisors, and 12.2 minutes for central incisors. Steinkruger (48) reported (in minutes) 5.3 ± 5.6 for anesthetic onset of second molars, 8.8 ± 7.8 for first molars, 10.2 ± 11.5 for second premolars, 11.1 ± 10.0 for first premolars, 17.1 ± 17.6 for lateral incisors, and 19.1 ± 11.1 minutes for central incisors. Hinkley (57) reported 8.8 ± 1.8 minutes for anesthetic onset of first molars, 10.6 ± 1.6 minutes for first premolars, and 12.3 ± 1.9 minutes for lateral incisors. Vreeland et al (2) reported 8.44 ± 1.85 minutes for onset of first molars and 13.20 ± 2.35 minutes for lateral incisors. Kanaa et al (78) reported 6.8 ± 5.8 minutes for anesthetic onset of first molars, 8.9 ± 7.9 minutes for premolars, and 10.9 ± 11.3 minutes for lateral incisors. McLean (62) showed anesthetic onset of 10.8 ± 2.0 minutes for first molars, 11.8 ± 1.9 minutes for first premolars, and 17.2 ± 2.9 minutes for lateral incisors.

Mean anesthetic duration times are found in Table 7 and Figure 10. There was no difference found between the upright and supine groups. On average, the lateral incisor
showed the longest duration, even though it had a lower onset rate than most the other teeth. In other words, if the lateral incisor was anesthetized at all, the anesthesia lasted longer than in the other teeth, on average. The Central Core Theory (79) again could possibly explain the lower rate of anesthetic onset, since the anesthetic would have to diffuse through more layers of the nerve bundle to reach the fibers that innervate the incisors. One explanation for the longer duration of anesthesia could be the smaller amount of innervation to the incisor teeth. Mandibular incisors usually have one canal, sometimes two, and are usually very narrow. Most likely, this means they have fewer nerve fibers that innervate their pulps. In a tooth with a lot of innervating fibers like, for instance, a first molar, there is a greater chance of some fibers losing anesthesia and responding to the EPT or other pulp testing techniques.

**Slow Onset, Short Duration, and Non-continuous Anesthesia**

Table 8 and Figure 11 show the results of the slow onset anesthesia (onset of pulpal anesthesia after 15 minutes). Overall, there was no significant difference found between the upright and supine groups. There was a noticeable difference, however, in the premolars, albeit, not a statistically significant difference. The first premolar showed a rate of 25% in the upright group and 17.6% in the supine group. The second premolar had a rate of 25% in the upright group and 16.5% in the supine group. Even though this was not a statistical difference, it definitely contributed to the lower anesthetic success rate mentioned earlier in the discussion. The current study’s findings are similar to other authors’ with exception of the incisors. The incisors in the current study showed a much higher rate of slow onset anesthesia than other similar studies, discussed below.
Droll et al (52) reported slow anesthetic onset rates of 15-20% in the second molar, 19-27% in the first molar, 24-31% in the second premolar, 27-33% in the first premolar, 26-27% in the lateral incisor, and 4-14% in the central incisor. Mikesell (49) reported a rate of 14% in the second molar, 19% in the first molar, 16% in the second premolar, 23% in the first premolar, 19% in the lateral incisor, and 16% in the central incisor. McLean (62) reported a 13% rate in the first molar, 23% in the first premolar, and 30% in the lateral incisor. Nusstein et al (1) reported 19-22% in the first molar, 19-27% in the first premolar, and 22-27% in the lateral incisor. Hinkley (57) reported an 11% rate in the first molar, 21% rate in the first premolar, and a 14% rate in the lateral incisor. Dagher et al (82) reported a rate of 7-13% in the first molar, 17-27% in the first premolar, and 17-30% in the lateral incisor. Yared and Dagher (6) reported a rate of 7-17% in the first molar, 3-10% in the first premolar, and 3-10% also in the lateral incisor. Vreeland et al (2) reported a rate of 3.3-23.3% in the molars, 6.7-20.0% in the canine, and 13.3-16.7% in the lateral incisor.

Table 9 and Figure 12 show values for short duration anesthesia (discontinuation of anesthesia before the end of the appointment). Overall, there was no statistical difference found between the upright and supine groups. However, again, there was a noticeable difference, this time, only in the first premolar. The rate of short duration anesthesia for the first premolar in the upright group was 18.4%, while in the supine group there was a rate of only 4.9%. There wasn’t a statistical difference between these two values, but this does contribute to difference found in the pulpal anesthetic success rate between the upright and supine groups. The rates of short duration anesthesia for the
teeth in this study seem to be much higher than those reported by similar studies, especially the incisors.

