# Speed of Injection Influences Efficacy of Inferior Alveolar Nerve Blocks: A Double-Blind Randomized Controlled Trial in Volunteers

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**Abstract**

This randomized double-blind crossover trial investigated the efficacy and discomfort associated with slow (60 seconds) and rapid (15 seconds) inferior alveolar nerve blocks (IANB) using 2.0 ml of 2% lidocaine with 1:80,000 epinephrine in securing mandibular first molar, premolar and lateral incisor pulp anesthesia in 38 healthy adult volunteers. Episodes of maximal stimulation (80 $\mu$A) without sensation on electronic pulp testing were recorded. Injection discomfort was self-recorded by volunteers on 100 mm visual analogue scales. Data were analyzed by McNemar, Friedman, Wilcoxon Signed Ranks, and paired *t* tests. Slow IANB produced more episodes of no response to maximal pulp stimulation than rapid IANB in molars (220 episodes versus 159, $p < 0.001$), premolars (253 episodes versus 216, $p = 0.003$) and lateral incisors (119 episodes versus 99, $p = 0.049$). Slow IANB was more comfortable than rapid IANB ($p = 0.021$). *(J Endod 2006;32:919–923)*

**Key Words**

Inferior alveolar nerve block, injection speed, lidocaine local anesthesia, pulpal anesthesia

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The success of inferior alveolar nerve block (IANB) is reported to range between 30 and 97% (1–9). Many factors can influence success, including anatomical, pathological, pharmaceutical, pharmacological, psychological, and other technical variables (10). Speed of injection has been shown to influence the effectiveness of some medical local anesthetic injections (11), however, the effect on inferior alveolar nerve block anesthesia has not been reported. The aim of this study was to test the hypothesis that there is no significant difference in local anesthetic effectiveness, onset of pulpal anesthesia and associated pain after slow and rapid IANB injection of 2% lidocaine with 1:80,000 epinephrine in adult volunteers.

## Materials and Methods

This study employed a randomized double blind cross-over design to compare the efficacy of slow and rapid IANB in securing pulpal anesthesia in the mandibular teeth of volunteers. Although a third party was involved in administering the local anesthetic injections, the study is classified as double-blind to acknowledge that both the trial subjects and the individual assessing outcome were blinded to the injection procedure (12).

A power calculation indicated that a sample size of 76 (two groups of 38 subjects) would provide 80% power to detect a difference of 30 points (60% versus 90%) in the success rate, assuming a significance level of 5%. Official clearances were obtained from the Newcastle upon Tyne Hospitals National Health Service Trust, the Medicines and Healthcare products Regulatory Agency and Local Research Ethics Committees.

Thirty-eight healthy adult volunteers aged between 19 and 30 years were included, each with a vital first molar, first or second premolar and lateral incisor on one side of the mandible. All participants provided informed, written consent to receive two IANB injections of 2 ml lidocaine 2% with epinephrine 1:80,000 (2% Xylocaine Dental with epinephrine 1:80,000, Dentsply, Weybridge, UK), one slow (60 seconds) and one rapid (15 seconds) at least 1 week apart. The order of injection was randomized using a computer generated program of random numbers. All injections were given by the same operator (IPC), who had practiced delivery at the prescribed speeds and had no involvement in assessing outcome. To accurately control the speed of injections, a clock was positioned in the operatory where it was visible to the operator, but not to the volunteer.

Injections were given with standard dental aspirating syringes (Claudius Ash, Hertfordshire, UK) fitted with 27 gauge, 35 mm dental needles (Henry Schein, Kent, UK). The local anesthetic needle was inserted midway between the internal oblique ridge and the pterygomandibular raphe and advanced until bony contact was made (direct or Halstead approach). Aspiration was achieved before depositing 2 ml of solution, either slowly over 60 seconds or rapidly over 15 seconds. To blind the patient to the procedure, the needle remained in place for 45 seconds before depositing solution in the case of rapid injection. No anesthetic solution was deposited as the needle was advanced to the target site. After needle withdrawal, volunteers were asked to self-record the discomfort associated with local anesthetic deposition, not initial needle penetration, on 100 mm visual analogue scales (VAS) with endpoints tagged as no pain (0 mm) and unbearable pain (100 mm).

