Effect of Preoperative Pain on Inferior Alveolar Nerve Block

Vivek Aggarwal, MDS,* Mamta Singla, MDS,† Arunajatesan Subbiya, MDS,‡ Paramasivam Vivekanandhan, MDS,‡ Vikram Sharma, MDS,† Ritu Sharma, MDS,† Venkatachalam Prakash, MDS,‡ and Nagarajan Geethapriya, MDS‡

*Department of Conservative Dentistry & Endodontics, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India, †Department of Conservative Dentistry & Endodontics, SGT Dental College, Gurgaon, India, and ‡Department of Conservative Dentistry & Endodontics, Sree Balaji Dental College and Hospital, Chennai, India

The present study tested the hypothesis that the amount and severity of preoperative pain will affect the anesthetic efficacy of inferior alveolar nerve block (IANB) in patients with symptomatic irreversible pulpitis. One-hundred seventy-seven adult volunteer subjects, actively experiencing pain in a mandibular molar, participated in this prospective double-blind study carried out at 2 different centers. The patients were classified into 3 groups on the basis of severity of preoperative pain: mild, 1–54 mm on the Heft-Parker visual analog scale (HP VAS); moderate, 55–114 mm; and severe, greater than 114 mm. After IANB with 1.8 mL of 2% lidocaine, endodontic access preparation was initiated. Pain during treatment was recorded using the HP VAS. The primary outcome measure was the ability to undertake pulp access and canal instrumentation with no or mild pain. The success rates were statistically analyzed by multiple logistic regression test. There was a significant difference between the mild and severe preoperative pain group ($P = .03$). There was a positive correlation between the values of preoperative and intraoperative pain ($r = .2$ and $.4$ at 2 centers). The amount of preoperative pain can affect the anesthetic success rates of IANB in patients with symptomatic irreversible pulpitis.

Key Words: Inferior alveolar nerve block; Preoperative pain; Central sensitization; Hyperalgesia; Irreversible pulpitis.

Successful local anesthesia is a critical aspect in alleviating pain during endodontic procedures. However, it is very difficult to achieve a 100% anesthetic success rate in nerve-block anesthesia.¹ Moreover, the local anesthetic solutions are even less effective in patients with irreversible pulpitis, especially in symptomatic mandibular molars.^{1,2} Various studies have shown a poor anesthetic success rate using single inferior alveolar nerve block with 1.8 mL of local anesthetic solution.^{1–3} A possible explanation for the decrease in success rates

of inflamed pulp might be the activation of nociceptors by inflammation.¹ The barrage of painful stimuli, along with tissue damage, alters and modulates the peripheral and the central pain pathways.^{4–6} The inflammatory mediators reduce the threshold for activation of peripheral nociceptors to a point that a minor stimulus now may fire these neurons.¹ The continuous firing of peripheral nociceptors causes neuroplastic changes in the dorsal horn, leading to an increase in dorsal horn neuron discharge rate and the size of the receptive field of A-delta fibers.^{1,4,7} The combined effect of these factors will cause hyperalgesia and allodynia.

The presence of preoperative pain can affect the local anesthetic success rates and postoperative pain. Arquetta-Figueroa et al⁸ evaluated the anesthetic efficacy of 4%

Received April 20, 2015; accepted for publication June 22, 2015.

Address correspondence to Dr Vivek Aggarwal, Department of Conservative Dentistry & Endodontics, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India 110024; drvivekaggarwal@gmail.com.

Anesth Prog 62:135–139 2015

© 2015 by the American Dental Society of Anesthesiology

ISSN 0003-3006/15

SSDI 0003-3006(15)

articaine with 1 : 100,000 epinephrine in patients with symptomatic and asymptomatic irreversible pulpitis in mandibular posterior teeth. The success rate was significantly less in patients with symptomatic irreversible pulpitis (64.2%) than in patients with asymptomatic irreversible pulpitis (86.9%). Henry et al⁹ reported that most patients with symptomatic necrotic teeth had significant postoperative pain. Yoldas et al¹⁰ evaluated the effect of 1- or 2-visit root canal treatment (and presence/absence of preoperative pain) on the postoperative pain in the retreatment cases and reported that the incidence of postoperative pain was higher in patients with symptomatic teeth. These studies have evaluated the effect of the presence/absence of preoperative pain on postoperative pain/anesthetic success, but to best of our knowledge, no study has evaluated the effect of amount/severity of preoperative pain on anesthetic success.

The purpose of the present multicenter double-blinded trial was to determine the anesthetic success of 1.8 mL of 2% lidocaine with 1 : 200,000 epinephrine in patients with symptomatic irreversible pulpitis and if the amount of preoperative pain (mild, moderate, or severe on Heft-Parker visual analog scale [HP VAS]) is correlated to local anesthesia success.

MATERIALS AND METHODS

This study was carried out at 2 centers in different cities (SGT Dental College, Gurgaon, India, and SB Dental College, Chennai, India). One-hundred eighty-two initial adult patients (90 at SGT and 92 at SB center) participated in this multicenter, randomized, double-blinded trial. The primary outcome (endpoint) was defined as “success or failure,” which was indicated as the ability of the clinician to undertake pulp access and canal instrumentation until the apical third with no or mild pain (HP VAS score <55 mm). The solution deposition pain on HP VAS was taken as a secondary outcome of the trial. The sample size calculation consisted of α -level type I error of .05 for a single-tailed test and β -level type II error of .20. A power analysis indicated that a sample size of 81 subjects would give 80% power to detect a 25% difference in the success rates. A dropout rate of 10% was assumed, and 30 subjects were enrolled in each group at both centers (90 at SGT and 92 at SB centers, respectively). An ethical clearance was taken from the departmental review committee (reference no. SBDCECM105/13/27), and informed written consent was obtained from each subject.