Droll et al (52) reported short duration rates of 3-8% in the second molar, 0-3% in the first molar, 2-7% in the second premolar, 0-7% in the first premolar, 0-10% in the lateral incisor, and 0-2% in the central incisor. McLean (62) reported a rate of 10% in the first molar, 7% in the first premolar, and 0% in the lateral incisor. Nusstein et al (1) reported a rate of 8-12% in the first molar, 6-7% in the first premolar, and 7-8% in the lateral incisor. Hinkley (57) reported a rate of 4% in the first molar and first premolar, and a rate of 0% in the lateral incisor. Dagher et al (82) reported a rate of 10-17% in the first molar, 20-30% in the first premolar, and 17-20% in the lateral incisor. Yared and Dagher (6) reported a rate of 7-17% in the first molar, 10-20% in the first premolar, and 3-10% in the lateral incisor. Vreeland et al (2) reported a rate of 3.3% in the molars, 3.3-6.7% in the canine, and 0-10% in the lateral incisor.

Table 10 and Figure 13 show the rates of non-continuous anesthesia (the teeth that go in and out of anesthesia during the appointment). Overall, there was no statistically significant difference found between the upright and supine groups. However, the first premolar especially, along with some other teeth, showed large enough differences to contribute to the significant difference found in the pulpal anesthetic success rate discussed earlier. The first premolar had non-continuous anesthesia rate of 13.6% in the upright group, and only 3.9% in the supine group. The values in Table 10 were found to be in the range of what other authors have reported.

Droll et al (52) reported a non-continuous anesthetic rate of 16-24% in the second
molar, 8-16% in the first molar, 16-23% in the second premolar, 9-17% in the first premolar, 8-13% in the lateral incisor, and 0-7% in the central incisor. McLean (62) reported a rate of 20% in the first molar, 3% in the first premolar, and 10% in the lateral incisor. Nusstein et al (1) reported a rate of 20% in the first molar, 8-12% in the first premolar, and 13-15% in the lateral incisor. Dagher et al (82) reported a rate of 17-20% in the first molar, 17-27% in the first premolar, and 17-27% in the lateral incisor as well. Yared and Dagher (6) reported a 0% rate in all teeth. Vreeland et al (2) reported a rate of 16.7-20.0% in the molars, 6.7-13.3% in the canine, and 10.0-20.0% in the central incisor.

Overall, there were no statistical differences found in rates of slow onset, short duration, and non-continuous anesthesia between the upright and supine groups. However, the upright group had slightly higher rates of each of these than the supine group. When added all together, they contributed to the lower pulpal anesthetic success rate found in the upright group when considering the first definition of success.
Summary and Conclusions

The purpose of this prospective, randomized study was to compare the degree of pulpal anesthesia obtained with placing the patient in an upright or supine position for an inferior alveolar nerve block, while additionally studying the injection pain of the IAN block using the Wand (CCLAD).

One hundred-ten healthy adult subjects participated in this study (55 males, 55 females). The test teeth selected for the study were the second molar, first molar, second premolar, first premolar, lateral incisor, and central incisor. Before injections were administered, a baseline reading with the EPT for each tooth was obtained to confirm pulp vitality. Subjects were instructed on how to rate their pain of injection at three different phases (needle insertion, needle placement, and solution deposition) using a 170 mm Heft-Parker visual analog scale.

Subjects were then given IAN blocks using 3.2 ml of 2% lidocaine with 1:100,000 epinephrine while in the upright and supine position at two different appointments spaced at least two weeks apart. The molars, premolars, and incisors were tested with an EPT every four minutes for fifty-five minutes post-injection. An EPT reading of 80/80 confirmed anesthesia of the pulp. Pulpal anesthesia was considered successful (first definition) with two consecutive 80/80 EPT readings within fifteen minutes of the injection, and sustained 80/80 readings for the rest of the testing period.
Pulpal anesthesia was also successful (second definition) with two consecutive 80/80 EPT readings at any time during the 60-minute appointment.

Subjects’ pain ratings were in the mild category for all phases of the injection except for needle placement, which was in the moderate pain category. This was similar to what other authors have found. However, lower VAS scores were reported in the needle insertion and solution deposition phases of the current study than in other studies that used the traditional syringe for their injections. It appears that the Wand (CCLAD) may be superior in decreasing pain of injection of the IAN block when compared to the traditional syringe.

By the first definition of success, the supine position had statistically higher rates of pulpal anesthesia (p= 0.0009). However, this was not true for the second definition of success. Even though there was a statistical difference, it most likely is not a big enough difference to be significant clinically since there was a large percentage in both the supine and upright groups that did not get numb.
APPENDIX A

TABLES
<table>
<thead>
<tr>
<th>GENDER</th>
<th>N</th>
<th>Mean Age (yrs)</th>
<th>Std Dev</th>
<th>Minimum Age (yrs)</th>
<th>Maximum Age (yrs)</th>
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<td>TOTAL</td>
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<td>25.8</td>
<td>2.9</td>
<td>20</td>
<td>36</td>
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Table 1: Biographical data for all subjects.
<table>
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<th>Upright (N=110)</th>
<th>Supine (N=110)</th>
<th>p-value*</th>
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<tr>
<td>Needle Insertion</td>
<td>22.0±19.3</td>
<td>25.1±18.7</td>
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<td>Needle Placement</td>
<td>67.5±29.3</td>
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<tr>
<td>Solution Deposition</td>
<td>22.9±22.3</td>
<td>21.7±20.8</td>
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</table>

Table 2: Mean injection pain ratings as measured on a 170 mm VAS (in mm).

