

The Significance of Needle Deflection in Success of the Inferior Alveolar Nerve Block in Patients with Irreversible Pulpitis

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The purpose of this prospective, randomized, blinded study was to compare the anesthetic efficacy of the conventional inferior alveolar nerve block, administered with the needle bevel oriented away from the mandibular ramus, to the bidirectional-needle-rotation technique, administered using the computer-assisted Wand II anesthesia system, in patients diagnosed with irreversible pulpitis. Sixty-four emergency patients diagnosed with irreversible pulpitis of a mandibular posterior tooth randomly received, in a blinded manner, 2.8 ml of 2% lidocaine with 1:100,000 epinephrine using either a conventional inferior alveolar nerve block or a bidirectional-needle-rotational technique using the Wand II injection system. The conventional inferior alveolar nerve block was administered with the needle bevel oriented away from the mandibular ramus so the needle would deflect inward toward the mandibular foramen. The bidirectional-needle-rotation technique was administered by rotating the Wand handpiece assembly in a clockwise-counterclockwise movement (like an endodontic hand file) to minimize needle deflection. Endodontic access was begun 17 min after solution deposition, and all patients were required to have profound lip numbness. Success was defined as none or mild pain (VAS recordings) on endodontic access or initial instrumentation. The results of this study showed no significant differences ($p > 0.05$) between the success rates of the two techniques. The conventional inferior alveolar nerve block, with the needle bevel oriented away from the mandibular ramus, had a 50% success rate. The bidirectional-needle-rotation technique with the Wand II had a 56% success rate. Neither technique resulted in an acceptable rate of anesthetic success in patients with irreversible pulpitis.

The inferior alveolar nerve (IAN) block is the most frequently used mandibular injection technique for achieving local anesthesia for endodontic treatment. However, the IAN block does not always result in successful pulpal anesthesia. Clinical studies in endodontics (1–3) have found failure with the IAN block occurring between 44% and 81% of the time.

Needle deflection has been theorized as a cause for failure with the IAN block (4–6). Various authors (4–9), using in vitro methods, have reported that beveled needles when passed through substances of varying densities will deflect toward the nonbeveled side, that is, the needle will deflect away from the bevel. For the IAN block, Davidson (5) has recommended that the bevel of the needle be placed away from the mandibular ramus. Therefore, on insertion into the tissue, the needle will deflect toward the mandibular ramus and foramen.

Recently, Hochman and Friedman (6) developed a bidirectional-needle-rotation technique designed to reduce needle deflection during needle insertion. The bidirectional technique relies on a pen-like grasp (Fig. 1), which makes it possible to rotate the needle in a back and forth motion—similar to the rotation described for endodontic hand files and acupuncture. The bidirectional technique is only applicable using the Wand handle/needle assembly because the traditional syringe cannot be rotated because of the thumb ring (Fig. 1). Hochman and Friedman (6) found that the bidirectional-needle-rotation technique canceled the force vectors of needle insertion so the needle traveled in a linear path.

The Wand local anesthesia computer-controlled injection system (Fig. 2) accommodates a standard local anesthetic cartridge, which is inserted into a plastic barrel that is linked by sterile microtubing to a disposable, pen-like handpiece with a Leur-Lok needle attached to the end. The device is activated by a foot control, which automates the infusion of local anesthetic solution at a controlled rate. Two flow rates, slow or fast, may be initiated and maintained by the foot-pedal control. The fast rate delivers 1.4 ml of solution in 1 min. The slow rate delivers 1.4 ml of solution in approximately 4 min and 45 s. A beeping noise corresponds to the rate of delivery and the lights on the front of the Wand indicate how much of the anesthetic solution has been delivered. The Wand also has a 5-s auto-aspirating feature, which may be turned on or off.

