PEOPLE HAVE PRIORITY

# Clinical studies
# Intraosseous anaesthesia

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# 1. Summary of the most important results

## 1.1. Intraosseous anaesthesia alone

Intraosseous anaesthesia worked with:

- 75% of maxillary molars
- 93% of mandibular molars
- 78% of mandibular incisors and
- 90% of maxillary incisors

**(Source 2.5)**

Anaesthetic administered by intraosseous anaesthesia is effective immediately. **(Source 2.7)**

Nerve-block anaesthesia alone in the mandible was:

- 90% effective for 2nd molars,
- 80% effective for 1st molars and
- 77% effective for 2nd premolars.

This can be improved to 100% in every case in conjunction with supplementary intraosseous anaesthesia. **(Source 2.10)**

Intraosseous anaesthesia can be used as the primary technique to eliminate the discomfort of lip numbness. **(Source 2.12)**

## 1.2. Anaesthetic effect of intraosseous anaesthesia and repeated intraosseous anaesthesia

The first injection with X-tip had a virtually 100% success rate. Statistically, the second injection extended the effectiveness of the anaesthetic by only about 15 minutes. **(Source 2.39)**

## 1.3. Supplementary intraosseous anaesthesia

In the USA, around one third of all endodontists use intraosseous anaesthesia, either as a sole injection or as a supplementary injection. **(Source 2.1)**

The application of intraosseous anaesthesia after ineffective nerve-block anaesthesia was successful in 86% of cases. **(Source 2.2)**

Intraosseous anaesthesia extended the general effect of the anaesthetic by 30 minutes with the use of mepivacaine 3%. This is particularly important for patients who are allergic to epinephrine. **(Source 2.8)**

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Nerve-block anaesthesia blocked pain completely in 41% of cases of irreversible pulpitis. If nerve-block anaesthesia was supplemented by intraosseous anaesthesia, the success rate increased to above 80%. **(Source 2.16)**

## 1.4. Anaesthetics

Effective duration of intraosseous anaesthesia with lidocaine 2% **(Source 2.10)** or articaine 4% up to 60 minutes. **(Source 2.29)**

Mepivacaine 3% up to 30 minutes. **(Source 2.8)**

Articaine 4% is more effective than lido 2% (active substance)

Nerve-block anaesthesia and infiltration anaesthesia with mepivacaine, prilocaine and lidocaine showed no differences in 30 tested patients (triple-blinded trial)

Success rate:

| | |
|---|---|
| Molars | 43 – 63% |
| Premolars | 53 – 67% |
| Incisors | 30 – 34% **(Source 2.27)** |

Comparison of anaesthetic efficiency (lidocaine and articaine) for infiltration of first molar and nerve-block anaesthesia:
Conclusion:

- articaine is successful in 88% of cases
- lidocaine in only 71% of cases **(Source 2.28)**.

Initial administration of articaine 4% + 1:100,000 epinephrine
One group received the second injection with articaine after 25 minutes. The other group received a mock injection. Repeated administration of articaine extended the effect from 28 to 109 minutes **(Source 2.29)**

## 1.5. Perforation

During drilling a temperature increase with no clinical relevance was recorded so long as the drilling time did not exceed 5 seconds. **(Source 2.9)**

## 1.6. Perforation and injection pain

There was no pain or very little pain during cortical perforation and during instillation:

- 6 patients showed reflux (18%)
- 27 patients (82%) could be treated. **(Source 2.26)**

## 1.7. Influence on heart rate

Administration of intraosseous anaesthesia increases the heart rate to 32 beats per minute. **(Source 2.2)**

A change in heart rate could be detected in 46% to 100% of all patients under intraosseous anaesthesia. **(Source 2.3)**

80% of all patients showed a negative influence of the heart rate **(Source 2.10)**

The pulse rate was increased under administration of lidocaine with epinephrine but returned to the original value within four minutes. This was attributed to the presence of epinephrine. This phenomenon occurred with 28 (67%) of 42 subjects. This effect was not observed with mepivacaine. **(Source 2.19)**

Only the heart rate was affected; blood pressure was not affected or only to a minimal degree **(Source 2.36)**

Fast injection and slow injection – heart rate:

- Fast injection with "the wand" took less than 45 seconds
- The slow injection was administered traditionally, taking 4 minutes and 45 seconds

Conclusion:

- The fast injection was associated with a statistically significant increase in heart rate of an average 21 to 28 beats
- Slow injection was associated with a 10 to 12 beat increase.

Slow injection means reduced effect on the heart rate. **(Source 2.41)**

## 1.8. Plasma levels of anaesthetic

Lidocaine and prilocaine reached their highest concentration in plasma after two minutes.

- For intraligamentary administration of lidocaine, the blood plasma level was 7% of the levels reached with intravenous administration
- For prilocaine, it was 25% **(Source 2.4**)

## 1.9. Science

Safe administration of intraosseous anaesthesia requires knowledge of the cortical thickness:
It is:

- at the base of condylar process 1.10 – 1.74 mm
- at the mandibular angle 1.47 – 1.97 mm
- in the mental foramen 2.14 – 2.38 mm. **(Source 2.11)**

## 1.10.Complications

Post-operative complications occurred in 2 – 15% of cases and lasted 1 – 14 days. **(Source 2.3)**

The majority had no or very little pain during administration of the intraosseous anaesthetic. Slow healing was observed in 3% of the perforation sites. **(Source 2.5)**

In the post-operative survey, patients listed only minor pain. **(Source 2.7)**

The majority of patients had no or very little pain during perforation or instillation. For 5%, the healing at the perforation site was delayed after the injection. **(Source 2.20)**

There were virtually no pain effects after using Stabident and X-tip. If pain was encountered, it occurred in the first three days. **(Source 2.33)**

## 1.11.Other statements on anaesthetic concepts

The most common form of anaesthesia is intraligamentary anaesthesia used by endodontists. **(Source 2.1)**

Reliable anaesthesia with nerve-block anaesthesia of the inferior alveolar nerve in only 42% of the cases **(Source 2.7)**

Complete failures of nerve-block anaesthesia alone in 32%. No complete failures when supplemented with intraosseous anaesthesia. **(Source 2.7)**

Intraligamentary anaesthesia and success rates:

- Molars 75 – 79%
- Premolars 58 – 63%
- Incisors 18% **(Source 2.21)**

Duration of anaesthesia 4 – 10 minutes **(Source 2.21)**

No increase in mobility observed after 45 minutes **(Source 2.21)**

Post-injection discomfort in 86 % of cases **(Source 2.21)**

36% reported that their teeth felt too high **(Source 2.21)**

Combination labial plus lingual infiltration of the mandibular lateral incisor
82 subjects, two tests:

- The first infiltration with articaine 4% + 1:100,000 epinephrine with labial and lingual infiltration
- The second test with labial infiltration and mock lingual infiltration

Conclusion: success rate:

- 98% for over one hour with combination infiltration
- 76% for well under one hour with exclusively labial infiltration**(Source 2.30)**

**Comparison of infiltration anaesthesia and intraosseous anaesthesia**
Conclusion:

- No difference was found in anaesthetising the pulp.
- The success rate for:
  - intraosseous anaesthesia was 98%
  - infiltration was 85%
- However, the duration was longer and the start of anaesthesia was faster with intraosseous anaesthesia **(Source 2.31).**

## 1.12.Administration restrictions

Administration restriction starts mesial to the 2nd molar. **(Source 2.9)**

Good planning is essential to prevent root damage. **(Source 2.9)**

**Efficacy of intraosseous anaesthesia for children and adolescents**

- The success rate was 91.2%
- The success rate for:
  - deciduous teeth was 95%
  - permanent teeth was 87.9%
- No differences were noted with different ages
- No differences with sensation or post-operative pain were noted. **(Source 2.37).**

# 2. Clinical studies

## 2.1. Bangerter, C., Mines, P. & Sweet, M. (2009). The use of intraosseous anesthesia among endodontists: results of a questionnaire. J Endod 35, 15-18.

### Source

US Army Endodontic Residency Program, Fort Bragg, North Carolina, USA.