*Wilcoxon matched-pairs, signed-ranks test with Step-down Bonferroni method of Holm
<table>
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<tr>
<th>Upright</th>
<th>p-value*</th>
</tr>
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<tr>
<td>Placement</td>
<td>Insertion</td>
</tr>
<tr>
<td>Placement</td>
<td>Deposition</td>
</tr>
<tr>
<td>Insertion</td>
<td>Deposition</td>
</tr>
<tr>
<td>Supine</td>
<td></td>
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<td>Placement</td>
<td>Insertion</td>
</tr>
<tr>
<td>Placement</td>
<td>Deposition</td>
</tr>
<tr>
<td>Insertion</td>
<td>Deposition</td>
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</table>

**Table 3: Within group injection phase pain comparison.**

*ANOVA with Tukey-Kramer p-value adjustment
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<tr>
<th>Phase</th>
<th>None</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Insertion</td>
<td>26 (24%)</td>
<td>73 (66%)</td>
<td>11 (10%)</td>
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<tr>
<td>Placement</td>
<td>2 (2%)</td>
<td>24 (22%)</td>
<td>75 (68%)</td>
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</tr>
<tr>
<td>Deposition</td>
<td>32 (29%)</td>
<td>68 (62%)</td>
<td>10 (9%)</td>
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<tr>
<td>Insertion</td>
<td>18 (16%)</td>
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<td>Placement</td>
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<td>27 (24%)</td>
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<td>Deposition</td>
<td>30 (27%)</td>
<td>71 (65%)</td>
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**Table 4: Categorized injection pain by group.**
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<tr>
<th>Tooth</th>
<th>Count</th>
<th>% Success</th>
<th>Tooth</th>
<th>Count</th>
<th>% Success</th>
<th>p-value*</th>
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<td>Central Incisor</td>
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Table 5: Success 1-defined by EPT reading of 80 by the 15 minute mark, and sustained throughout the rest of the 60 minute testing period.

*Cochran-Mantel-Haenszel Statistical Test
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<thead>
<tr>
<th>Tooth</th>
<th>Count</th>
<th>% Success</th>
<th>Tooth</th>
<th>Count</th>
<th>% Success</th>
<th>p-value*</th>
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<td></td>
<td>Supine (N=110)</td>
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Table 6: Success 2-defined by two consecutive EPT readings of 80 at any time during the 60 minute testing period.

*Cochran-Mantel-Haenszel Statistical Test
<table>
<thead>
<tr>
<th>Tooth</th>
<th>Upright N</th>
<th>Upright Mean</th>
<th>Upright Range</th>
<th>Supine N</th>
<th>Supine Mean</th>
<th>Supine Range</th>
<th>p-value*</th>
<th>p-adj**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Incisor</td>
<td>32</td>
<td>22.9±12.5</td>
<td>7-47</td>
<td>33</td>
<td>19.1±11.6</td>
<td>5-55</td>
<td>0.0626</td>
<td>0.3756</td>
</tr>
<tr>
<td>Lateral Incisor</td>
<td>61</td>
<td>19.8±11.6</td>
<td>7-51</td>
<td>67</td>
<td>18.6±11.9</td>
<td>5-55</td>
<td>0.6288</td>
<td>0.7314</td>
</tr>
<tr>
<td>First Premolar</td>
<td>103</td>
<td>14.1±9.8</td>
<td>5-50</td>
<td>103</td>
<td>12.3±8.9</td>
<td>5-50</td>
<td>0.0925</td>
<td>0.4623</td>
</tr>
<tr>
<td>Second Premolar</td>
<td>96</td>
<td>12.4±8.9</td>
<td>5-54</td>
<td>96</td>
<td>10.8±8.2</td>
<td>5-54</td>
<td>0.1871</td>
<td>0.5967</td>
</tr>
<tr>
<td>First Molar</td>
<td>95</td>
<td>12.7±10.4</td>
<td>5-41</td>
<td>102</td>
<td>12.7±11.1</td>
<td>5-53</td>
<td>0.3657</td>
<td>0.7314</td>
</tr>
<tr>
<td>Second Molar</td>
<td>104</td>
<td>9.8±7.2</td>
<td>5-37</td>
<td>106</td>
<td>9.6±9.1</td>
<td>5-45</td>
<td>0.1492</td>
<td>0.5967</td>
</tr>
</tbody>
</table>