Although Hochman and Friedman (6) found that in vitro needle deflection was statistically less with the bidirectional-needle-rotation

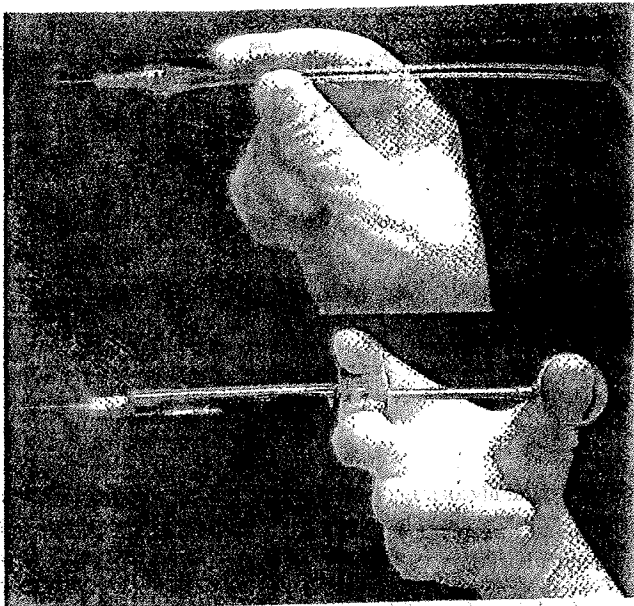


Fig 1. The clockwise-counterclockwise movement of the bidirectional rotation technique is only possible using the handpiece assembly of the Wand (top). The thumb grasp on a traditional syringe does not allow rotation (bottom).

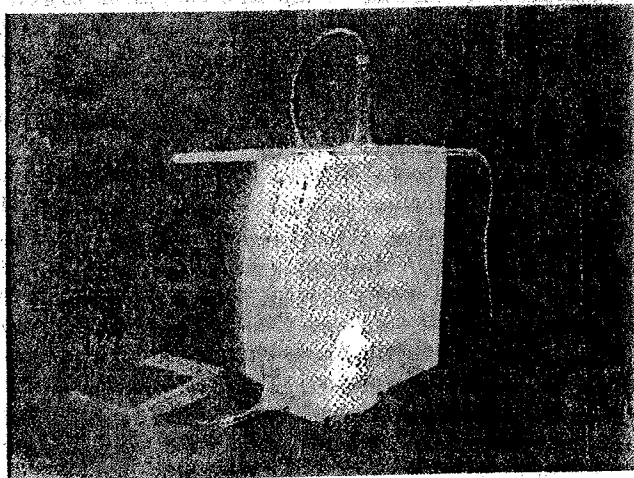


Fig 2. Wand II computer-assisted local anesthetic delivery unit. The Wand handpiece assembly and microtubing also are seen.

tion technique, no clinical study has evaluated the importance of this technique to the success of the IAN block. Therefore, the purpose of this prospective, randomized, blinded study was to compare the anesthetic efficacy of the conventional IAN block, administered with the needle bevel oriented away from the mandibular ramus, to the bidirectional-needle-rotation technique, administered using the computer-assisted Wand II anesthesia system, in patients diagnosed with irreversible pulpitis.

MATERIALS AND METHODS

Sixty-four adult patients participated in this study. All were emergency patients of the College of Dentistry and were in good

Place a mark on the line below to show the amount of pain that you feel.

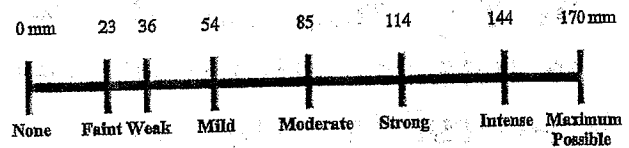


Fig 3. Heft-Parker VAS pain scale used for assessment of pain. The millimeter demarcations were not shown on the patients' VAS scale.

Ohio State University Human Subjects Review Committee approved the study and written informed consent was obtained from each patient.