### Abstract

The purpose of this study was to investigate the use of supplemental intraosseous (IO) anesthesia among endodontists in the United States. The study also looked at the types of anesthetic solutions commonly used for IO anesthesia and in which diagnostic conditions IO anesthesia is used. A Web-based survey of 2,528 active members of the American Association of Endodontists was sent out by e-mail. Data from 833 respondents were collected with a response rate of 33%. It was discovered that 94.77% of the respondents used some form of IO anesthesia, with the periodontal ligament injection (PDL) being the most commonly administered (49.78%). Symptomatic irreversible pulpitis is the pulpal diagnosis for which respondents most often use some form of IO anesthesia (61.99%), and 2% lidocaine with epinephrine 1:100,000 is the most common anesthetic solution used in IO anesthesia (37.62%). Although more than half of the respondents use some form of IO anesthesia more than twice a week, newer IO anesthesia delivery systems such as Stabident (Fairfax Dental, San Francisco, CA) and X-Tip (Dentsply International, Johnson City, TN) are used less often than the PDL injection.

## 2.2. Bigby, J., Reader, A., Nusstein, J., Beck, M. & Weaver, J. (2006). "Articaine for supplemental intraosseous anesthesia in patients with irreversible pulpitis." J Endod 2006;32, 1044-1047.

### Source

Section of Endodontics, College of Dentistry, The Ohio State University, Columbus, Ohio 43218, USA.

### Abstract

The purpose of this study was to determine the anesthetic efficacy and heart rate effect of 4% articaine with 1:100,000 epinephrine for supplemental intraosseous injection in mandibular posterior teeth diagnosed with irreversible pulpitis. Thirty-seven emergency patients, diagnosed with irreversible pulpitis of a mandibular posterior tooth, received an inferior alveolar nerve block and had moderate-to-severe pain upon endodontic access. The Stabident system was used to administer 1.8 ml of 4% articaine with 1:100,000 epinephrine. Success of the intraosseous injection was defined as none or mild pain upon endodontic access or initial instrumentation. The results demonstrated that anesthetic success was obtained in 86% (32 of 37) of the patients. Maximum mean heart rate was increased 32 beats/minute during the intraosseous injection. We can conclude that when the inferior alveolar nerve block fails to provide profound pulpal anesthesia, the intraosseous injection of 4% articaine with 1:100,000 epinephrine

would be successful 86% of the time in achieving pulpal anesthesia in mandibular posterior teeth of patients presenting with irreversible pulpitis.

## 2.3. Brown R. Intraosseous anesthesia: a review. J Calif Dent Assoc 1999; 27:785-92.

### Source

Department of Endodontics, University of the Pacific School of Dentistry, San Francisco, CA 94115, USA.

### Abstract

The recent introduction of intraosseous injection devices has renewed interest in the modality of local anesthesia. Three devices currently available are the Stabident System, the Hypo Brand Intraosseous Needle, and the Cyberjet System. The Stabident System is the most popular and the only one for which published research is available. Primary intraosseous anesthesia is 45 percent to 93 percent effective but of short duration. Supplemental intraosseous anesthesia is 80 percent to 90 percent effective and provides profound anesthesia of long duration (60 minutes or longer). It is used when a prior conventional infiltration or nerve block is inadequate. During use of an anesthetic solution with a vasoconstrictor for intraosseous anesthesia, 46 percent to 100 percent of patients reported an increase in heart rate. There was a 2 percent to 27 percent incidence of moderate and sometimes severe pain during the intraosseous procedure. Postoperative complications occurred in 2 percent to 15 percent of patients and lasted one to 14 days

## 2.4. Cannell H, Kerwala C, Webster K, Whelpton R. “Are intraligamentary injections intravascular?” Brit Dent J 1993; 175:281-4.

### Source

Department of Oral and Maxillo-Facial Surgery, London Hospital Medical College.

### Abstract

A pressure type syringe was used to give intraligamentary injections (IL) to upper teeth of two formulations commonly used in general practice, lignocaine and prilocaine. Assay of plasma levels of drug was carried out by high performance liquid chromatography. Results of assays after intraligamentary injections were then compared with results of assays after intravenous injections of plain drug in the same subjects. Both formulations of local anaesthetic were found as peak levels in the circulation, presumably after intraosseous spread, by 2 minutes following the intraligamentary injections. For lignocaine the peak amount was nearly 7% of the intravenous dose and for prilocaine the peak amount was 25% of the intravenous dose, at 2 minutes after injection. It was concluded that IL injections for healthy adults were unlikely to cause systemic unwanted effects when given in small doses.

## 2.5. Coggins R, Reader A, Nist R, Beck M, Meyers WJ. "Anesthetic efficacy of the intraosseous injection in maxillary and mandibular teeth." Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996;81:634-41.

### Source

Ohio State University, USA.

### Abstract

**OBJECTIVE:**

The objective of this study was to determine the anesthetic efficacy of the intraosseous injection as a primary technique in human maxillary and mandibular teeth.

**STUDY DESIGN:**

Forty subjects received two sets of intraosseous injections with 1.8 ml of 2% lidocaine with 1:100,000 epinephrine at two successive appointments. The experimental teeth consisted of 40 groups of maxillary and mandibular first molars and lateral incisors. Each experimental tooth and adjacent teeth were tested with an electric pulp tester at 4-minute cycles for 60 minutes. Anesthetic success was defined as no subject response to the maximum output of the pulp tester (80 reading) for two consecutive readings.

**RESULTS:**

Anesthetic success occurred in 75% of mandibular first molars, in 93% of maxillary first molars, in 78% of mandibular lateral incisors, and in 90% of maxillary lateral incisors. Overall, for the intraosseous injection onset was immediate, the duration of pulpal anesthesia steadily declined over the 60 minutes, there was a 78% incidence of subjective increase in heart rate, the majority of the subjects had no pain or mild pain with perforation and solution deposition, and 3% of the subjects had slow healing perforation sites.

**CONCLUSIONS:**

The results of this study indicate that the intraosseous injection may provide pulpal anesthesia in 75% to 93% of noninflamed teeth as a primary technique. However, the duration of pulpal anesthesia declines steadily over an hour.

## 2.6. Coury KA. "Achieving profound anesthesia using the intraosseous technique." Tex Dent J 1997;114:34-9.

### Abstract

The intraosseous technique has been described as a useful adjunct to primary anesthetic administration. It has several advantages (Table 3) over other supplemental techniques in that it is relatively simple to implement into routine practice, it affords fast, predictable results, and it is relatively painless. The technique has been shown to be very successful in achieving profound pulpal anesthesia when administered as a supplement to the inferior alveolar nerve block and is effective in achieving profound anesthesia in irreversibly inflamed teeth, especially mandibular molars

## 2.7. Dunbar D, Reader A, Nist R, Beck M, Meyers W. "Anesthetic efficacy of the intraosseous injection after an inferior alveolar nerve block." J Endod 1996;22:481-6.

### Source

Graduate Endodontic Program, College of Dentistry, Ohio State University, Columbus 43210, USA.

### Abstract

The purpose of this study was to determine the contribution of the intraosseous (IO) injection to the inferior alveolar nerve (IAN) block in human first molars. Using a repeated-measures design, 40 subjects randomly received either a combination IAN block + IO injection (on the distal of the first molar) using 2% lidocaine with 1:100,000 epinephrine or an IAN block+mock IO injection (gingival penetration only) at two successive appointments. The first molar and adjacent teeth, and contralateral canine (+/-controls) were blindly tested with an Analytic Technology pulp tester at 2-min cycles for 60 min. An 80 reading was used as the criterion for pulpal anesthesia. One hundred percent of the subjects had lip numbness with the IAN block. For the first molar, anesthetic success, defined as achieving an 80 reading within 15 min and keeping this reading for 60 min, was 42% with the IAN and 90% with the IAN + IO. Anesthetic failure defined as never achieving two 80 readings during the 60 min was 32% with the IAN and 0% with the IAN + IO. The onset of anesthesia was immediate with the IO injection. Eighty percent of the subjects sampled had a subjective increase in heart rate with the IO injection. The IO injection and postinjection questionnaire recorded low pain ratings

## 2.8. Gallatin E, Stabile P, Reader A, Nist R, Beck M. "Anesthetic efficacy and heart rate effects of the intraosseous injection of 3% mepivacaine after an inferior alveolar nerve block." Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000; 89:83-7.

### Source

Division of Endodontics, The Ohio State University, Columbus 43210, USA.

### Abstract

**OBJECTIVE:**

The purpose of this study was to determine the anesthetic efficacy and heart rate effects of an intraosseous injection of 3% mepivacaine after an inferior alveolar nerve block.