**Table 7: Onset of anesthesia (minutes).**

* Wilcoxon matched-pairs, signed-ranks test
** Step-down Bonferroni method of Holm
<table>
<thead>
<tr>
<th>Tooth</th>
<th>Upright N</th>
<th>Upright Mean</th>
<th>Upright Range</th>
<th>Supine N</th>
<th>Supine Mean</th>
<th>Supine Range</th>
<th>p-value*</th>
<th>p-adj**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Incisor</td>
<td>32</td>
<td>21.7±17.8</td>
<td>4-49</td>
<td>33</td>
<td>23.8±17.0</td>
<td>2-49</td>
<td>0.7352</td>
<td>1.0000</td>
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<tr>
<td>Lateral Incisor</td>
<td>61</td>
<td>27.2±16.9</td>
<td>4-51</td>
<td>67</td>
<td>26.7±18.2</td>
<td>2-59</td>
<td>0.9007</td>
<td>1.0000</td>
</tr>
<tr>
<td>First Premolar</td>
<td>103</td>
<td>19.3±17.6</td>
<td>1-46</td>
<td>103</td>
<td>16.4±17.4</td>
<td>1-48</td>
<td>0.3482</td>
<td>1.0000</td>
</tr>
<tr>
<td>Second Premolar</td>
<td>96</td>
<td>16.2±15.8</td>
<td>1-46</td>
<td>96</td>
<td>13.9±14.8</td>
<td>1-52</td>
<td>0.3685</td>
<td>1.0000</td>
</tr>
<tr>
<td>First Molar</td>
<td>95</td>
<td>23.9±18.9</td>
<td>4-51</td>
<td>102</td>
<td>22.6±19.6</td>
<td>4-55</td>
<td>0.8869</td>
<td>1.0000</td>
</tr>
<tr>
<td>Second Molar</td>
<td>104</td>
<td>21.0±18.6</td>
<td>2-51</td>
<td>106</td>
<td>17.5±18.2</td>
<td>1-51</td>
<td>0.2433</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Table 8: Duration of anesthesia (minutes).

* Wilcoxon matched-pairs, signed-ranks test  
** Step-down Bonferroni method of Holm
<table>
<thead>
<tr>
<th>Tooth</th>
<th>Upright N=110</th>
<th>Supine N=110</th>
<th>RAW_P*</th>
<th>Adj_P**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Incisor</td>
<td>19 (55.9%)</td>
<td>14 (42.2%)</td>
<td>0.2891</td>
<td>1.0000</td>
</tr>
<tr>
<td>Lateral Incisor</td>
<td>29 (47.5%)</td>
<td>28 (40.6%)</td>
<td>0.6291</td>
<td>1.0000</td>
</tr>
<tr>
<td>First Premolar</td>
<td>26 (25%)</td>
<td>18 (17.6%)</td>
<td>0.2863</td>
<td>1.0000</td>
</tr>
<tr>
<td>Second Premolar</td>
<td>24 (25%)</td>
<td>16 (16.5%)</td>
<td>0.1893</td>
<td>1.0000</td>
</tr>
<tr>
<td>First Molar</td>
<td>26 (27.1%)</td>
<td>28 (27.2%)</td>
<td>1.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>Second Molar</td>
<td>17 (16.3%)</td>
<td>16 (14.9%)</td>
<td>0.8318</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

**Table 9: Slow onset.**

* McNemar tests
** Step-down Bonferroni method of Holm
<table>
<thead>
<tr>
<th>Tooth</th>
<th>Upright N=110</th>
<th>Supine N=110</th>
<th>RAW_P*</th>
<th>Adj_P**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Incisor</td>
<td>11 (33.3%)</td>
<td>13 (38.2%)</td>
<td>0.4531</td>
<td>1.0000</td>
</tr>
<tr>
<td>Lateral Incisor</td>
<td>16 (26.2%)</td>
<td>16 (23.5%)</td>
<td>1.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>First Premolar</td>
<td>19 (18.4%)</td>
<td>5 (4.9%)</td>
<td>0.0129</td>
<td>0.0776</td>
</tr>
<tr>
<td>Second Premolar</td>
<td>21 (22.1%)</td>
<td>18 (18.8%)</td>
<td>0.6072</td>
<td>1.0000</td>
</tr>
<tr>
<td>First Molar</td>
<td>17 (17.9%)</td>
<td>20 (19.6%)</td>
<td>0.7905</td>
<td>1.0000</td>
</tr>
<tr>
<td>Second Molar</td>
<td>19 (18.3%)</td>
<td>16 (15.1%)</td>
<td>0.8036</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Table 10: Short duration.

* McNemar tests
** Step-down Bonferroni method of Holm
### Table 11: Non-continuous.

