# Comparison of the Anesthetic Efficacy between Bupivacaine and Lidocaine in Patients with Irreversible Pulpitis of Mandibular Molar

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## Abstract

**Introduction:** The purpose of this study was to compare the anesthetic efficacy of 0.5% bupivacaine with 1:200,000 epinephrine with that of 2% lidocaine with 1:100,000 epinephrine during pulpectomy in patients with irreversible pulpitis in mandibular posterior teeth. **Methods:** Seventy volunteers, patients with irreversible pulpitis admitted to the Emergency Center of the School of Dentistry at the University of São Paulo, randomly received a conventional inferior alveolar nerve block containing 3.6 mL of either 0.5% bupivacaine with 1:200,000 epinephrine or 2% lidocaine with 1:100,000 epinephrine. During the subsequent pulpectomy, we recorded the patients' subjective assessments of lip anesthesia, the absence/presence of pulpal anesthesia through electric pulp stimulation, and the absence/presence of pain through a verbal analog scale. **Results:** All patients reported lip anesthesia after the application of either inferior alveolar nerve block. By measuring pulpal anesthesia success with the pulp tester, lidocaine had a higher success rate (42.9%) than bupivacaine (20%). For patients reporting none or mild pain during pulpectomy, the success rate of bupivacaine was 80% and lidocaine was 62.9%. There were only statistically significant differences to the success of pulpal anesthesia. **Conclusions:** Neither of the solutions resulted in an effective pain control during irreversible pulpitis treatments of mandibular molars. *(J Endod 2012;38:594–597)*

## Key Words

Bupivacaine, inferior alveolar nerve block, irreversible pulpitis, lidocaine

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Conventional inferior alveolar nerve block (IANB) is the most commonly used technique for achieving pulpal anesthesia in posterior mandibular endodontic procedures (1–7). However, IANB has a high failure rate (2, 7, 8), and success rates are even lower when applied for the treatment of mandibular posterior teeth with irreversible pulpitis (2, 8–12).

No study has tested the effect of bupivacaine in IANB in patients with irreversible pulpitis. The use of bupivacaine, a long-lasting local anesthetic, could be considered for providing anesthesia during endodontic treatment as well as in the postoperative period because it has been observed that patients undergoing single-session root canal treatment experience a slightly higher frequency of edema and have reported significantly more use of analgesics (13, 14). For several decades, bupivacaine hydrochloride has been used in oral surgery for the removal of third molars because swelling and postoperative pain are expected in these cases (15–19). The purpose of this study was to compare the anesthetic efficacy of 0.5% bupivacaine plus 1:200,000 epinephrine with 2% lidocaine plus 1:100,000 epinephrine for IANBs in patients with mandibular molars experiencing pulpitis.

## Materials and Methods

Seventy adult patients (n = 70) were included in this prospective, randomized, double-blind clinical study. All patients were admitted to the Emergency Center of the School of Dentistry at the University of São Paulo with a clinical diagnosis of irreversible pulpitis in the first or second lower molar. Patients had moderate to severe spontaneous pain and exhibited a positive response to the electric pulp test and a prolonged response to cold testing with Endo-Frost (Coltene-Roeko, Langenau, Germany). To be included in the study, the patients had to be between 18 and 50 years old and in good health as established according to a health history questionnaire. Each participant had at least 1 molar adjacent to a molar presenting irreversible pulpitis and a healthy contralateral canine with no deep carious lesions, extensive restoration, advanced periodontal disease, a history of trauma, or sensitivity. Patients making use of medication that could potentially interact with any of the anesthetics used in the study were excluded. The study was approved by the Committee on the Ethics of Research on Human Beings of the School of Dentistry at the University of São Paulo (protocol 34/2010), and each patient was asked to provide written informed consent.

The methodology was adopted as described earlier (12). The 70 patients were divided into 2 groups of 35 patients who received IANB injections of 3.6 mL (equivalent to 2 cartridges) of either 2% lidocaine (Alphacaine 100; DFL, Rio de Janeiro, RJ, Brazil) with 1:100,000 epinephrine or 0.5% bupivacaine (Neocaine 0.5%; Cristália, Itapira, SP, Brazil) with 1:200,000 epinephrine, respectively. To ensure the blindness of the study, 2 cartridges (3.6 mL) of either anesthetic solution were sealed in envelopes. At the time of application, the senior researcher who administered the 2 consecutive anesthesia injections chose 1 of the envelopes at random. Electric pulp stimulations to assess pulpal anesthesia and the pulpectomy were performed by a different professional to guarantee that the anesthetic solution remained unknown, thus maintaining the double

blindness of the study. Two consecutive negative responses to the maximum pulp stimulus (80 $\mu$A) were the criteria to determine a pulpal anesthesia as successful.