**STUDY DESIGN:**

Through use of a repeated-measures design, each of 48 subjects randomly received 2 combinations of injections at 2 separate appointments. The combinations were (1) an inferior alveolar nerve block (with 1.8 mL of 3% mepivacaine) + intraosseous injection with 1.8 mL of 3% mepivacaine and (2) an inferior alveolar nerve (with 1. 8 mL of 3% mepivacaine) + mock intraosseous injection. The first molar was blindly pulp tested at 2-minute cycles for 60 minutes postinjection. Anesthesia was considered successful with 2 consecutive 80 readings. Heart rate (pulse rate) was measured with a pulse oximeter.

**RESULTS:**

All subjects had lip numbness with both of the inferior alveolar nerve + intraosseous techniques. Anesthetic success for the first molar was significantly increased for 30 minutes with intraosseous injection of

mepivacaine in comparison with the inferior alveolar nerve block alone (mock intraosseous injection). Subjects receiving the intraosseous injection of mepivacaine experienced minimal increases in heart rate.
**CONCLUSIONS:**
The intraosseous injection of 1.8 mL of 3% mepivacaine, when used to augment an inferior alveolar nerve block, significantly increased anesthetic success for 30 minutes in the first molar. The 3% mepivacaine had a minimal effect on heart rate and would be useful in patients with contraindications to epinephrine use.

## 2.9. Graetz, C., Rühlng, A. & Dörfer, C. E. (2008). Temperature changes during intraosseous anaesthesia in vitro. J Dent Res 87 (Spec Iss B): 3320.

**Conclusions:**
With increasing rotation time no significant increase of the needle deformation appeared. A significant increase of the intraosseous temperature was observed, however, it was low and notfrom clinical relevance as far as the drilling time did not exceed 5s (7,8,9). The different thickness of the cortical substance of the human jaw, especially the lower jaw (10), had no influence on drilliing time or needle tip deformation. The presnce of deformation and the absende of intraosseous needle tip fracture proved the high strength of the materials used. However, the evaluation of the in vitro investigations showed a clear restriction of the use of IOA mesial to the second molar. A careful planning of the drilling location is essential to avoid root damages. Further tests need to be performed.

## 2.10. Guglielmo A, Reader A, Nist R, Beck M, Weaver J. “Anesthetic efficacy and heart rate effects of the supplemental intraosseous injection of 2 percent mepivacaine with 1:20,000 levonordefrin.” Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999;87:284-93.

### Source
The Ohio State University, Columbus 43210, USA.

### Abstract
**OBJECTIVE:**
The purpose of this study was to determine the anesthetic efficacy and heart rate effects of a supplemental intraosseous injection of 2% mepivacaine with 1:20,000 levonordefrin.
**STUDY DESIGN:**
Through use of a repeated-measures design, 40 subjects randomly received 3 combinations of injections at 3 separate appointments. The combinations were as follows: inferior alveolar nerve (IAN) block (with 3% mepivacaine) + intraosseous injection of 1.8 mL of 2% mepivacaine with 1:20,000 levonordefrin; IAN block + intraosseous injection of 1.8 mL of 2% lidocaine with 1:100,000 epinephrine (positive control); IAN block + mock intraosseous injection (negative control). Each first molar, second molar, and second premolar was blindly tested with a pulp tester at 2-minute cycles for 60 minutes after injection. Anesthesia was considered successful when 2 consecutive readings of 80 were obtained. Heart rate (pulse rate) was measured with a pulse oximeter.

**RESULTS:**
One hundred percent of the subjects had lip numbness with the IAN block + intraosseous mock technique and IAN block + intraosseous techniques. The anesthetic success rates for IAN block + mock intraosseous injection, IAN block + intraosseous lidocaine, and IAN block + intraosseous mepivacaine, respectively, were as follows: 80%, 100%, and 100% for the first molar; 90%, 100%, and 100% for the second molar; 77%, 97%, and 97% for the second premolar. For the first molar and second premolar, the differences were significant (P< .05) when the intraosseous mepivacaine and lidocaine techniques were compared with the IAN block + mock intraosseous injection. There were no significant differences between the intraosseous mepivacaine and lidocaine techniques. Eighty percent of the subjects had a mean increase in heart rate of 23-24 beats per minute with the intraosseous injection of the mepivacaine and lidocaine solutions; there were no significant differences between results with the 2 solutions.
**CONCLUSIONS:**
We concluded that intraosseous injection of 1.8 mL of 2% lidocaine with 1:100,000 epinephrine or 2% mepivacaine with 1:20,000 levonordefrin, used to supplement an IAN block, significantly increased anesthetic success in first molars and second premolars. The 2 solutions were equivalent with regard to intraosseous anesthetic success rate, failure rate, and heart rate increase after IAN block

## 2.11. Heibel, H., Alt, K. W., Wächter, R. & Bähr, W. (2001). Kortikalisdicke am Unterkiefer unter besonderer Berücksichtigung der Miniplattenostheosynthese. Morphologische Analyse an Sektionsmaterial. Mund Kiefer GesichtsChir 3, 180-185.

Mund Kiefer Gesichtschir.2001 May;5(3):180-5.

**[Cortical thickness of the mandible with special reference to miniplate osteosynthesis. Morphometric analysis of autopsy material].**

[Article in German]

### Source

Klinik und Poliklinik für Zahnärztliche Chirurgie und Mund-, Kiefer- und Gesichtschirurgie, Universität Köln, Kerpener Strasse 62, 50937 Köln. HolgerHeibel@web.de

### Abstract

Thirty-two human mandibles were marked with three typical fracture lines: a low condylar fracture, a fracture of the mandibular angle, and one through the mental foramen on each side. The mandibles were sectioned at the fixation sites of the miniplate screws. The thickness of the cortical layer was measured with a scaled magnifying glass at the points of anthropological interest and at the marked screw holes. The inferior cortical layer turned out to be thickest in the anterior area. In contrast, it was very thin at the mandibular angle, which might explain the higher complication rate in treating fractures in this region. The thickness of the lingual cortex increased up to the symphysis, whereas the buccal cortical layer showed a decline in size from the mandibular angle up to the chin. The cortical bone at the alveolar ridge was porous. The cortical supply for miniplate osteosynthesis at the condylus ranged from 1.1 mm up to 1.74 mm, which seems to be limited, but due to the small diameter of the condylus most common screws obtain additional anchorage in the inner cortex. The thickness of the cortical layer at the mandibular angle

increased from 1.47 mm at the ramus up to 1.97 mm at the beginning of the corpus, reaching 2.14-2.38 mm for the lower plate at the mental foramen. The results for the upper plate were slightly lower

## 2.12. Kleber, C. H. (2003). Intraosseous anesthesia: implications, instrumentation and techniques. J Am Dent Assoc 134, 487-491.

### Source

IntraVantage, Plymouth, Minn., USA. ckleber1@san.rr.com

### Abstract

**BACKGROUND:**

The author reviews historical methods and the instruments used to bring about intraosseous anesthesia, or IOA; discusses the criteria for successful use of the intraosseous injection, or IOI, technique; and provides recommendations.

**TYPES OF STUDIES REVIEWED:**

Articles from before 1990 consisted of subjective reports of patient types and procedures performed using IOI as a primary technique. Studies published after 1990 yielded subjective findings on indications for expanded clinical use. The author discusses the expansion of the role of IOI relative to integrated local anesthetic delivery systems.

**RESULTS:**

The literature and studies verify the efficacy of IOI as a supplemental or primary technique. The author recommends anesthetics and infusion sites, and reports on the patients' perceptions of comfort.

**CONCLUSIONS AND CLINICAL IMPLICATIONS:**

IOI can be used as a supplemental or primary technique to bring about local anesthesia in routine dental procedures. It can be used as a supplemental technique with mandibular nerve blocks to enhance deep pulpal anesthesia. It can be used as a primary technique so that patients do not experience numb lips or tongues postoperatively. Dentists can appreciate the immediate onset of anesthesia and reduced dosage levels of anesthetics associated with using IOI.

## 2.13. Leonard MS. “The efficacy of an intraosseous injection system of delivering local anesthetic.” JADA 1995;126:81-6.

### Source

Dentistry Department, Hennepin County Medical Center, Minn.

### Abstract

This article describes the clinical testing of a new system for the intraosseous delivery of local anesthesia. The author concluded that the system delivered local anesthetic very effectively (in some situations more effectively than the traditional delivery method), thus offering a great potential advantage to both dentists and patients.