* McNemar tests  
** Step-down Bonferroni method of Holm

<table>
<thead>
<tr>
<th>TOOTH</th>
<th>Upright N=110</th>
<th>Supine N=110</th>
<th>RAW_P*</th>
<th>Adj_P**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Incisor</td>
<td>7 (21.9%)</td>
<td>8 (22.9%)</td>
<td>1.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>Lateral Incisor</td>
<td>11 (18.3%)</td>
<td>9 (13.2%)</td>
<td>1.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>First Premolar</td>
<td>14 (13.6%)</td>
<td>4 (3.9%)</td>
<td>0.0654</td>
<td>0.3926</td>
</tr>
<tr>
<td>Second Premolar</td>
<td>16 (16.7%)</td>
<td>12 (12.5%)</td>
<td>0.2266</td>
<td>1.0000</td>
</tr>
<tr>
<td>First Molar</td>
<td>12 (12.5%)</td>
<td>13 (12.7%)</td>
<td>0.6072</td>
<td>1.0000</td>
</tr>
<tr>
<td>Second Molar</td>
<td>14 (13.5%)</td>
<td>11 (10.4%)</td>
<td>1.0000</td>
<td>1.0000</td>
</tr>
</tbody>
</table>
APPENDIX B

FIGURES
Figure 1: Success 1-defined by EPT reading of 80 by the 15 minute mark, and sustained throughout the rest of the 60 minute testing period –by position and tooth.
Figure 2: Success 2-defined by two consecutive EPT readings of 80 at any time during the 60 minute testing period –by position and tooth.
Figure 3: Percentage of pulpal anesthesia by time (minutes) for central incisor.
Figure 4: Percentage of pulpal anesthesia by time (minutes) for lateral incisor.
Figure 5: Percentage of pulpal anesthesia by time (minutes) for first premolar.
Figure 6: Percentage of pulpal anesthesia by time (minutes) for second premolar.
Figure 7: Percentage of pulpal anesthesia by time (minutes) for first molar.
Figure 8: Percentage of pulpal anesthesia by time (minutes) for second molar.
Figure 9: Mean onset of anesthesia (minutes) by position and tooth.
Figure 10: Mean duration of anesthesia (minutes) by position and tooth.
Figure 11: Percentage of slow anesthetic onset by position and tooth.

<table>
<thead>
<tr>
<th></th>
<th>1M</th>
<th>1P</th>
<th>2M</th>
<th>2P</th>
<th>CI</th>
<th>LI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supine</td>
<td>27.18</td>
<td>17.64</td>
<td>14.95</td>
<td>16.49</td>
<td>42.42</td>
<td>40.58</td>
</tr>
<tr>
<td>Upright</td>
<td>27.08</td>
<td>25</td>
<td>16.34</td>
<td>25</td>
<td>55.88</td>
<td>47.54</td>
</tr>
</tbody>
</table>
Figure 12: Percentage of short anesthetic duration by position and tooth.
Figure 13: Percentage of non-continuous anesthesia by position and tooth.
APPENDIX C

GENERAL CONSENT FORM
The Ohio State University Consent to Participate in Research

Study Title: Upright versus supine position for inferior alveolar nerve blocks

Principal Investigator: Melissa Drum DDS, MS

Sponsor: None

- This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate. Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to participate.

- Your participation is voluntary. You may refuse to participate in this study. If you decide to take part in the study, you may leave the study at any time. No matter what decision you make, there will be no penalty to you and you will not lose any of your usual benefits. Your decision will not affect your future relationship with The Ohio State University. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status.

- You may or may not benefit as a result of participating in this study. Also, as explained below, your participation may result in unintended or harmful effects for you that may be minor or may be serious depending on the nature of the research.

- You will be provided with any new information that develops during the study that may affect your decision whether or not to continue to participate. If you decide to participate, you will be asked to sign this form and will receive a copy of the form. You are being asked to consider participating in this study for the reasons explained below.

1. Why is this study being done?

The purpose of this study is to, by using a common numbing technique, compare numbing success on patients while they are sitting upright or laying down flat.

2. How many people will take part in this study?

One hundred twenty (120) people will take part in this study.