Previous to the IANB injections, the molar tooth with irreversible pulpitis, the adjacent molar tooth, and the contralateral canine were tested for pulp vitality with an electric pulp stimulator (Vitality Scanner 2006; SybronEndo, Orange, CA). The electric pulp stimulation of the contralateral canine, which had not been anesthetized, was used as a control to ensure that the equipment was working properly and that patients were responding adequately.

For the injections, we used a side-loading carpule syringe fitted with a 27-G 0.4 × 35-mm needle (Teruno Dental Needle; DFL Indústria e Comércio Ltda, Rio de Janeiro, RJ, Brazil) and equipped with a blood aspiration device and a thumb ring (Können; Kennen Indústria e Comércio Ltda, São Paulo, Brazil). Blood aspiration tests were performed before each anesthesia injection as well as when changing the needle position. The 2 cartridges of the respective anesthetic solution were applied as follows. In the first step of the first anesthesia (1 cartridge, 1.8 mL), the needle was introduced 3- to 5-mm deep, the blood was aspirated, and approximately 0.3 mL of the anesthetic solution was injected. In the second step, the syringe was directed to the premolar region of the opposite side, where the needle was inserted until establishing bone contact. Thereafter, the needle was withdrawn 1–2 mm, the blood was aspirated, and the remaining 1.5 mL of anesthetic solution was slowly injected. The second anesthesia (1 cartridge, 1.8 mL) was initiated immediately after the second step of the first anesthesia. The average injection time for each cartridge was approximately 2 minutes.

Ten minutes after the IANB, we evaluated the subjective lip anesthesia by asking the patient whether his/her lip was numb. Thereafter and immediately before the pulpectomy, the electric pulp stimulations were repeated to determine pulpal anesthesia. During the pulpectomy procedure, the patients were instructed to report any painful sensation. To evaluate the intensity of pain during the pulpectomy, the following verbal analog scale was adopted: 0, no pain; 1, mild, bearable pain; 2, moderate, unbearable pain; and 3, severe, intense, and unbearable pain. The anesthesia was considered successful when the dentist accessed the pulp chamber without the patient reporting pain (pain scores 0 or 1). In these cases, the pulpectomy procedure was continued. Pain scores of 2 or 3 classified the IANB as unsuccessful. In these cases, periodontal ligament injections or, if necessary, an intrapulpal anesthesia was performed, and the pulpectomy procedure was over.

The responses to the electric pulp tester (negative or positive) and the pain recorded in the 2 test groups under different anesthetic solutions were compared by using the chi-square test. Potential differences in age between the 2 groups were analyzed with the Mann-Whitney *U* test. The distribution of the types of teeth with irreversible pulpitis and sex in both groups were compared with the chi-square test. For all performed tests, the level for significance of differences was $P \leq .05$.

## Results

We found no statistically significant differences between sex distribution (bupivacaine group, 54.3% female; lidocaine group, 54.3% female; $P = 1.00$), age (average age: bupivacaine group, 29.4 years; lidocaine group, 32.3 years; $P = .8$), and the types of teeth with irreversible pulpitis ($P = .47$) between the 2 groups (Table 1); consequently, the results obtained with both anesthetic solutions can be directly compared.

All 70 patients (100%) reported subjective lip anesthesia 10 minutes after the IANB. Before initiation of the pulpectomy procedure, 15 patients (42.9%) in the lidocaine group and 7 patients (20%) in the bupivacaine group exhibited pulpal anesthesia (Fig. 1) (ie, a negative response to electrical stimuli generated with an electric pulp tester). A significant difference between the 2 experimental groups for the pulpal anesthesia was observed, with more individuals in the lidocaine group presenting a negative response to electrical stimuli ($P = .039$) (Fig. 1). During the pulpectomy, 7 patients in the bupivacaine group (20%) and 13 in the lidocaine group (37.1%) reported pain (pain scores 2 and 3). This difference was not statistically significant ($P = .112$) (Fig. 2).