**2.14. Malamed, SF. "Handbook of local anesthesia." 5th ed., 2004, Mosby, ISBN0-323-02449-1.**

**2.15. Nusstein J, Berlin J, Reader A, Beck M, Weaver J. "Comparison of injection pain, heart rate increase and post-injection pain of articaine and lidocaine in a primary intraligamentary injection administered with a computer-controlled local anesthetic delivery system."Anesth Prog 2004; 51:126-33.**

## Source

Department of Graduate Endodontics, College of Dentistry, The Ohio State University, Columbus, Ohio 43218, USA.

## Abstract

The purpose of this prospective, randomized, double-blind study was to compare the pain of injection, heart rate increase, and postinjection pain of the intraligamentary injection of 4% articaine with 1:100,000 epinephrine and 2% lidocaine with 1:100,000 epinephrine administered with a computer-controlled local anesthetic delivery system. Using a crossover design, intraligamentary injections of 1.4 mL of 4% articaine with 1:100,000 epinephrine and 1.4 mL of 2% lidocaine with 1:100,000 epinephrine were randomly administered on the mesial and distal aspects of the mandibular first molar with a computer-controlled local anesthetic delivery system in a double-blind manner at 2 separate appointments to 51 subjects. The results demonstrated the incidence of moderate pain was 14%-27% with needle insertion, with 0%-4% reporting severe pain. For solution deposition, moderate pain was reported 8%-18% of the time, with no reports of severe pain. There were no significant differences between the articaine and lidocaine solutions. Regarding heart rate changes, neither anesthetic solution resulted in a significant increase in heart rate over baseline readings. On day 1 postinjection, there was a 31% incidence of moderate/severe pain with the articaine solution and 20% incidence of moderate/severe pain with the lidocaine solution. The moderate/severe pain ratings decreased over the next 2 days. There were no significant differences between the articaine and lidocaine solutions. We concluded that the intraligamentary injection of 4% articaine with 1:100,000 epinephrine was similar to 2% lidocaine with 1:100,000 epinephrine for injection pain and postinjection pain in the mandibular first molar when administered with a computer-controlled local anesthetic delivery system. For both anesthetic solutions, heart rate did not significantly increase with the intraligamentary injection using the computer-controlled local anesthetic system

## 2.16. Nusstein J, Reader A, Nist R, Beck M, Meyers WJ. “Anesthetic efficacy of the supplemental intraosseous injection of 2 percent lidocaine with 1:100,000 epinephrine in irreversible pulpitis.” J Endod 1998; 24:487-91.

### Source

Division of Endodontics, Ohio State University, College of Dentistry, Columbus 43210, USA.

### Abstract

The purpose of this study was to determine the anesthetic efficacy of a supplemental intraosseous injection of 2% lidocaine with 1:100,000 epinephrine in teeth diagnosed with irreversible pulpitis. Fifty-one patients with symptomatic, vital maxillary, and mandibular posterior teeth diagnosed with irreversible pulpitis received conventional infiltrations or inferior alveolar nerve blocks. Pulp testing was used to determine pulpal anesthesia after "clinically successful" injections. Patients who were positive to the pulp tests, or were negative to the pulp tests but felt pain during endodontic access, received an intraosseous injection using 1.8 ml of 2% lidocaine with 1:100,000 epinephrine. The results demonstrated that 42% of the patients who tested negative to the pulp tests reported pain during treatment and required supplemental anesthesia. Eighty-one percent of the mandibular teeth and 12% of maxillary teeth required an intraosseous injection due to failure to gain pulpal anesthesia. Overall, the Stabident intraosseous injection was found to be 88% successful in gaining total pulpal anesthesia for endodontic therapy. We concluded that, for posterior teeth diagnosed with irreversible pulpitis, the supplemental intraosseous injection of 2% lidocaine (1:100,000 epinephrine) was successful when conventional techniques failed

## 2.17. Reisman D, Reader A, Nist R, Beck M, Weaver J. “Anesthetic efficacy of the supplemental intraosseous injection of 3 percent mepivacaine in irreversible pulpitis.” Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;84:676-82.

### Source

Ohio State University, Columbus, USA.

### Abstract

**OBJECTIVE:**

To determine the efficacy of a supplemental intraosseous injection of 3% mepivacaine in mandibular posterior teeth with irreversible pulpitis. Intraosseous injection pain, subjective heart rate increase, and pain ratings during endodontic treatment were also assessed.

**STUDY DESIGN:**

Forty-eight patients with irreversible pulpitis received conventional inferior alveolar nerve blocks. Electric pulp testing was used to determine pulpal anesthesia. Patients who were positive to the pulp testing, or negative to pulp testing but felt pain during endodontic treatment, received an intraosseous injection of 1.8 ml of 3% mepivacaine. A second intraosseous injection of 3% mepivacaine (1.8 ml) was given if the first injection was unsuccessful.

**RESULTS:**

Seventy-five percent of patients required an initial intraosseous injection because of failure to gain pulpal anesthesia. The inferior alveolar block was 25% successful; the first intraosseous injection increased success to 80%. A second intraosseous injection further increased success to 98%. These differences were significant ($p < 0.05$). Eight percent (4/48) of the initial intraosseous injections resulted in solution being expressed into the oral cavity: these were considered technique failures.

**CONCLUSIONS:**

For mandibular posterior teeth with irreversible pulpitis, a supplemental intraosseous injection of 3% mepivacaine increased anesthetic success. A second intraosseous injection, when necessary, further improved success.

## 2.18. Reitz J, Reader A, Nist R, Beck M, Meyers WJ. Anesthetic efficacy of a repeated intraosseous infection given 30 min. following an inferior alveolar nerve block/intraosseous injection. Anesth Prog 1998;45:143-9.

### Source

Section of Graduate Endodontics, College of Dentistry, Ohio State University, Columbus 43210, USA.

### Abstract

To determine whether a repeated intraosseous (IO) injection would increase or prolong pulpal anesthesia, we measured the degree of anesthesia obtained by a repeated IO injection given 30 min following a combination inferior alveolar nerve block/intraosseous injection (IAN/IO) in mandibular second premolars and in first and second molars. Using a repeated-measures design, we randomly assigned 38 subjects to receive two combinations of injections at two separate appointments. The combinations were an IAN/IO injection followed approximately 30 min later by another IO injection of 0.9 ml of 2% lidocaine with 1:100,000 epinephrine and a combination IAN/IO injection followed approximately 30 min later by a mock IO injection. The second premolar, first molar, and second molar were blindly tested with an Analytic Technology pulp tester at 2-min cycles for 120 min postinjection. Anesthesia was considered successful when two consecutive readings of 80 were obtained. One hundred percent of the subjects had lip numbness with IAN/IO and with IAN/IO plus repeated IO techniques. Rates of anesthetic success for the IAN/IO and for the IAN/IO plus repeated IO injection, respectively, were 100% and 97% for the second premolar, 95% and 95% for the first molar, and 87% and 87% for the second molar. The repeated IO injection increased pulpal anesthesia for approximately 14 min in the second premolar and for 6 min in the first molar, but no statistically significant differences ($P > 0.05$) were shown. In conclusion, the repeated IO injection of 0.9 ml of 2% lidocaine with 1:100,000 epinephrine given 30 min following a combination IAN/IO injection did not significantly increase pulpal anesthesia in mandibular second premolars or in first and second molars

# Clinical studies
# Intraosseous anaesthesia

## 2.19. Replogle K, Reader A, Nist R, Beck M, Weaver J, Meyers W. "Cardiovascular effects of intraosseous injections of 2 percent lidocaine with 1:100,000 epinephrine and 3 percent mepivacaine. " JADA 1999; 130:649-57.

### Source

Graduate Endodontics, Ohio State University, Columbus 43210, USA.

### Abstract

**BACKGROUND:**

Because a number of patients have reported an increase in heart rate with the intraosseous, or i.o., injection, it is important to evaluate changes in the cardiovascular system with this injection technique. The purpose of this study was to determine the cardiovascular effects of an i.o. injection of 2 percent lidocaine with 1:100,000 epinephrine and 3 percent mepivacaine.

**METHODS:**

With the use of a repeated-measures design, the authors randomly assigned 42 subjects to receive i.o. injections of 1.8 milliliters of 2 percent lidocaine with 1:100,000 epinephrine or 1.8 mL of 3 percent mepivacaine in a double-blinded manner at two appointments. At each appointment the authors monitored electrocardiographic findings, cardiac rate, systolic and diastolic blood pressure, and mean arterial pressure before, during and after administration of anesthetic solutions.