3. What will happen if I take part in this study?
I will receive two injections (shots) using the inferior alveolar nerve block technique (on the inside of the cheek, numbs the lower teeth). The shots will be with lidocaine (numbing solution like “novocaine”), with epinephrine. The lidocaine numbing solution is not experimental. It is a routine anesthetic and has been approved by the FDA for dental use. Prior to the first injection, I will be required to complete a medical history questionnaire. A device called an electric pulp tester will be used to test my teeth for numbness. The electric pulp tester is a battery operated device that delivers a very small amount of current to the tooth resulting in a tingling sensation that might be uncomfortable or cause pain in the tooth being tested and which may last up to one second. It will be used on my teeth before the injections of numbing solutions. Six of my lower teeth as well as a tooth on the opposite side (control tooth) will be tested with the electric pulp tester to be sure that my teeth respond (are alive). This will take about 6 minutes. I will have two appointments spaced at least two weeks apart. I will receive two injections at each appointment. I will receive 2.8 ml (a little less than two anesthetic cartridge) of 2% lidocaine with 1:100,000 epinephrine. The injections will be given using a computer-controlled injection system. The first injection will take about 2 minutes. The second injection will take about one minute. My numb teeth will then be pulp tested every 4 minutes for 60 minutes to determine how well the injections (shots) get my teeth numb. In addition, the electric pulp tester will be used on one of my teeth on the opposite side (where I am not numb). Teeth that are not numb or are being used as a control will experience a tingling sensation or discomfort at which time the device will be removed immediately. I will be asked to rate the amount of pain I feel when the injections are being given. I will do this by marking my pain experience on a line graph with a pen.

4. **How long will I be in the study?**

I am aware that I will have two appointments. Each will last approximately 70 minutes - 10 minutes for baseline pulp testing and filling out health information and receiving the initial injection. My teeth will be pulp tested for a total of 60 minutes.

5. **Can I stop being in the study?**

You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University.

6. **What risks, side effects or discomforts can I expect from being in the study?**

I may have pain associated with the local anesthetic (numbing solution) or soreness at the site of the injections (shots) for approximately two days. Where I receive the injection, I may have swelling (hematoma-a collection of blood in my mouth) or a bruise may develop (1%). I may experience a feeling of anxiety, lightheadedness or fainting (3.2%).
and/or a temporary increase in my heart rate (1%). The tingling sensation and/or slight discomfort (pain) produced by the pulp tester may be uncomfortable to me. I may have an allergic reaction to the local anesthetic (itching or hives, very rare), or have an unexpected gum infection (rare, 1%). I may have soreness of my gum tissue for a few days or a possible altered sensation of my lip (1%) that may last up to a few weeks.

If I am a woman able to have children, I will be questioned regarding pregnancy or suspected pregnancy and will not be allowed to participate if pregnant, suspect a pregnancy, trying to become pregnant, or nursing. Additionally, I will be required to take a urine pregnancy test before I can start this study. If I am a woman, I must also be using a reliable method of contraception (oral contraceptives, condoms, diaphragm, or abstinence) during the next 24 hours. The reason for excluding pregnant or potentially pregnant women is an attempt to minimize this population group in the study because the potential risks to the fetus and nursing baby are unknown. There are no adequate and well-controlled studies of lidocaine in pregnant women. This pregnancy test will be paid for by the study.

7. What benefits can I expect from being in the study?

I will not directly benefit from this study. Society may benefit if the anesthesia (numbing) proves to work better in either the upright or supine position.

8. What other choices do I have if I do not take part in the study?

You may choose not to participate without penalty or loss of benefits to which you are otherwise entitled. No dental treatment will be done, so no other choices are available.

9. Will my study-related information be kept confidential?

Efforts will be made to keep your study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law.

Also, your records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- U.S. Food and Drug Administration;
- The Ohio State University Institutional Review Board or Office of Responsible Research Practices;
You may also be asked to sign a separate Health Insurance Portability and Accountability Act (HIPAA) research authorization form if the study involves the use of your protected health information.

10. What are the costs of taking part in this study?

The study will pay for the cost of the study drugs (lidocaine) and urine pregnancy test. You may need to pay for parking while participating in the study.

11. Will I be paid for taking part in this study?

Yes, I will be paid $70.00 for my participation. I will receive $70.00 for completing all aspects of the study. If I am unable or unwilling to complete both sessions of the study, I will be paid a pro-rated $30.00 per session. After completing the questionnaires, I will personally deliver them to the endodontic clinic front office, at which time I will receive payment for the completed parts of the study for which I have not yet received payment. Payment is to compensate me for time and travel expenses.

By law, payments to subjects are considered taxable income.

12. What happens if I am injured because I took part in this study?

If you suffer an injury from participating in this study, you should notify the researcher or study doctor immediately, who will determine if you should obtain medical treatment at The Ohio State University Medical Center.

The cost for this treatment will be billed to you or your medical or hospital insurance. The Ohio State University has no funds set aside for the payment of health care expenses for this study.

13. What are my rights if I take part in this study?

If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.

You will be provided with any new information that develops during the course of the research that may affect your decision whether or not to continue participation in the study.

You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled.
An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

14. Who can answer my questions about the study?

For questions, concerns, or complaints about the study you may contact Dr. Melissa Drum or Dr. Chase Crowley at (614) 292-5399.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

If you are injured as a result of participating in this study or for questions about a study related injury, you may contact Dr. Melissa Drum or Dr. Chase Crowley at (614) 292-5399.