**TABLE 1.** Types of Teeth with Irreversible Pulpitis (actual frequency and percentage of afflicted teeth in both experimental groups)

| | Tooth | | |
|---|---|---|---|
| Group | First molar | Second molar | Total |
| Bupivacaine (%) | 20 (57.1) | 15 (42.9) | 35 (100) |
| Lidocaine (%) | 17 (48.6) | 18 (51.4) | 35 (100) |
| Total (%) | 37 (52.9) | 33 (47.1) | 70 (100) |

## Discussion

In this study, we have shown that although both local anesthetic solutions resulted in profound lip anesthesia after application, pulpal anesthesia was not necessarily achieved, which is in agreement with other studies (7, 12, 20–22). We also agree with Wali et al (23) that asking the patient if the lip is numb only indicates soft-tissue anesthesia but does not guarantee successful pulpal anesthesia and that the time of onset of lip numbness might not indicate the onset of pulpal anesthesia. Our results found that only 15 patients (42.9%) in the lidocaine group and 7 patients (20%) in the bupivacaine group exhibited pulpal anesthesia (Fig. 1); the difference between groups was statistically significant.

The use of the 80-$\mu$A reading (maximum output of the pulp tester) as a criterion for pulpal anesthesia was based on the studies of Dreven et al (24) and Certosimo and Archer (25). These studies showed that no patient response to an 80 reading ensures pulpal anesthesia in vital asymptomatic teeth. In addition, Certosimo and Archer (25) showed that electric pulp testing readings lower than 80 resulted in pain during

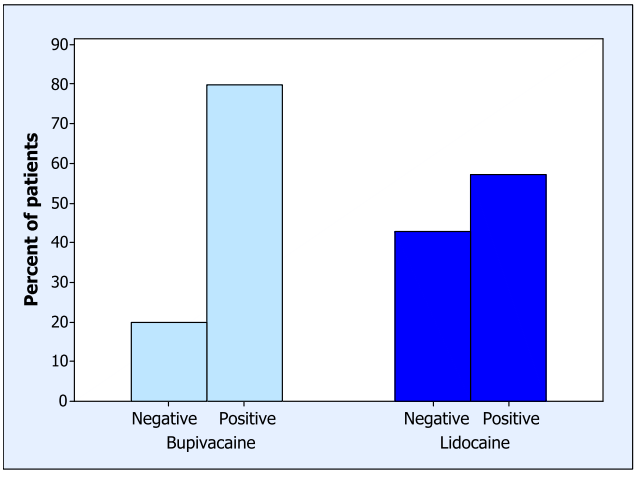


**Figure 1.** A bar graph of responses to the pulp tester (percentage) after the respective IANB solutions (0.5% bupivacaine with 1:200,000 epinephrine and 2% lidocaine with 1:100,000 epinephrine).

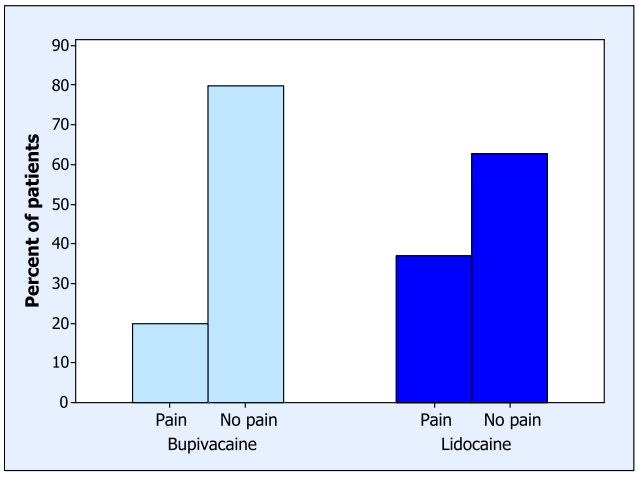


**Figure 2.** A bar graph of the occurrence of pain (percentage) after the respective IANB solutions (0.5% bupivacaine with 1:200,000 epinephrine and 2% lidocaine with 1:100,000 epinephrine).

operative procedures in asymptomatic teeth, and the pulp test reading of 80 does not always guarantee clinical analgesia in irreversible pulpitis.

Recent studies (9, 10, 12) have also shown that pulpal anesthesia is not a reliable indicator for actual analgesia. Therefore, a negative electric pulp test is no guarantee for pulpal anesthesia in irreversible pulpitis. On the contrary, in the present study, we found pulpal anesthesia (as determined by a positive response to stimuli lower than 80 $\mu$A) absent in 80% of patients in the bupivacaine group. However, analgesia was present during pulpectomy in 80% of the patients. Therefore, the pulpal anesthesia was confirmed by the pulp tester (as determined by a negative response to a maximum stimulus of 80 $\mu$A) in only 20% of the patients.