**RESULTS:**

With the 2 percent lidocaine with 1:100,000 epinephrine solution, 28 (67 percent) of 42 subjects experienced an increase in heart rate that might be attributed to the effect of the epinephrine. In 22 (79 percent) of these subjects, the heart rate returned to within 5 beats of baseline values within four minutes after solution deposition. The authors found no significant increase in heart rate in subjects receiving the 3 percent mepivacaine. No significant differences ($P > .05$) were found in mean diastolic, mean systolic or mean arterial blood pressure values between the subjects receiving 2 percent lidocaine with 1:100,000 epinephrine and those receiving 3 percent mepivacaine.

**CONCLUSIONS:**

The majority of subjects receiving the i.o. injection of the 2 percent lidocaine-epinephrine solution experienced a transient increase in heart rate. No significant increase in heart rate was seen with the i.o. injection of 3 percent mepivacaine.

**CLINICAL IMPLICATIONS:**

While patients would likely notice the heart rate increase with the lidocaine-epinephrine solution, it would not be clinically significant in most healthy patients. In patients whose medical condition, drug therapies or epinephrine sensitivity suggests caution, 3 percent mepivacaine is a good alternative for i.o. injections.

## 2.20. Replogle K, Reader A, Nist R, Beck M, Weaver J, Meyers WJ. Anesthetic efficacy of the intraosseous injection of 2 percent lidocaine (1:100,000 epinephrine) and 3 percent mepivacaine in mandibular first molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;83:30-7.

### Source

Ohio State University, Columbus, USA.

### Abstract

**OBJECTIVES:**

This study compared the anesthetic efficacy of a primary intraosseous injection of 2% lidocaine with 1:100,000 epinephrine and 3% mepivacaine in human mandibular first molars. Injection pain and healing postoperatively were also assessed for the intraosseous injection.

**STUDY DESIGN:**

With the use of a repeated-measures design, 42 subjects randomly received intraosseous injections of 1.8 ml of 2% lidocaine with 1:100,000 epinephrine or 1.8 ml of 3% mepivacaine in a double-blind manner at two successive appointments. The first molar and adjacent teeth were blindly tested with an electric pulp tester at 2-minute cycles for 60 minutes. Anesthetic success was defined as no subject response to the maximum output of the pulp tester (80 reading) for two consecutive readings.

**RESULTS:**

Anesthetic success occurred in 74% of the first molars with 2% lidocaine with 1:100,000 epinephrine and in 45% with 3% mepivacaine. The difference was statistically significant ($p < 0.05$). Overall, onset was rapid for the intraosseous injections, the duration of pulpal anesthesia steadily declined over the 60 minutes, the majority of the subjects had no pain or mild pain with perforation and solution deposition, and 5% of the subjects had delayed healing at the perforation sites.

**CONCLUSIONS:**

The results of this study indicate that the primary intraosseous injection of 2% lidocaine with 1:100,000 epinephrine is more successful and results in a longer duration of pulpal anesthesia as compared with 3% mepivacaine in noninflamed mandibular first molars. Most subjects reported no or mild pain during perforation and injection.

## 2.21. White JJ, Reader A, Beck M, Meyers WJ. “The periodontal ligament injection: A comparison of the efficacy in human maxillary and mandibular teeth”. J Endodon 1988; 14:508-14.

The purpose of this study was to evaluate, with an electric pulp tester, the anesthetic efficacy of the periodontal ligament injection in human maxillary and mandibular teeth. The success rate of profound pulpal anesthesia was highest in the molar (75 to 79%) and premolar (58 to 63%) teeth, and lowest in the mandibular lateral incisors (18%). The duration of anesthesia was approximately 4 to 10 min. Distal teeth were anesthetized more successfully than mesial teeth. Initial needle penetration on the mesial was mildy to moderately discomforting; distal needle insertion and injection of solution were only mildy discomforting (the maxillary lateral incisors had significantly higher discomfort ratings). No increase in mobility was

observed 45 min following the injections. Postinjection discomfort was experienced by 86% of the subjects and 36% reported that their teeth felt high in occlusion. No clinically observable pulpal or periodontal damage was seen 4 wk postinjection, except in one maxillary molar.
This study was supported by research funding from the Ohio Association of Endodontists, J. David Brilliant Memorial Fund.
This article was adapted from a thesis submitted by Dr. White in partial fulfillment of the requirements for the MS degree at The Ohio State University, Columbus, OH. A portion of this article was presented at the 44th Annual Session of the American Association of Endodontists, San Antonio, TX.

## 2.22. Small JC, Whiterspoon DE, Regan JD, Hall E Procedural mishaps with trephine-based intraoesseous anesthesia. Tex Dent J. 2011 Jan;128(1):23-30

### Abstract

Failure to achieve profound anesthesia during dental treatment can be a significant problem for dental clinicians, especially for endodontic procedures on teeth in the mandibular arch with irreversible pulpitis. A number of supplemental local anesthesia techniques exist, the most effective of which may be the intraosseous injection. Two cases are presented demonstrating the dangers associated with the use of the intraosseous anesthesia technique. While the technique can provide profound anesthesia in otherwise difficult to anesthetize cases, care must be taken during its administration. Both cases show the damage done to the root and overlying bone by the injudicious use of the trephine. It is incumbent on the clinician to fully consider the anatomy in the area prior to insertion of the trephine. Intraosseous anesthesia techniques are a valuable addition to the clinicians' armamentarium. However careless administration can result in problems of endodontic or periodontal nature that may be difficult to rectify.

## 2.23. Woodmansey KF, White RK HeJ. Osteonecrosis related to intraosseous anesthesia: report a case J. Endod. 2009 Feb; 35 (2): 288-291.

Department of Graduate Endodontics, Baylor College of Dentistry, Dallas, TX 75246, USA. KFW@Prodigy.net

### Abstract

Intraosseous anesthesia is an effective and increasingly used technique with few reported complications. The technique uses a specialized drill to perforate the osseous cortex where local anesthetic can then be deposited to anesthetize teeth. It has been reported that separation of the perforation drills from their plastic bases can occur because of the friction generated during osseous perforation. Prolonged rotation of the perforator drills in the bone can also cause excessive heat, which can lead to bone necrosis. This report describes a case of focal osteonecrosis subsequent to intraosseous anesthesia and discusses possible etiologies of this sequela.

## 2.24. Nusstein JM, Reader A, Drum M. local anesthesia strategies for the patient with a "hot" tooth Dent. Clin North Am 2010 Apr. 54 (2); 237-47 Review

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### Abstract

Attaining local anesthesia for the treatment of teeth diagnosed with irreversible pulpitis ("hot" tooth) can be a challenge. This article looks at the strategies a dentist can use to help achieve adequate pulpal anesthesia for the patient, thereby eliminating or reducing treatment pain.

## 2.25. Vergleichende Bewertung verschiedener Arten einer ergänzenden Lokalanästhesie bei akuter Pulpitis

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### Zusammenfassung

Die Autoren vergleichen die klinische Wirksamkeit der folgenden ergänzenden Zahnanästhesietypen nach erfolgter Blockade des Nervus alveolaris inferior bei akuter Pulpitis: intraligamentäre, pulpale sowie intraossäre Anästhesie. Die Studie zeigt, dass die Blockade des Nervus alveolaris inferior als alleinige Anästhesiemethode bei akuter Pulpitis nicht immer wirksam ist. Durch den gemeinsamen Einsatz einer intraossären bzw. intraligamentären Anästhesie mit der Blockade des Nervus alveolaris inferior wird die lokalanästhetische Wirkung deutlich erhöht. Außerdem wird auf die schmerzfreie Durchführung dieser Anästhesiemethoden sowie die geringe Anzahl der nach der Injektion auftretenden Komplikationen hingewiesen.
Schlüsselwörter: akute Entzündung, intraligamentäre Anästhesie, pulpale Anästhesie, intraossäre Anästhesie, akute Pulpitis, ergänzende Anästhesie
Makeeva I.M., Erokhin A.I., Voronkova V.V., Kuzin A.V.