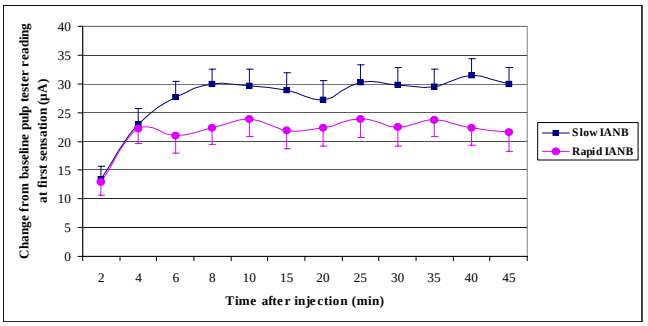


**Figure 1.** Change from base line mean pulp tester readings ($\mu$A) at first sensation and standard error of mean in first molars at time intervals after slow and rapid IANB.

The individual testing anesthetic efficacy (MDK) was blinded to the injection speed. Pulp sensitivity was determined with an Analytic Technology Pulp Tester (Analytic Technology, Redmond, WA), at a rate of 5 $\mu$A $s^{-1}$ on the mandibular first molar, first or second premolar, and lateral incisor of the anesthetized side of the mandible twice before injection to establish a baseline reading. Baseline pulp sensation was taken as the mean of these two readings. Pulp testing was then repeated every 2 minutes after injection for the first 10 minutes and then at 5 minute intervals for 45 minutes post-injection. Thirty-five volunteers received their injections on the right side and three on the left. To test the validity of the reading, a control unanesthetised tooth on the contralateral side of the mandible was tested at the same times.

The change in pulp tester reading at first sensation from baseline was calculated at each time point to detect if there were any subtle changes short of complete anesthesia resulting from the two techniques. Similarly, the number of episodes of no response at the maximal stimulation of 80 $\mu$A was recorded.

The onset of pulpal anesthesia was considered as the first time there was no response to maximal stimulation (80 $\mu$A).

Data were analyzed by McNemar, Friedman, Wilcoxon Signed Ranks, and paired *t* tests in SPSS (SPSS 11.0, SPSS Inc., Chicago, IL).

## Results

Thirty-eight healthy adult volunteers were recruited, 17 males (44.7%) and 21 females (55.3%), age range 19 to 30 years (mean, 22.6 yr; SD, 2.3). Eighteen volunteers received the slow IANB first.

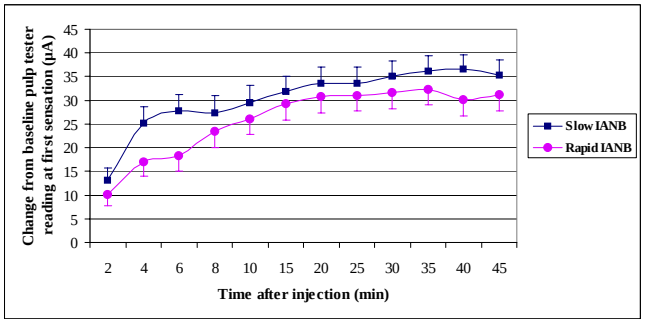


**Figure 2.** Change from base line mean pulp tester readings ($\mu$A) at first sensation and standard error of mean in first or second premolars at time intervals after slow and rapid IANB.

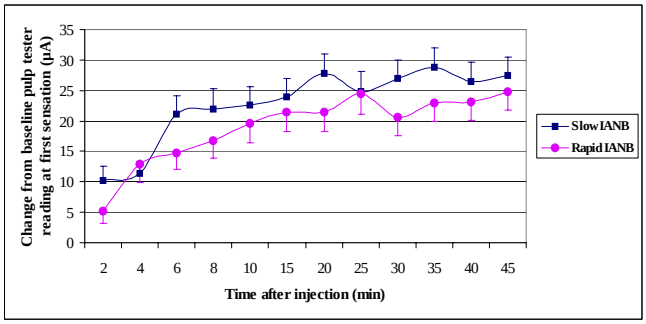


**Figure 3.** Change from base line mean pulp tester readings ($\mu$A) at first sensation and standard error of mean in lateral incisors at time intervals after slow and rapid IANB.

### Changes From Baseline Pulp Tester Readings at First Sensation in Molars, Premolars, and Lateral Incisors

Mean changes from baseline first molar pulp tester readings at first sensation over time after slow and rapid IANB are shown in Fig. 1. The greatest mean change was recorded 40 min after slow (31.5 $\mu$A) and 10 min after rapid IANB (24.0 $\mu$A). Mean change from the baseline pulp tester reading in first molars was significantly higher after slow than rapid IANB injection (paired *t* test, $t = 5.5$, $p < 0.001$).