Signing the consent form

I have read (or someone has read to me) this form and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

---

Printed name of subject

Signature of subject

AM/PM

Date and time

Printed name of person authorized to consent for subject (when applicable)

Signature of person authorized to consent for subject (when applicable)

AM/PM

Relationship to the subject

Date and time
**Investigator/Research Staff**

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

<table>
<thead>
<tr>
<th>Printed name of person obtaining consent</th>
<th>Signature of person obtaining consent</th>
<th>AM/PM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Date and time</td>
</tr>
</tbody>
</table>

**Witness(es) - May be left blank if not required by the IRB**

<table>
<thead>
<tr>
<th>Printed name of witness</th>
<th>Signature of witness</th>
<th>AM/PM</th>
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<tbody>
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<td></td>
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<table>
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<th>Printed name of witness</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Date and time</td>
</tr>
</tbody>
</table>
APPENDIX D

PATIENT PRIVACY FORM
Upright versus supine position for inferior alveolar nerve blocks

OSU Protocol Number:

Principal Investigator: Melissa Drum, DDS, MS

Subject Name__________________________________________________________

Before researchers use or share any health information about you as part of this study, The Ohio State University is required to obtain your authorization. This helps explain to you how this information will be used or shared with others involved in the study.

- The Ohio State University and its hospitals, clinics, health-care providers and researchers are required to protect the privacy of your health information.
- You should have received a Notice of Privacy Practices when you received health care services here. If not, let us know and a copy will be given to you. Please carefully review this information. Ask if you have any questions or do not understand any parts of this notice.
- If you agree to take part in this study your health information will be used and shared with others involved in this study. Also, any new health information about you that comes from tests or other parts of this study will be shared with those involved in this study.
- Health information about you that will be used or shared with others involved in this study may include your research record and any health care records at the Ohio State University. For example, this may include your medical records, x-ray or laboratory results. Psychotherapy notes in your health records (if any) will not, however, be shared or used. Use of these notes requires a separate, signed authorization.

Please read the information carefully before signing this form. Please ask if you have any questions about this authorization, the University’s Notice of Privacy Practices or the study before signing this form.

Initials/Date: ______________
Those Who May Use, Share And Receive Your Information As Part Of This Study

- Researchers and staff at The Ohio State University will use, share and receive your personal health information for this research study. Authorized Ohio State University staff not involved in the study may be aware that you are participating in a research study and have access to your information. If this study is related to your medical care, your study-related information may be placed in your permanent hospital, clinic or physician’s office records.

- Those who oversee the study will have access to your information, including:
  - Members and staff of the Ohio State University’s Institutional Review Boards, including the Western Institutional Review Board
  - The Office for Responsible Research Practices
  - University data safety monitoring committees
  - The Ohio State University Research Foundation

- Your health information may also be shared with federal and state agencies that have oversight of the study or to whom access is required under the law. These may include:
  - The Food and Drug Administration
  - The Office for Human Research Protections
  - The National Institutes of Health
  - The Ohio Department of Job and Family Services

These researchers, companies and/or organization(s) outside of The Ohio State University may also use, share and receive your health information in connection with this study:

- None

The information that is shared with those listed above may no longer be protected by federal privacy rules.

Initials/Date_________
Authorization Period

This authorization will not expire unless you change your mind and revoke it in writing. There is no set date at which your information will be destroyed or no longer used. This is because the information used and created during the study may be analyzed for many years, and it is not possible to know when this will be complete.

Signing the Authorization

- You have the right to refuse to sign this authorization. Your health care outside of the study, payment for your health care, and your health care benefits will not be affected if you choose not to sign this form.
- You will not be able to take part in this study and will not receive any study treatments if you do not sign this form.
- If you sign this authorization, you may change your mind at any time. Researchers may continue to use information collected up until the time that you formally changed your mind. If you change your mind, your authorization must be revoked in writing. To revoke your authorization, please write to:
  Dr. Melissa Drum at the College of Dentistry, 305 W. 12th Avenue, The Ohio State University, Columbus, Ohio 43210
  or Dr. Fonda Robinson at the College of Dentistry, 305 W. 12th Avenue, The Ohio State University, Columbus, Ohio 43210

- Signing this authorization also means that you will not be able to see or copy your study-related information until the study is completed. This includes any portion of your medical records that describes study treatment.

Contacts for Questions

- If you have any questions relating to your privacy rights, please contact Dr. Fonda Robinson at the College of Dentistry, 305 W. 12th Avenue, The Ohio State University, Columbus, Ohio 43210
- If you have any questions relating to the research, please contact Dr. Melissa Drum at the College of Dentistry, 305 W. 12th Avenue, The Ohio State University, Columbus, Ohio 43210

Signature

I have read (or someone has read to me) this form and have been able to ask questions. All of my questions about this form have been answered to my satisfaction. By signing below, I permit Dr. Melissa Drum and the others listed on this form to use and share my personal health information for this study. I will be given a copy of this signed form.