### Abstract

Authors of article have done a comparison clinical study of various methods additional anesthesia of teeth with an acute inflammation of pulp (irreversible pulpitis), after carrying out mandibular block: PDL anesthesia, intrapulpar anesthesia, intraosseus anaesthesia. By the results of the study it has been revealed that mandibular block as an independent anesthesia method was inefficient in most cases. PDL

anesthesia or intraosseus anaesthesia together with mandibular block allows to raise efficiency of local anesthesia. It is noted also painless of carrying out them and small quantity of postinjection complications.
Key words: acute inflammation, intraosseus anaesthesia, PDL anesthesia, intrapulpar anesthesia, irrevisibal pulpitis, additional anaesthesia

## 2.26. Nusstein, J., Kennedy, S., Reader, A., Beck, M. 6 Weaver, J. (2003) Anesthetic efficacy of the supplemental X-tip intraosseous injection in patients with irreversible pulpitis. J Endo 29,724-728

Department of Oral Biology, The Ohio State University, Columbus 43218, USA.

### Abstract

The purpose of this study was to determine the anesthetic efficacy of the supplemental intraosseous injection, using the X-tip system in an apical location, in mandibular posterior teeth diagnosed with irreversible pulpitis when the conventional inferior alveolar nerve block failed. Thirty-three emergency patients, diagnosed with irreversible pulpitis of a mandibular posterior tooth, received an inferior alveolar nerve block and had moderate-to-severe pain on endodontic access. The X-tip system was used to administer 1.8 ml of 2% lidocaine with 1:100,000 epinephrine. The X-tip injection site was 3- to 7-mm apical to the mucogingival junction of the affected tooth. Success of the X-tip intraosseous injection was defined as none or mild pain on endodontic access or initial instrumentation. The results of this study demonstrated that 6 of 33 (18%) X-tip injections resulted in backflow of anesthetic solution into the oral cavity; none were successful in obtaining anesthesia. Twenty-seven of the remaining 33 X-tip injections (82%) were successful. We conclude that when the inferior alveolar nerve block fails to provide profound pulpal anesthesia, the X-tip system, when used in an apical location and when there was no backflow of the anesthetic solution into the oral cavity, was successful in achieving pulpal anesthesia in mandibular posterior teeth of patients presenting with irreversible pulpitis.

## 2.27. Mc Lean et al: An evalution of 4% prilocaine and 3% mepivacaine compared with 2% lidocaine 1:100,00 epinephrine for inferior alveolar nerve block J Endodon 1993; 19:146-50

### Source

Department of Endodontics, College of Dentistry, Ohio State University, Columbus.

### Abstract

The purpose of this study was to measure the degree of anesthesia obtained with 4% prilocaine and 3% mepivacaine compared with 2% lidocaine (1:100,000 epinephrine) for inferior alveolar nerve block. Using a repeated measures design, 30 subjects randomly received an inferior alveolar injection using masked cartridges of each solution at three successive appointments. The first molar, first premolar, lateral incisor, and contralateral canine (control) were blindly tested with an Analytic Technology pulp tester at 3-min cycles for 50 min. Anesthetic success was defined as no subject response to the maximum output of the pulp tester (80 reading) within 16 min and maintenance of this reading for 50 min. Although subjects felt numb subjectively, anesthetic success as defined here occurred in 43 to 63% of the molars,

in 53 to 67% of the premolars, and in 30 to 37% of the lateral incisors. No statistically significant differences in onset, success, or failure were found among the solutions. We conclude that the three preparations are equivalent for an inferior alveolar nerve block of 50-min duration

## 2.28. Haase A, ReaderA, Nusstein J, Beck M, Drum M. Comparing anesthetic efficacy of articaine versus lidocaine as supplemental buccal infiltration of mandibular first molar after an inferior alveolar nerve block. J Am Dent Assoc 2008;139;1228-1235

### Source

Endodontics, College of Dentistry, The Ohio State University, Columbus, OH 43210, USA.

### Erratum in

J Am Dent Assoc. 2008 Oct;139(10):1312.

### Abstract

**BACKGROUND:**

The authors conducted a prospective, randomized, double-blind, crossover study comparing the degree of pulpal anesthesia achieved by means of mandibular first molar buccal infiltrations of two anesthetic solutions: 4 percent articaine with 1:100,000 epinephrine and 2 percent lidocaine with 1:100,000 epinephrine after an inferior alveolar nerve (IAN) block with the use of 4 percent articaine with 1:100,000 epinephrine.

**METHODS:**

Seventy-three blinded adult subjects randomly received buccal infiltrations at the first molar site with a cartridge of 4 percent articaine with 1:100,000 epinephrine at one appointment and a cartridge of 2 percent lidocaine with 1:100,000 epinephrine at another appointment after receiving a standard IAN block with the use of 4 percent articaine with 1:100,000 epinephrine in a crossover design. After the injections, the authors used an electric pulp tester to test the first molar for anesthesia in three-minute cycles for 60 minutes. They considered anesthesia to be successful when two consecutive 80 readings were obtained within 10 minutes of the IAN block and infiltration injection, and the 80 reading was sustained continuously through the 60th minute.

**RESULTS:**

The authors found that with the use of the 4 percent articaine formulation, successful pulpal anesthesia occurred 88 percent of the time for the first molar. With the 2 percent lidocaine formulation, successful pulpal anesthesia occurred 71 percent of the time. The results show a significant difference ($P < .05$) between the articaine and lidocaine formulations.

**CONCLUSION AND CLINICAL IMPLICATIONS:**

For a mandibular buccal infiltration of the first molar after a standard IAN block, 4 percent articaine with 1:100,000 epinephrine resulted in a higher success rate (88 percent) than did 2 percent lidocaine with 1:100,000 epinephrine (71 percent success rate).

## 2.29. Pabst L, Nusstein J, Drum M, Reader A, Beck M.. The efficacy of a repeated buccal infiltration of articaine in prolonging duration of pulpal anesthesia in the mandibular first molar. Anest Prog 2009;56:128-134

The Ohio State University, Columbus, Ohio 43210, USA.

### Abstract

Previous studies have shown declining rates of pulpal anesthesia over 60 minutes when a cartridge of 4% articaine is used with 1:100,000 epinephrine for buccal infiltration in the mandibular first molar. The authors conducted a prospective, randomized, single-blind, crossover study comparing the degree of pulpal anesthesia obtained with 2 sets of mandibular first molar buccal infiltrations, given in 2 separate appointments, to 86 adult subjects: an initial infiltration of a cartridge of 4% articaine with 1:100,000 epinephrine plus a repeated infiltration of the same anesthetic and dose given 25 minutes following the initial infiltration versus an initial infiltration of a cartridge of 4% articaine with 1:100,000 epinephrine plus a mock repeated infiltration given 25 minutes following the initial infiltration. The authors used an electric pulp tester to test the first molar for anesthesia in 3-minute cycles for 112 minutes after the injections. The repeated infiltration significantly improved pulpal anesthesia from 28 minutes through 109 minutes in the mandibular first molar. A repeated infiltration of a cartridge of 4% articaine with 1:100,000 epinephrine given 25 minutes after an initial infiltration of the same type and dose of anesthetic significantly improved the duration of pulpal anesthesia, when compared with only an initial buccal infiltration, in the mandibular first molar

## 2.30. Nuzum FM, Drum M, Nusstein J, Reader A, Beck M. Anesthetic efficacy of articaine for a combination labial plus lingual infiltration versus a labial infiltration in the mandibular lateral incisor. J Endod 2010;36:952-956

Division of Endodontics, College of Dentistry, The Ohio State University, Columbus, Ohio 43210, USA.

### Abstract

**INTRODUCTION:**

Previous studies have shown higher success rates when using an articaine formulation versus a lidocaine formulation for buccal mandibular first molar infiltrations. However, there is little information on articaine's effect in mandibular anterior teeth.

**METHODS:**

The authors conducted a prospective, randomized, single-blind, crossover study comparing the degree of pulpal anesthesia obtained with 2 sets of mandibular lateral incisor infiltrations given in 2 separate appointments in 82 adult subjects. One set of infiltrations consisted of an initial labial infiltration of a cartridge of 4% articaine with 1:100,000 epinephrine plus a lingual infiltration of the same anesthetic and dose. The other set of infiltrations consisted of an initial labial infiltration of a cartridge of 4% articaine with 1:100,000 epinephrine plus a mock lingual infiltration. The authors used an electric pulp tester to test the lateral incisor for pulpal anesthesia in 2-minute cycles for 60 minutes after the injections.