In premolars (Fig. 2), the greatest mean change was recorded 40 minutes after slow (36.6 $\mu$A) and 35 minutes after rapid IANB (32.3 $\mu$A). Mean change from baseline pulp tester reading was significantly higher after slow than rapid IANB injection (paired *t* test, $t = 4.0$, $p < 0.001$).

In lateral incisors (Fig. 3), the highest mean change was recorded 35 minutes after slow (28.9 $\mu$A) and 45 minutes after rapid IANB (24.9 $\mu$A). Mean change from the baseline pulp tester reading was significantly higher after slow than rapid IANB injection (paired *t* test, $t = 3.7$, $p < 0.001$).

### Episodes of Maximal Stimulation (80 $\mu$A) Without Sensation

Figures 4, 5, and 6 show the percentage of volunteers with no pulp response to maximal pulp tester stimulation (80$\mu$A) at time intervals after slow and rapid IANB injection in molars, premolars and lateral incisors respectively. Across the trial period, differences were significant for molars (220 cases versus 159, respectively, McNemar test $p < 0.001$), premolars (253 cases versus. 216 respectively, McNemar test $p = 0.003$), and lateral incisors (119 cases versus 99, respectively, McNemar test $p = 0.049$).

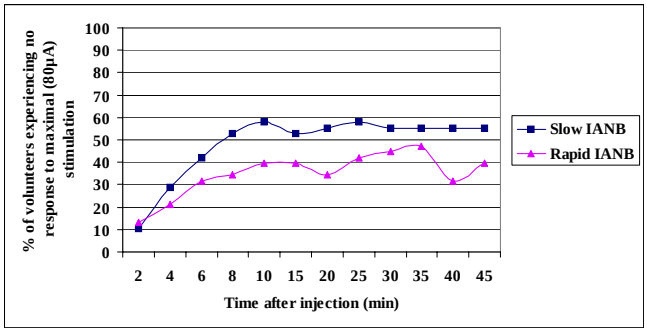


**Figure 4.** Percentage of volunteers reporting no pulp sensation on maximal stimulation (80 $\mu$A) in first molars at time intervals after slow and rapid IANB.

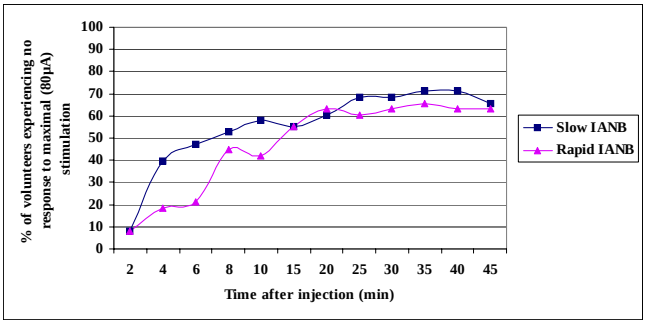


**Figure 5.** Percentage of volunteers reporting no pulp sensation on maximal stimulation (80 μA) in first or second premolars at time intervals after slow and rapid IANB.

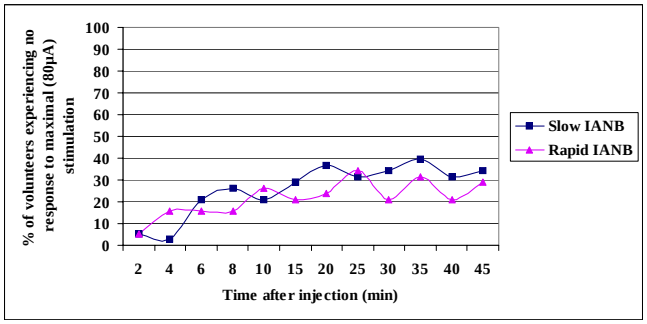


**Figure 6.** Percentage of volunteers reporting no pulp sensation on maximal stimulation (80 μA) in lateral incisors at time intervals after slow and rapid IANB.

### Onset of Pulpal Anesthesia

Table 1 shows the onset of pulpal anesthesia for molars, premolars, and lateral incisors after slow and rapid IANB. First molar pulpal anesthesia (80 μA stimulation without sensation) was shown in 24 and 23 volunteers after slow and rapid IANB injections, respectively. In premolars, the corresponding numbers were 28 and 31, while in lateral incisors they were 23 and 19, respectively.