To qualify for the study, each patient had a vital mandibular posterior tooth (molar or premolar), was actively experiencing pain, and had a prolonged response to cold testing with Endo-ice (1,1,1,2 tetrafluoroethane; Hygenic Corp., Akron, OH). Patients with no response to cold testing or periradicular pathosis (other than a widened periodontal ligament) were excluded from the study. Therefore, each patient had a tooth that fulfilled the criteria for a clinical diagnosis of irreversible pulpitis.

Each patient rated his or her initial pain on a Heft Parker visual analogue scale (10) (Fig. 3). The VAS scale was divided into four categories. None corresponded to 0 mm. 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. Severe pain was defined as greater than or equal to 114 mm. Severe pain included the descriptors of strong, intense, and maximum possible.

The 64 patients randomly received 2.8 ml of 2% lidocaine with 1:100,000 epinephrine using either a conventional IAN block (32 patients) or a bidirectional-rotation-technique using the Wand II computer-assisted anesthesia system (32 patients). Each patient was randomly assigned a four-digit random number to determine which IAN block technique was administered. The senior author administered all injections.

For the conventional IAN block, standard anesthetic cartridges of 2% lidocaine with 1:100,000 epinephrine (Xylocaine with epinephrine, AstraZeneca, Wilmington, DE) were loaded into 5-ml Luer-Lok syringes equipped with aspirating ring assemblies (Becton Dickinson, Rutherford, NJ), and the volume was adjusted to 2.8 ml. A 1.25-inch, 27-gauge needle (Monoject, Sherwood Medical, St. Louis, MO) was attached to the syringe. Before administering the IAN block, the needle bevel was determined by inspection of the needle end using the operatory light. The needle bevel reflected light from its flat surface when it was rotated back and forth. Once the needle bevel was determined, the syringe and aspirating ring assembly were oriented so the needle faced away from the mandibular ramus for needle insertion and placement. A standard IAN block (11) was administered. After reaching the target area and performing aspiration, 2.8 ml of 2% lidocaine with 1:100,000 epinephrine was deposited over a period of 2 min.

For the bidirectional-needle-rotation technique for administering the IAN block with the Wand II, a standard cartridge of 2% lidocaine with 1:100,000 epinephrine (Xylocaine with epinephrine) was loaded into the drive unit of the Wand II. A 1.25-inch, 27-gauge needle (Monoject) was attached to the handpiece assembly. The foot pedal was depressed and released to purge air from

trated, the Wand II handpiece assembly, with attached needle, was slowly advanced using a bidirectional technique. That is, the handpiece assembly was continuously rotated back and forth between the thumb and forefinger (similar to the rotation described for endodontic hand files) every 0.5 s as the needle was advanced. The needle was advanced approximately 1 mm, using active rotation, until the target site was reached (penetration depth of 16–20 mm). Aspiration was performed by depressing the foot pedal for four audible beeps and then releasing the pressure on the foot pedal. The Wand II aspiration cycle took 5 s. The anesthetic solution was deposited by fully depressing the foot pedal (fast speed) and 1.4 ml of anesthetic solution was deposited over a 1-min time period at the target site. A trained research assistant replaced the used cartridge with a new cartridge of 1.8 ml of 2% lidocaine with 1:100,000 epinephrine. The needle remained in place at the target site while the cartridge was replaced. The foot pedal was fully depressed and an additional 1.4 ml of anesthetic solution was deposited at the target site. Because of the residual amount of anesthetic solution remaining within the cartridge and handpiece tubing, the injection volume per cartridge was 1.4 ml. Therefore, both the conventional and the bidirectional techniques used a total volume of 2.8 ml.

After both IAN blocks, a conventional long buccal injection (11) was given with a standard aspirating syringe and 2% lidocaine with 1:100,000 epinephrine. Approximately 0.45 ml of anesthetic solution was deposited at the target site.

The blinding of the IAN blocks was accomplished by blindfolding all subjects for the IAN block injections. Additionally, during the conventional IAN block injection, a research assistant activated the Wand II on cruise control, so the patient would hear the unit beeping.