One of the possible reasons for the disparity of this positive response to the electric test but a negative response to pain during the pulpectomy may be the false-positive responses that might occur when the pulp tester is used, as previously mentioned (26). False-positive responses can also be involved with the complex mechanism of neuroinflammatory and neuropulpal interactions (nerve-odontoblast interactions), which still need to be clarified (27). There are suppositions to relate the type of intrapulpal sensory nerve fibres (A-delta and A-beta myelinated fibers and unmyelinated C fibers) to clinical pulp testing methods (28). (A-delta fibers are those stimulated in electric pulp testing because of their distribution, larger diameter than that of C fibers, their conduction speed, and their myelin sheath, whereas C fibers do not respond to electric pulp testing because of their high threshold; therefore, a stronger electric current is needed to stimulate them.)

Another possible reason for this disparity is the existing controversy on the onset period of bupivacaine in blocking the inferior alveolar nerve. We cannot ensure that the 10-minute waiting period previous to the early pulp vitality test was enough for the anesthesia to act on the molars pulp. Therefore, this fact can explain the positive response to the pulp tester. However, when the pulpectomy was performed, >10 minutes had certainly passed because the pulpectomy was only started after the conclusion of the pulpal electric tests, which were performed for 2 consecutive times on the 3 teeth (adjacent molar, molar with pulpitis and contralateral canine) and the pulpal anesthesia may have been achieved.

The rate of the onset anesthetic action is related to the $pk_a$ of the local anesthetic solution. Bupivacaine has a $pk_a$ of 8.1, whereas lidocaine has a $pk_a$ of 7.7. Therefore, at a tissue pH of 7.4, bupivacaine would have fewer anesthetic molecules available in the free base form to diffuse through the nerve membrane; the result is a slower onset (29). According to Malamed (29), the onset of pulpal anesthesia of lidocaine is 2 to 3 minutes and bupivacaine is 6 to 10 minutes.

It is difficult to compare the results of the previous studies with the current study because of the different methodologies used. We found 4 studies (21, 22, 30, 31) that compared the pulpal anesthesia of lidocaine with bupivacaine solutions using an electric pulp stimulator, but vital asymptomatic teeth were tested instead. Additionally, in 1 case (30), the maxillary infiltration technique was used.

In a sample of 32 patients, Volpato et al (31) found an onset period of 14 minutes in the IANB in asymptomatic teeth. Nevertheless, in 7 patients, this time was over 17 minutes, and in 5 patients it did not reach pulpar anesthesia. Branco et al (22), in a sample of 30 patients, found an onset period of <10 minutes, except for 3.3% of the molars studied, whereas Fernandez et al (21), in a sample of 39 patients, found 13.9 and 10.7 minutes, respectively, for the first and second molars. Previous studies have reported the onset of bupivacaine to be <10 minutes (15–17, 32), but the methodology used in these studies was different than the 1 of the current study and no electric pulp stimulator was used.

In a previous study with lidocaine in patients with mandibular posterior teeth experiencing pulpitis using identical methodology to the current study (12), we found higher success rates of pulpal anesthesia (70%) and a lower percentage (45%) of patients with successful anesthesia (pain scores 0 to 1 during pulpectomy) than the current study, which were 42.9% and 62.9%, respectively. The number of patients in the current study was higher (n = 35), whereas in the previous study it was only 20 patients. In the current study, only first (n = 17) and second (n = 18) molars were included, whereas in the previous study premolars (n = 4), third molars (n = 2), first molars (n = 9), and second molars (n = 5) were included.

When the traditional IANB in patients with irreversible pulpitis of mandibular molars fails, the practitioners should consider supplemental techniques such as periodontal ligament injections (33), intraosseous injections (9, 10, 33), mandibular buccal infiltration injection with articaine (33, 34), intrapulpal injections (33) or preemptive strategies to improve success of the IANB injection (33, 35–37).

Exactly why analgesia in patients with irreversible pulpitis of mandibular molars is not always obtained remains an enigma. Various factors such as anatomic variations (cross-innervations and accessory innervations with the lingual nerve, the buccal nerve, the mylohyoid nerve, or the cervical plexus) (36, 38), acute tachyphylaxis of local anesthetics (36), the effect of inflammation on nociceptors (35, 36), the effect of inflammation on central sensitization, and psychological factors (36) may be causes of this failure to achieve analgesia. However, the exact significance of these factors in anesthetic failure remains to be elucidated.