Nonparametric statistics for matched mean onset of molar pulpal anesthesia was not significant between slow (5.4 minutes; SD, 3.2 minutes) and rapid IANB (6.7 minutes; SD, 7.1 minutes) (Wilcoxon Signed Ranks, $p = 0.98$). No significant differences were found for premolars, with the mean onset of pulpal anesthesia being 8.9 minutes (SD, 8.2 minutes) after slow compared to 11.1 minutes (SD, 9.7 minutes) after rapid IANB (Wilcoxon Signed Ranks, $p = 0.30$). For lateral incisors, the difference was not significant with mean onset at 13.3 minutes (SD = 9.8) after slow, compared with 11.6 minutes (SD = 10.1) after rapid IANB (Wilcoxon Signed Ranks, $p = 0.42$).

Nonparametric statistics showed differences in the mean onset of pulpal anesthesia between molars, premolars, and lateral incisors after slow IANB (Friedman, $p = 0.003$) but not after rapid IANB (Friedman, $p = 0.48$). After slow IANB, the mean onset of pulpal anesthesia was significantly quicker in molars and premolars than lateral incisors (Wilcoxon Signed Ranks, $p = 0.018$ and $p = 0.005$, respectively), although the difference between molars and premolars was not significant (Wilcoxon Signed Ranks, $p = 1.00$). No significant differences were found when the onset of pulpal anesthesia in molars and premolars was compared to lateral incisors (Wilcoxon Signed Ranks, $p = 0.65$ and $p = 0.36$, respectively) or when molars and premolars were compared (Wilcoxon Signed Ranks, $p = 0.64$) after rapid IANB injections.

### Injection Discomfort

Discomfort associated with IANB injection varied between 0 and 73 mm overall (mean, 25.7; SD 19.9). In males, it ranged between 1 and 73 mm (mean, 28.2; SD, 21.7) and in females between 0 and 65 mm (mean, 23.6; SD, 18.4). The difference between the genders was not significant (paired samples test, $t = 0.75$, $p = 0.46$). Injection discomfort ranged from 0 to 65 mm after slow injection (mean, 20.9; SD, 17.3) and 3 to 73 after rapid injection (mean, 30.5; SD, 21.4). The difference was significant (paired *t* test, $t = 2.4$, $p = 0.021$).

## Discussion

The influence of technical factors such as injection speed on the efficacy of local anesthesia is incompletely understood (10, 13–15). One investigation studied the influence of speed of injection during axillary block in 100 patients (11). The results showed that superior outcomes were obtained after slow compared to rapid injection. There are few available data in dentistry, but Hargreaves and Keiser (2002) suggest that rapid injection may enhance spread and efficacy of local anesthetics.

This study is the first to look at the influence of IANB injection speed on first molar, premolar and lateral incisor pulp anesthesia. Injection speeds reported in the literature for IANB have ranged between 20 s and 2 min for approximately 2 ml of solution (6, 16–21). The injection speeds selected for this trial were based on estimates of rapid (15 s) and slow (60 s) injection of 2 ml of solution in a clinically realistic setting.

### Efficacy of Anesthesia

Stimulation with an analogue electronic pulp tester has become the standard method of assessing the efficacy of pulp anesthesia in local anesthetic trials (1, 3, 4, 7). Numerical values allow objective observations on the change of pulp sensitivity from baseline and with time, and facilitate comparison between different episodes of testing in cross-over studies.

Overall, slow IANB injection produced significantly more episodes of no pulp response than rapid IANB injection in first molars, premolars and lateral incisors. This may have clinical relevance as clinicians strive to optimize the outcome of their IANB injections. Limitations in translating the current research to patients with inflamed pulps, and the fact

**TABLE 1.** Onset of pulpal anesthesia for first molars, first or second premolars, and lateral incisors after slow and rapid IANB

| Injection speed | Onset of pulpal anesthesia (min) | | | | | |
|---|---|---|---|---|---|---|
| | First molar | | Premolar | | Lateral incisor | |
| | Mean | SD | Mean | SD | Mean | SD |
| Slow IANB | 5.4 | 3.2 | 8.9 | 8.2 | 13.3 | 9.8 |
| Rapid IANB | 6.7 | 7.1 | 11.1 | 9.7 | 11.6 | 10.1 |
| Wilcoxon signed ranks | $p = 0.98$ | | $p = 0.30$ | | $p = 0.42$ | |

IANB, inferior alveolar nerve block.

that 100% success was not achieved even in this volunteer study supports the need for further research to optimize IANB efficacy.