**RESULTS AND CONCLUSIONS:**

The labial plus lingual infiltration significantly improved the success rate (no response to 2 consecutive 80 readings with the pulp tester) to 98% when compared with a labial infiltration of a cartridge of the same articaine formulation (76% success). The combination labial and lingual infiltrations did not provide pulpal anesthesia for an hour.


## 2.31. Nusstein J, Wood M, Reader A, Beck M, Weaver J. Comparison of the degree of pulpal anesthesia achieved with the intraosseous injection and infiltration injection using 2% lidocaine with 1:100,00 epinephrine. Gen Dent 2005;53:50-53

Department of Endodontics, The Ohio State University, Columbus, USA.

### Abstract

This prospective, randomized study compared the degree of pulpal anesthesia obtained from an intraosseous injection to an infiltration injection that used 2% lidocaine with 1:100,000 epinephrine. The success rate for the intraosseous injection was 98%; for the infiltration injection, the success rate was 85%. There was no significant difference between the two techniques. The mean time for the onset of pulpal anesthesia was significantly faster with the intraosseous injection and the infiltration injection resulted in a significantly longer duration of pulpal anesthesia

## 2.32. Gallatin J, Reader A, Nusstein J, Beck M, Weaver J. A comparison of two intraosseous anesthetic techniques in mandibular posterior teeth. J Am Dent Assoc 2003;134:1476-1484

The Ohio State University, College of Dentistry, Columbus 43218, USA.

### Abstract

**BACKGROUND:**

A number of studies have evaluated the Stabident (Fairfax Dental, Miami) intraosseous anesthesia technique. A second intraosseous technique--the X-tip system (X-tip Technologies, Lakewood, N.J.)--has been introduced, but no scientific studies have yet compared its effectiveness to that of the Stabident system. The authors undertook a study to compare the two systems' anesthetic outcomes in primary intraosseous injections in mandibular posterior teeth.

**METHODS:**

The authors, using a crossover design, randomly administered a primary Stabident intraosseous injection and a primary X-tip intraosseous injection, at two separate appointments, to 41 subjects. Subjects were asked if they perceived an increase in heart rate with the intraosseous injections. The research team blind-tested each subject's first molar, second molar and second premolar with a pulp tester at two-minute cycles for 60 minutes after the injection. Anesthesia was considered successful when two consecutive pulp tester readings of 80 were obtained.

**RESULTS:**
Anesthetic success rates for the Stabident technique and the X-tip technique, respectively, were 93 percent and 93 percent for the first molar; 95 percent and 95 percent for the second molar; and 81 percent and 83 percent for the second premolar, with no significant differences (P > .05) between the two techniques. For both intraosseous techniques, onset of pulpal anesthesia occurred within the first two minutes, but the duration of anesthesia declined steadily over the 60 minutes. Eighty-five percent of the subjects had a perceived increase in heart rate with the Stabident injection and 93 percent with the X-tip injection, with no significant differences (P > .05) between the techniques.
**CONCLUSIONS AND CLINICAL IMPLICATIONS:**
The two primary intraosseous injection techniques were similar regarding anesthetic success, onset, duration and perceived heart rate increases.

## 2.33. Gallatin J, Reader A, Nusstein J, Beck M, Weaver J. A comparison of injection pain and postoperative pain of two intraosseous anesthetic techniques. Anesth Prog 2003;50:288-120

The Ohio State University, Columbus, Ohio 43210, USA.

### Abstract

The purpose of this prospective, randomized, blinded study was to compare injection pain and postoperative pain of an apical primary X-Tip intraosseous technique to a coronal primary Stabident intraosseous technique in mandibular first molars. Using a repeated-measures design, 41 subjects randomly received 2 primary intraosseous injections at 2 separate appointments. Using a site distal to the mandibular first molar for both injections, the subjects received 1.8 mL of 2% lidocaine with 1: 100,000 epinephrine administered with the X-Tip system using an apical location in alveolar mucosa or 1.8 mL of 2% lidocaine with 1: 100,000 epinephrine administered with the Stabident system using a coronal location in attached gingiva. The pain of infiltration, perforation, needle insertion, solution deposition, mock or actual guide sleeve removal and postoperative pain were recorded on a Heft-Parker visual analogue scale (VAS) scale for the 2 intraosseous systems. The results demonstrated that the apical primary X-Tip intraosseous technique was not statistically different (P > .05) from the coronal primary Stabident technique regarding pain ratings of infiltration, perforation, needle insertion, solution deposition, mock or actual guide sleeve removal and postoperative pain (at the time subjective anesthesia wore off). However, on postoperative days 1 through 3, significantly (P < .05) more males experienced postoperative pain with the X-Tip system than with the Stabident system.

## 2.34. Reitz J, Reader A, Nist R, Beck M, Meyers WJ. Anesthetic efficacy of the intraosseous injection of 0.9ml of 2% lidocaine (1:100,00 epinephrine9 to augament an inferior alveolar nerve block. Oral Surg Oral med Oral Pathol Oral Radiol Endod 1998;86:516-523

Ohio State University, Columbus, USA.

### Abstract

**OBJECTIVE:**

The purpose of this study was to determine the anesthetic efficacy of an intraosseous injection of 0.9 mL of 2% lidocaine with 1:100,000 epinephrine to augment an inferior alveolar nerve block in mandibular posterior teeth.

**STUDY DESIGN:**

With the use of a repeated-measures design, each of 38 subjects randomly received one or the other of 2 combinations of injections at 2 separate appointments. The combinations were inferior alveolar nerve block + intraosseous injection (on the distal of the second premolar) through use of 0.9 mL of 2% lidocaine with 1:100,000 epinephrine and inferior alveolar nerve block + mock intraosseous injection. The first molar, second premolar, and second molar were blindly tested with an Analytic Technology pulp tester at 2-minute cycles for 120 minutes postinjection. Anesthesia was considered successful when 2 consecutive 80 readings were obtained.

**RESULTS:**

One hundred percent of the subjects had lip numbness with the inferior alveolar nerve block + intraosseous injection combination technique. The respective anesthetic success rates for the inferior alveolar nerve block + mock intraosseous injection combination and the inferior alveolar nerve block + intraosseous injection combination were 60% and 100% for the second premolar, 71% and 95% for the first molar, and 74% and 87% for the second molar. The differences were significant ($P < .05$) for the second premolar through 50 minutes and for the first molar through 20 minutes. There were no significant ($P > .05$) differences for the second molar. Sixty-eight percent of the subjects had a subjective increase in heart rate with the intraosseous injection.

**CONCLUSIONS:**

The results of this study indicate that the supplemental intraosseous injection of 0.9 mL of 2% lidocaine with 1:100,000 epinephrine, given distal to the second premolar, significantly increased the success of pulpal anesthesia in the second premolar (for 50 minutes) and first molar (for 20 minutes) in comparison with the inferior alveolar nerve block alone. The intraosseous injection did not statistically increase success in the second molar

## 2.35. Stabile P, Reader A, Gallatine E, Beck M, Weaver J. Anesthetic efficacy and haert rate effects of the intraosseous injection of 1.5% etidocaine (1:200,00 epinephrine) after an inferior alveolar nerve block. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000;89:407-411

The Ohio State University, College of Dentistry, Columbus, OH 43210, USA.

### Abstract

**OBJECTIVE:**

The purpose of this study was to determine the anesthetic efficacy and heart rate effects of an intraosseous (IO) injection of 1.5% etidocaine with 1:200,000 epinephrine after an inferior alveolar nerve block.

**STUDY DESIGN:**

In a repeated-measures designed study, 48 subjects randomly received 2 combinations of injections at 2 separate appointments. The combinations were an inferior alveolar nerve (IAN) block (with 3% mepivacaine) + IO injection with 1.8 mL of 1.5% etidocaine hydrochloride containing 1:200,000 epinephrine, and an IAN + mock IO injection. The first molar was blindly tested with a pulp tester at 2-minute cycles for 60 minutes after the injection. Anesthesia was considered successful when 2 consecutive 80 readings (no subject response) were obtained. Heart rate (pulse rate) was measured with a pulse oximeter.