Future research related to pharmacologic mechanisms of local anesthesia with neuroinflammatory and neuropulpal interactions from the perspective of identifying potential mechanisms for local anesthetic failures is needed. Both local anesthetic solutions used in the present study had analgesic effects. We found no statistical difference between the number of patients who felt pain during pulpectomy in both groups (Fig. 2). Our results showed that neither of the local anesthetic solutions used for IANB ensures total absence of pain during pulpectomy, which agrees with previous studies (2, 5, 7, 8, 12, 24). For patients reporting none or mild pain during pulpectomy, the success rate of bupivacaine was 80% and the success rate of lidocaine was 62.9%. This difference was not statistically significant. We concluded that neither of the solutions resulted in effective pain control during irreversible pulpitis treatments of mandibular molars.

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## References

1. Vreeland DL, Reader A, Beck M, Meyers W, Weaver J. An evaluation of volumes and concentrations of lidocaine in human inferior alveolar nerve blocks. J Endod 1989; 15:6–12.
2. Cohen HP, Cha BY, Spangberg LSW. Endodontic anesthesia in mandibular molars: a clinical study. J Endod 1993;19:370–3.
3. Childers M, Reader A, Nist R, Beck M, Meyers WJ. Anesthetic efficacyof the periodontal ligament injection after an inferior alveolar nerve block. J Endod 1996; 22:317–20.
4. Dagher BF, Yared GM, Machtou P. An evaluation of 2% lidocaine with different concentrations of epinephrine for inferior alveolar nerve block. J Endod 1997; 23:178–80.
5. Claffey E, Reader A, Nusstein J, Beck M, Weaver J. Anesthetic efficacy of articaine for inferior alveolar nerve blocks in patients with irreversible pulpitis. J Endod 2004;30: 568–71.
6. Mikesell P, Nusstein J, Reader A, Beck M, Weaver J. A comparison of articaine and lidocaine for inferior alveolar nerve blocks. J Endod 2005;31:265–70.
7. Goldberg S, Reader A, Drum M, Nusstein J, Beck M. Comparison of the anesthetic efficacy of the conventional inferior alveolar, Gow-Gates, and Vazirani-Akinosi techniques. J Endod 2008;34:1306–11.
8. Aggarwal V, Jain A, Kabi D. Anesthetic efficacy of supplemental buccal and lingual inflitrations of articaine and lidocaine after an inferior alveolar nerve block in patients with irreversible pulpitis. J Endod 2009;35:925–9.
9. Reisman D, Reader A, Nist R, Beck M, Weaver J. Anesthetic efficacy of the suplemental intraosseus injection of 3% mepivacaine in irreversible pulpitis. Oral Surg Oral Med Oral Pathol 1997;84:676–82.
10. Nusstein J, Reader A, Nist R, Beck M, Meyers WJ. Anesthetic efficacy of the suplemental intraosseous injection of 2% lidocaine with 1:100,000 epinephrine in irreversible pulpitis. J Endod 1998;24:487–91.
11. Kennedy S, Reader A, Nusstein J, Beck M, Weaver J. The significance of needle deflection in sucess of the inferior alveolar nerve block in patients with irreversible pulpits. J Endod 2003;29:630–3.
12. Tortamano IP, Siviero M, Costa CG, Buscariolo IA, Armonia PL. A comparison of the anesthetic efficacy of articaine and lidocaine in patients with irreversible pulpitis. J Endod 2009;35:165–8.
13. Figini L, Lodi G, Gorni F, Gagliano M. Single versus multiple visits for endodontic treatment of permanent teeth: a Cochrane systematic review. J Endod 2008;34:1041–7.
14. Sathorn C, Parashos P, Messer HH. Effectiveness of single-versus multiple-visit endodontic treatment of teeth with apical periodontitis: a systematic review and meta-analysis. Int Endod J 2005;38:347–55.
15. Laskin JL, Wallace WR, Deleo B. Use of bupivacaine hydrochloride in oral surgery: a clinical study. J Oral Surg 1977;35:25–9.
16. Pricco DF. An evaluation of bupivacaine for regional nerve block in oral surgery. J Oral Surg 1977;35:126–9.