At 10 min postinjection, the patient was questioned regarding lip numbness. If profound lip numbness was not recorded, the block was considered missed and the patient was eliminated from the study. A total of five patients, two from the bidirectional technique and three from the conventional technique were eliminated. None of these subjects were included in the data analysis.

At 17 min postinjection, the teeth were isolated with a rubber dam and access performed. If the patient felt pain, they rated their discomfort using the Heft-Parker visual analogue scale (10) (Fig. 3). The extent of access achieved when the patient felt pain was recorded as within dentin, entering the pulp chamber, or initial file placement. The success of the IAN blocks was defined as the ability to access and instrument the tooth without pain (VAS score of zero) or mild pain (VAS rating ≤ 54 mm).

Comparisons between the conventional IAN block and bidirectional IAN block for anesthetic success were analyzed using the Chi-square test. Comparisons of age and initial pain scores were made using the independent *t* test. The Chi-square test was used to compare differences in sex and tooth type. Comparisons were considered significant at $p < 0.05$.

RESULTS

The age, gender, and initial pain of the patients are presented in Table 1. There were no significant differences ($p > 0.05$) between the two groups. The distribution of the teeth is outlined in Table 2. There were no significant differences ($p > 0.05$) between the two groups. One hundred percent of the subjects had subjective lip anesthesia with both IAN blocks.

Anesthetic success is presented in Table 3. The success rate for the conventional IAN block was 50% and for the bidirectional

TABLE 1. Initial values for conventional and bidirectional IAN block techniques

| Value | Conventional IAN | Bidirectional IAN | p value* |
|----------------|------------------------|------------------------|----------|
| Age | 34 years | 35 years | 0.51 |
| Gender | 15 females 17 males | 16 females 16 males | 0.80 |
| Initial pain** | 113 \pm 38 | 107 \pm 34 | 0.38 |

* There were no significant differences ($p > 0.05$) between the two groups.

** Mean \pm SD; Heft Parker VAS ratings.

TABLE 2. Distribution of teeth for conventional and bidirectional IAN blocks

| Tooth | Conventional IAN <i>n</i> = 32 | Bidirectional IAN* <i>n</i> = 32 |
|-----------------|-----------------------------------|-------------------------------------|
| First premolar | 0 (0%) | 0 (0%) |
| Second premolar | 6 (19%) | 5 (16%) |
| First molar | 17 (53%) | 14 (44%) |
| Second molar | 9 (28%) | 13 (41%) |

* There were no significant differences ($p > 0.05$) between the two groups.

TABLE 3. Percentages and number of patients who achieved anesthetic success with conventional and bidirectional IAN blocks

| | Conventional IAN | Bidirectional IAN* |
|--------------------|------------------|--------------------|
| Anesthetic success | 50% (16 of 32) | 56% (18 of 32) |

* There was no significant difference ($p > 0.05$) when the conventional IAN block was compared to the bidirectional IAN block.

TABLE 4. Discomfort ratings for patients experiencing greater than mild pain (anesthetic failure) on access with conventional and bidirectional IAN blocks

| Technique | Moderate Ratings* (>54 mm and <114 mm) | Severe Ratings* (≥ 114 mm) |
|-------------------|---|-------------------------------------|
| Dentin | | |
| Conventional IAN | 7 (44%) | 5 (31%) |
| Bidirectional IAN | 8 (57%) | 3 (21%) |
| Pulp | | |
| Conventional IAN | 3 (19%) | 0 (0%) |
| Bidirectional IAN | 1 (7%) | 1 (7%) |
| Instrumentation | | |
| Conventional IAN | 0 (0%) | 1 (6%) |
| Bidirectional IAN | 1 (7%) | 0 (0%) |

n = 16 for the conventional IAN block.

n = 14 for the bidirectional IAN block.