Mandibular pulp innervation is not entirely from the inferior alveolar nerve, with additional innervation possible from the lingual (22) and mylohyoid nerves (23) and from the contralateral inferior alveolar nerve. Pulp anesthesia after IANB has been reported as particularly poor in the mandibular lateral incisor region (21), which may be explained by central crossover innervation (24), greater possibility of accessory supply from the mylohyoid nerve (25) or by coring of nerve fibers (26). These suggestions may explain why fewer episodes of no pulp response were found in lateral incisors than premolars and molars. More episodes of no pulp response were found in premolars than first molars; this finding was consistent after both slow and rapid IANB injections.

This latter finding agrees with studies that have reported the success rate of IANB injections to range from 23 to 78% in molars, 23 to 93% in premolars, and 23 to 70% in lateral incisors (17–19) in patients with pulpitis. In volunteers without toothache, the success rate of IANB has been reported to range from 42 to 73% in molars (6, 20, 21, 27), 38 to 90% in premolars (6, 20, 21, 27, 28), and 30 to 50% in lateral incisors (4, 6, 21). In these studies, dose and speed of injection ranged from 2.0 to 3.6 ml and 20 s to 120 s, respectively. The greater success with premolars might suggest that premolars are less likely than molars to receive collateral supply.

It has been suggested that slow IANB may allow deeper penetration of the nerve trunk with anesthetic agent than rapid injection (11). The results of the present study offer some support to the influence of nerve fiber coring on lower incisor anesthesia after regional block injections. The onset of pulpal anesthesia in the present study was significantly quicker in molars and premolars compared to lateral incisors after slow IANB injections although no significant difference was found between molars and premolars. Significant differences were not found after rapid IANB even though the mean onset of molar pulpal anesthesia was recorded approximately 4 to 5 minutes earlier than premolars and lateral incisors, respectively (Table 1).

In premolars, pulp anesthesia occurred approximately 2 minutes more quickly after slow than rapid IANB. In molars, the onset of pulp anesthesia was also quicker after slow injection, though the differences were not significant. The influence of injection speed on the onset of pulp anesthesia following IANB has not been reported previously. Certainly, the results of the present study suggest that a slow injection does not waste clinical time as onset of anesthesia is not compromised.

The results of the present study suggest that improved anesthetic efficacy may be achieved in the mandibular first molars, premolars and lateral incisors of volunteers after slow IANB injection. However, further investigation is required to confirm if this observation is mirrored in patients with pulpal inflammation where a greater depth of anesthesia is required to block afferent signals from the inflamed tissues.

### Discomfort and Injection Speed

In the present study, IANB injections were significantly more comfortable when given slowly than rapidly. Pain scores from visual analogue scales (VAS) have previously been described as none if 0 mm, mild if >0 to 30 mm, moderate if >30 to 54 mm, and severe if >54 to 100 mm (29). The results of this investigation show that slow injection was in the mild range and rapid in the moderate category. Injection speed has been shown to influence the discomfort of other intra-oral injections but inferior alveolar nerve block has not been investigated in this regard. One study has shown that injection with low pressure (0.5 ml in 80 seconds) is more comfortable than higher pressure (0.5 ml in 15 seconds) submucosally (30). Similarly, another study has reported a lower pain experience after slow palatine injection (0.3 ml in 48.3 seconds) compared to rapid palatine injection (0.3 ml in 5.7 seconds) using the Wand computerized local anesthetic delivery system (31).

Computerised injection systems have been developed to allow very slow injection (32–34). In the present study, we used conventional delivery systems for both rapid and slow injections to blind the volunteers. In pediatric dentistry, delivery with a computerized system and traditional injection produced comparable discomfort (35). Both were well tolerated by the patients (36). Computer-controlled and conventional delivery techniques have been shown to be comparably effective for mandibular anesthesia in adults (18, 37).

In contrast with a number of other studies (38–41), male volunteers reported more discomfort (VAS mean 28.2 mm) than females (VAS mean 23.6 mm) but the difference was not significant.

## Conclusions

Slow IANB produced more episodes of no sensation on maximal electronic pulp stimulation in first molars, premolars, and lateral incisors than rapid injection. Slow IANB was more comfortable than rapid injection.

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