**RESULTS:**

Lip numbness occurred in 100% of the subjects with both the techniques. For the first molar, anesthetic success for the IAN + mock IO and the IAN + IO etidocaine hydrochloride groups, respectively, were 81% and 100%. The differences were significant (P <.05) when the IAN + IO etidocaine hydrochloride technique was compared with the IAN + mock IO. A mean increase in heart rate of 32 beats/min occurred in 90% of the subjects with the IO injection of the etidocaine hydrochloride solution. In 89% of these subjects, the heart rate returned to within 5 beats of baseline values 4 minutes or less after solution deposition.

**CONCLUSIONS:**

The IO injection of 1.8 mL of 1.5% etidocaine hydrochloride with 1:200,000 epinephrine, when used to augment an inferior alveolar nerve block, significantly increased anesthetic success in the first molar. The majority of subjects receiving the IO injection of the etidocaine hydrochloride solution had a transient increase in heart rate

## 2.36. Chamberlain T, Davis R, Murchison D, Hansen S, RichardsonB. Systemic effects of an intraosseous injection of 2% lidocaine with 1:100,00 epinephrine. Gen Dent 200;48:299-302

### Abstract

The effect of a mandibular intraosseous injection of 2% lidocaine with 1:100,000 epinephrine on the heart rate and blood pressure of 20 volunteer patients was examined. Changes in blood pressure from preoperative levels were minimal and did not vary significantly at any time of measurement. The only

statistically significant change in heart rate occurred immediately after the intraosseous injection (an increase of 12 beats per minute). In young healthy adults, the intraosseous injection of 1.5 mL of 2% lidocaine with 1:100,000 epinephrine resulted in a slight transient elevation in heart rate but had no significant effect on systolic or diastolic blood pressure

## 2.37. Sixou JL, Barbosa-Rogier ME. Efficacy of intraosseous injection of anesthetic in children and adolescents. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:173-178

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### Abstract

**OBJECTIVE:**

The goal of this study was to determine the efficacy of the intraosseous (IO) injections of anesthetic as a primary technique in children and adolescents.

**STUDY DESIGN:**

A cohort of 181 children and adolescents underwent a total of 225 sessions of IO injections of 4% articaine with 1:200,000 epinephrine using the Quick Sleeper 2 system.

**RESULTS:**

Evaluations could be performed in 215 sessions (171 patients, 247 teeth), yielding success rates of 91.2% (sessions) and 91.9% (teeth). The success rate was 95% (133 of 140) for temporary teeth (endodontics 96.6%, restorations 100%, extractions 88%) and 87.9% (94 of 107) for permanent teeth (endodontics 92.3%, restorations 89.9%, extractions 75%). No difference was noted in terms of age ($P > .05$). No cases of biting of mucosa or postinjection pain were noted.

**CONCLUSIONS:**

The IO injection of anesthetic using a computer-controlled osseous perforation and delivery system can be considered as a good alternative or supplement to classic infiltration techniques in children and adolescents.

## 2.38. Prophic S, Sulejmanagic H, Secic S. The efficacy of supplemental intraosseous anesthesia after insufficient mandibular block. Bosn J Basic Med SCi 2005;5:57-60

Department of Oral Surgery and Oral Medicine, School of Dental Medicine, Bolnicka 4a, 71000 Sarajevo, Bosnia and Herzegovina.

### Abstract

It is a well-known scientific fact that only a small percentage of infiltration of inferior alveolar nerve is clinically proven to be efficient. The objective of this study was to determine the anesthetic efficacy of supplemental intraosseous injection, used after the insufficient classical mandibular block that didn't provide deep pulp anesthesia of mandibular molar planed for extraction. The experimental teeth consisted of 98 mandibular molars with clinical indication for extraction. Based on the history of disease,

we indicated the extraction of the tooth. After that each tooth was tested with a electric pulp tester P1. We tested the pulp vitality and precisely determined the level of vitality. After that, each patient received classical mandibular block, and the pulp vitality was tested again. If the pulp tester indicated negative vitality for the certain mandibular molar, and the patient didn't complain about pain or discomfort during the extraction, the molar was extracted and the result was added to anesthetic success rate for the classical mandibular block. If, five minutes after receiving the mandibular block, the pulp tester indicated positive vitality (parameters of vitality) or the patient complained about pain or discomfort (parameters of pain and discomfort), we used the Stabident intraosseous anesthesia system. Three minutes after the application of supplemental intraosseous injection the molar was tested with the pulp tester again. The anesthetic solution used in both anesthetic techniques is lidocaine with 1:100.000 epinephrine. The results of this study indicate that the anesthetic efficacy of the mandibular block is 74.5%, and that supplemental intraosseous anesthesia, applied after the insufficient mandibular block, provides pulpal anesthesia in 94.9% of mandibular molars. The difference between anesthetic efficacy of the classical mandibular block and anesthetic efficacy of the supplemental intraosseous anesthesia, applied after the insufficient mandibular block, is obvious

## 2.39. Jensen J, Nusstein J, Drum M, Reader A, Beck M. Anesthetic efficacy of a repeated intraosseous injection following a primary intraosseous injection. J Endod 2008;34:126-130

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### Abstract

The purpose of this prospective, randomized, single-blinded study was to determine the anesthetic efficacy of a repeated intraosseous injection given 30 minutes after a primary intraosseous injection. Using a crossover design, 55 subjects randomly received a primary X-tip intraosseous injection (Dentsply Inc, York, PA) of 1.4 mL of 2% lidocaine with epinephrine (using the Wand; Milestone Scientific, Deerfield, IL) and a repeated intraosseous or mock injection at 30 minutes in two appointments. The first molar and adjacent teeth were pulp tested every 2 minutes for a total of 120 minutes. Success was defined as obtaining two consecutive 80 readings with the electric pulp tester. Success of the initial intraosseous injection was 100% for the first molar. The repeated intraosseous injection mimicked the initial intraosseous injection in terms of pulpal anesthesia and statistically provided another 15 minutes of pulpal anesthesia. In conclusion, using the methodology presented, repeating the intraosseous injection 30 minutes after an initial intraosseous injection will provide an additional 15 minutes of pulpal anesthesia

# Clinical studies
# Intraosseous anaesthesia

## 2.40. Wood M, Reader A, Nusstein J, Beck M, Padget D, Weaver J. Comparison of intraosseous and infiltration injections for venous lidocaine blood concentrations and heart rate changes after injection of 2% lidocaine with 1:100,00 epinephrine. J Endod 2005;31:435-438

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### Abstract

The purpose of this prospective, randomized study was to compare the venous blood levels of lidocaine and heart rate changes after intraosseous and infiltration injections of 1.8 ml of 2% lidocaine with 1:100,000 epinephrine. Using a crossover design, 20 subjects randomly received an intraosseous and infiltration injection at two separate appointments. The heart rate was measured using a pulse oximeter. Venous blood samples were collected before the injections and at 2, 5, 10, 15, 20, 25, 30, 45, and 60 min after the injections. The blinded plasma samples were analyzed for lidocaine concentrations using high-performance liquid chromatography (HPLC). The intraosseous injection resulted in a statistically significant increase in heart rate, when compared to the infiltration injection, during solution deposition and for 2 min after the injection. The plasma levels of lidocaine were not statistically different for maxillary anterior intraosseous and infiltration injections when using 1.8 ml of 2% lidocaine with 1:100,000 epinephrine.

## 2.41. Susi L, Reader A, Nusstein J, Beck M, Weaver J, Drum M. Heart rate effects if intraosseous injection using slow and fast rates of anesthetic solution deposition. Anesth Prog 2008;55:9-15

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### Abstract

The authors, using a crossover design, randomly administered, in a single-blind manner, 3 primary intraosseous injections to 61 subjects using: the Wand local anesthetic system at a deposition rate of 45 seconds (fast injection); the Wand local anesthetic system at a deposition rate of 4 minutes and 45 seconds (slow injection); a conventional syringe injection at a deposition rate of 4 minutes and 45 seconds (slow injection), in 3 separate appointments spaced at least 3 weeks apart. A pulse oximeter measured heart rate (pulse). The results demonstrated the mean maximum heart rate was statistically higher with the fast intraosseous injection (average 21 to 28 beats/min increase) than either of the 2 slow intraosseous injections (average 10 to 12 beats/min increase). There was no statistically significant difference between the 2 slow injections. We concluded that an intraosseous injection of 1.4 mL of 2% lidocaine with 1 : 100,000 epinephrine with the Wand at a 45-second rate of anesthetic deposition resulted in a significantly higher heart rate when compared with a 4-minute and 45-second anesthetic solution deposition using either the Wand or traditional syringe.