17. Trieger N, Gillen GH. Bupivacaine anesthesia and post-operative analgesia in oral surgery. Anesth Prog 1979;26:20–3.
18. Chapman PJ, Macleod AWG. A clinical study of bupivacaine for mandibular anesthesia in oral surgery. Anesth Prog 1985;69–72.
19. Bouloux GF, Punnia-Moorthy A. Bupivacaine versus lidocaine for third molar surgery: a double-blind, randomized, crossover study. J Oral Maxillofac Surg 1999;57:510–4.
20. McLean C, Reader A, Beck M, Meyers WJ. An evaluation of 4% prilocaine and 3% mepivacaine compared with 2% lidocaine (1:100,000 epinephrine) for inferior alveolar nerve block. J Endod 1993;19:146–50.
21. Fernandez C, Reader A, Beck M, Nusstein J. A prospective, randomized, double-bind comparison of bupivacaine and lidocaine for inferior alveolar nerve blocks. J Endod 2005;31:499–503.
22. Branco FP, Ranali J, Ambrosano GMB, Volpato MC. A double-blind comparison of 0.5% bupivacaine with 1:200,000 epinephrine and 0.5% levobupivacaine with 1:200,000 epinephrine for the inferior alveolar nerve block. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:442–7.
23. Wali M, Drum M, Reader A, Nusstein J. Prospective, randomized single-blind study of the anesthetic efficacy of 1.8 and 3.6 milliliters of 2% lidocaine with 1:50.000 epinephrine for inferior alveolar nerve block. J Endod 2010;36:1459–62.
24. Dreven LJ, Reader A, Michael B, Meyers WJ, Weaver J. An evaluation of an eletric pulp tester as a measure of analgesia in human vital teeth. J Endod 1987;13:233–8.
25. Certosimo AJ, Archer RD. A clinical evaluation of the eletric pulp tester as an indicator of local anesthesia. Oper Dent 1996;21:25–30.
26. Cooley RL, Stilley J, Lubow RM. Evaluation of a digital pulptester. Oral Surg 1984;58: 437–42.
27. Hargreaves KM, Goodis HE, Seltzer S. Seltzer and Bender's Dental Pulp. Chicago: Quintessence Pub Co Inc; 2002.
28. Abd-Elmeguid A, Yu DC. Dental pulp neurophysiology: part 1. Clinical and diagnostic implications. CDA J 2009;75:55–9.
29. Malamed SF. Handbook of Local Anesthesia. 5th ed. St. Louis, MO: Mosby; 2004.
30. Gross R, McCartney M, Reader A, Beck M. A prospective, randomized, double-blind comparison of bupivacaine and lidocaine for maxillary inflitrations. J Endod 2007; 33:1021–4.
31. Volpato MC, Ranali J, Ramacciato JC, Oliveira PC, Ambrosano GMB, Groppo FC. Anesthetic efficacy of bupivacaine solutions in inferior alveolar nerve block. Anesth Prog 2005;52:132–5.
32. Dunsky JL, Moore PA. Long-action local anesthetics: a comparison of bupivacaine and etidocaine in endodontics. J Endod 1984;10:457–60.
33. Nusstein JM, Reader A, Drum M. Local anesthesia strategies for the patient with a "hot" tooth. Dent Clin North Am 2010;54:237–47.
34. Matthews R, Drum M, Reader A, Nusstein J, Beck M. Articaine for supplemental buccal mandibular infiltration anesthesia in patients with irreversible pulpitis when the inferior alveolar nerve block fails. J Endod 2009;35:343–6.
35. Aggarwal V, Singla M, Rizvi A, Miglani S. Comparative evaluation of local infiltration of articaine, articaine plus ketorolac, and dexamethasone on anesthetic efficacy of inferior alveolar nerve block with lidocaine in patients with irreversible pulpitis. J Endod 2011;4:445–9.
36. Hargreaves KM, Keiser K. Local anesthetic failure in endodontics. Endod Topics 2002;1:26–39.
37. Parirokh M, Ashouri R, Rekabi AR, et al. The effect of premedication with ibuprofen and indomethacin on the success of inferior alveolar nerve block for teeth with irreversible pulpitis. J Endod 2010;36:1450–4.
38. Aggarwal V, Singla M, Kabi D. Comparative evaluation of anesthetic efficacy of Gow-Gates mandibular conduction anesthesia, Vazirani-Akinosi technique, buccal-plus-lingual infiltrations, and conventional inferior alveolar nerve anesthesia in patients with irreversible pulpitis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010; 109:303–8.