* Heft Parker VAS ratings.

technique success was 56%. There was no significant difference ($p > 0.05$) between the two techniques. Nine patients had no pain (VAS score of zero) on access in the conventional technique and seven patients had no pain in the bidirectional technique. Seven patients had mild pain (VAS score ≤ 54 mm) on access in the conventional technique and 11 patients had mild pain in the bidirectional technique. Discomfort ratings for patients experiencing greater than mild pain (anesthetic failure) on access with the conventional and bidirectional IAN blocks are summarized in Table 4.

DISCUSSION

The patients' age, gender, posterior tooth type, and initial pain were not significantly different between the two IAN techniques (Tables 1 and 2). Therefore, the effect of age, gender, posterior tooth type, and initial pain would be minimized between the two techniques. The mean initial pain ratings of 113 mm for the patients in the conventional IAN group and 107 mm for the patients in the bidirectional group correlated to moderate pain (Fig. 3). This pain is representative of patients with an irreversible pulpitis (2, 3, 12-14) who present for emergency treatment.

The bidirectional IAN block technique did not record statistically higher success rates compared with the conventional IAN block (Table 3). Hochman and Friedman (6) demonstrated that a standard beveled needle that traverses 20 mm of tissue-like substance can deflect as much as 5 mm. They also found that the bidirectional-needle-rotation technique minimized needle deflection—with the highest deflection of 1.7 mm. Because *in vitro* studies (4-9) have shown the needle deflects toward the nonbeveled side, we positioned the needle bevel away from the mandibular ramus in the conventional IAN block to take advantage of needle deflection toward the mandibular foramen (5). Therefore, both the conventional IAN and the bidirectional IAN techniques should result in needle placement near the mandibular foramen clinically. If needle placement, as used in this study, played a large role in success with the IAN block, anesthetic success rates for both techniques should have been much higher than recorded in this study.

The objective of the IAN block is to direct the needle into the pterygomandibular space as close to the IAN as possible so the local anesthetic solution is deposited in close proximity to the nerve. Berns and Sadove (15), using radiopaque dyes and radiographs of needle placement, found that even with accurate needle placement, 25% of IAN blocks resulted in inadequate anesthesia. Hannan et al. (16), using a medical ultrasound technique for needle placement for IAN blocks, concluded that accurate needle placement did not result in more successful pulpal anesthesia. Galbreath and Eklund (17) felt that the course of anesthetic solution migration could not be accurately predicted; the course was determined by the path of least resistance and by the fascial planes and structures encountered in the pterygomandibular space. Anesthetic solution migration may help explain why accurate needle placement may not result in pulpal anesthesia.

In previous studies of endodontic patients with irreversible pulpitis, success rates of 19% to 56% have been reported for the IAN block (1-3). All patients in these studies had lip numbness with the IAN block. Although lip numbness has typically been used as an indicator of a clinically successful block, clinicians must realize this does not guarantee successful pulpal anesthesia. Our results are similar to the 56% success rate recorded by Cohen et al. (1) but higher than the 19% and 25% success rates reported by Reisman et al. (2) and Nusstein et al. (3). Differences in measurement of onset time, initial criteria for pulpal anesthesia using the electric pulp tester or cold stimuli, and patient populations may account for the varied success rates in the previous studies.

Discomfort ratings for patients experiencing greater than mild pain (anesthetic failure) on access demonstrated that many patients (21-57%) experienced moderate-to-severe pain in dentin (Table 4). Obviously, the clinician would have difficulty entering the pulp to give an intrapulpal injection. Therefore, practitioners should

consider supplemental techniques (such as intraosseous (2, 3) or periodontal ligament injections (1)) to achieve pulpal anesthesia when an IAN block fails to provide pulpal anesthesia for a particular tooth.

For mandibular posterior teeth with irreversible pulpitis, neither the conventional IAN block, administered with the needle bevel oriented away from the mandibular ramus, nor the bidirectional-needle-rotation technique, administered using the computer-assisted Wand II anesthesia system, resulted in an acceptable rate of anesthetic success.

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