Signature________________________________________________________

(Subject or Legally Authorized Representative)

Name ____________________________________________________________
(Print name above)

(If legal representative, also print relationship to subject.)
Date___________ Time __________ AM / PM
APPENDIX E

MEDICAL HISTORY QUESTIONNAIRE
The Ohio State University
College of Dentistry

Patient Name
Date
Date of Birth

Biographical Data

Chief Complaint (Why is the patient seeking dental care?)

Present Illness (History of Chief Complaint)

MEDICAL HISTORY

1. Do you have or have you had any of the following?
   a. rheumatic fever or rheumatic heart disease...
   b. heart murmur or mitral valve prolapse...
   c. heart disease/heart attack...
   d. artificial heart valve...
   e. irregular heart beat...
   f. pacemaker...
   g. high blood pressure...
   h. chest pains or angina...
   i. stroke...
   j. artificial joint...
   k. hepatitis/liver disease...
   l. tuberculosis (TB)...
   m. thyroid trouble...
   n. kidney disease...
   o. diabetes (sugar)...
   p. asthma...
   q. HIV or other immunosuppressive disease...
   r. radiation or cancer therapy...

2. Do you have or have you had any disease, condition, or problem not listed here?

3. Have you ever been hospitalized?

4. Have you had excessive or prolonged bleeding requiring special treatment?

5. Have you had an allergic reaction to any drugs or medications?
   (Circle all that apply: penicillin; codeine; aspirin; anesthetics; other)

6. Are you currently under the care of a physician (M.D., D.O.)?
   When were you last seen by a physician?
   Name of Physician ___________________________
   Street address _____________________________
   City, State, and Zip Code _____________________
   Phone ____________________________

7. Are you pregnant or nursing? Estimated Date of Delivery...

8. Have you had any trouble associated with previous dental treatment?

9. Do you have any lumps or sores in your mouth now?

10. Do you smoke or use smokeless tobacco?

11. How often do you have dental check ups? _________ Date of last Exam _________
12. Are you currently taking any drugs or medications (such as antibiotics, heart medicine, birth control pills)?

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Generic Name</th>
<th>Dose/Frequency</th>
<th>Reason</th>
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I have reviewed the information I have provided, and to the best of my knowledge it is correct and complete.

Patient/Guardian Signature ____________________________ Date: ______________________

SUMMARY OF PATIENT’S MEDICAL STATUS:

________________________________________________________________________

MEDICAL RISK ASSESSMENT (check one)

☐ ASA I (healthy individual) ☐ ASA III (severe disease but not incapacitating)

☐ ASA II (mild systemic disease) ☐ ASA IV (incapacitating systemic disease, constant threat to life)

MEDICAL CONSULTATION REQUIRED

☐ No (healthy and/or stabilized disease)

☐ Yes (ASA III or IV; cardiac murmur; vague hx; recent major disease; recent diagnosis/operation; uncontrolled disease; blood pressure; etc.)

Does the chief complaint require emergency treatment? _____________________ NO YES

_________________________ Student / L.D.# _______________________________ Instructor / L.D.# _______________________________ Date _____________________
APPENDIX F

INJECTION PAIN FORM (HEFT-PARKER VISUAL ANALOG SCALE)
INJECTION INFORMATION SHEET

Name: _____________________  Patient #: _________

Date: _________  Side: ___

Code #: __________  Injection # 1  or  2

Needle Insertion

1. When advised by the doctor, please place an “X” on the line below to rank the level of pain felt during needle insertion.

   _____________________________________________________________________________

   None       Faint       Weak       Mild       Moderate       Strong       Intense       Maximum
   Possible

Needle Placement

2. When advised by the doctor, please place an “X” on the line below to rank the level of pain felt during needle placement.

   _____________________________________________________________________________

   None       Faint       Weak       Mild       Moderate       Strong       Intense       Maximum
   Possible

Solution Deposition

3. When advised by the doctor, please place an “X” on the line below to rank the level of pain felt during solution deposition.

   _____________________________________________________________________________

   None       Faint       Weak       Mild       Moderate       Strong       Intense       Maximum
   Possible
APPENDIX G

ELECTRIC PULP TESTING FORM
EPT Values

Date:__________  Patient # ________________  Side:_________________

Sex:  M    F  Patient Age: ___________

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<tr>
<th>2nd molar</th>
<th>1st molar</th>
<th>2nd premolar</th>
<th>1st premolar</th>
<th>Lateral incisor</th>
<th>Central incisor</th>
<th>Contra-lateral canine</th>
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<tr>
<td>Min. Pre-test</td>
<td>Min. Pre-test</td>
<td>Base-line</td>
<td>* Indicates tooth will be tested with a mock electrode</td>
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<th>Numbness Lip / Tongue</th>
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References


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