The methodology was similar to previous studies dealing with the evaluation of anesthetic efficacy of

various anesthetic solutions in patients with asymptomatic/symptomatic pulpitis. The inclusion criteria for the study were active pain in the mandibular first or second molar (>0 mm on the HP VAS of 170 mm),¹¹ a prolonged response to cold testing with an ice stick and an electric pulp tester, the absence of any periapical radiolucency on radiographs except for a widened periodontal ligament, a vital coronal pulp on access opening, American Society of Anesthesiologists class I or II medical history, and the ability to understand the use of pain scales. Exclusion criteria included known allergy or contraindications to any content of local anesthetic solution, patients who were pregnant or breast-feeding, a history of known or suspected drug abuse, and patients taking any drugs that could have affected the pain perception. Patients having active pain in more than 1 mandibular molar were excluded from the study. The treatment procedure and the use of pain scales were explained to the patients. The millimeter marks were removed from the scale, and the scale was divided into 4 categories: “no pain” corresponded to 0 mm; “faint, weak, or mild” pain corresponded to 1 to 54 mm; “moderate” pain corresponded to 55 to 114 mm; and severe pain corresponded to greater than 114 mm and included “strong, intense, and maximum possible” pain.² The patients were classified into 3 groups on the basis of preoperative pain (mild: 1–54 mm on HP VAS; moderate: 55–114 mm; and severe: greater than 114 mm). The patients were given an alpha-numeric code. The diagnosis of preoperative pain was done by one of the authors, and the clinician was blinded to rest of the clinical procedures.

The patients received inferior alveolar nerve block injections using 1.8 mL of 2% lidocaine with 1 : 200,000 epinephrine using a direct Halsted approach. The area of injection was dried using sterile gauze, and topical anesthesia of 20% benzocaine was applied using a sterile cotton tip applicator for 60 seconds. The solution was injected via a 5-mL disposable syringe with a 31-mm 24-G needle. After reaching the target area, aspiration was performed, and the solution was deposited over a period of 120 seconds. No anesthetic solution was deposited during needle insertion and placement. After needle withdrawal, the subjects were asked to rate the solution deposition pain on another 170-mm HP VAS. The solution deposition and the endodontic treatment were performed by the same clinician, who was blinded to the initial diagnosis of preoperative pain. Only the codes and the primary/secondary outcomes were recorded. The code was broken only after completion of the study.

After 15 minutes, each patient was asked whether his or her lip was numb. If profound lip numbness was not recorded, the block was considered unsuccessful, and the

Table 1. Comparison of Age and Gender of Patients

Center SGT	Age, y (mean, SD)*	37, 7.4, range 24–51
	Gender*	40 men, 46 women
Center SB	Age, y (mean, SD)*	45, 4.7, range 25–52
	Gender*	51 men, 40 women

* There was no statistically significant difference between the groups ($P > .05$).

patients were excluded from the study. A conventional access opening was initiated after isolation with a rubber dam. Patients were instructed to raise their hand if any pain was felt during the procedure. In the case of pain during the treatment, the procedure was stopped, and patients were asked to rate the pain on the HP VAS. Success was defined as no pain or weak/mild pain during endodontic access preparation and instrumentation (HP VAS score <55 mm).

The findings were recorded on a Microsoft Excel sheet (Microsoft Office Excel 2003; Microsoft Corporation, Redmond, Wash) for statistical evaluation by using the program BioEstat (version 4.0; Mamiraua Institute, Belem, Brazil). Age, gender, and solution deposition pain of the subjects were summarized by using means and standard deviations. Multiple comparison analysis of variance (Mann-Whitney U) and t tests were used to determine significant differences at $P < .05$. The anesthetic success rates were compared using multiple logistic regression tests. Odds ratios with 95% confidence intervals were calculated.

RESULTS

One-hundred seventy-seven adult volunteer subjects, 91 men and 86 women, with an average age of 42 years (range, 24–52 years), participated in this prospective clinical study. Of the original 182 patients, 1 patient from the moderate preoperative pain group, 3 patients from the severe preoperative pain group at the SGT center, and 1 patient from the severe preoperative pain group at the SB center did not have profound lip numbness at 15 minutes and were excluded from the study. All patients included in the study had profound lip anesthesia after 15 minutes. The age, gender, and mean solution deposition pain of all the patients are presented

in Table 1. There was no statistical difference in age or gender ($P > .05$) of the patients.

The comparison of percentage of patients with successful anesthesia at individual centers (“no pain” or “weak/mild” pain during endodontic access preparation and instrumentation) is presented in Table 2. Patients with mild preoperative pain had 33% (9 of 30 patients at the SGT center, 11 of 30 patients at the SB center) and patients with moderate preoperative pain had 29% (7 of 29 patients at the SGT center, 10 of 31 patients at the SB center) success rates. The patients with severe preoperative pain presented the lowest success rate of 16% (3 of 27 patients at the SGT center, 6 of 30 patients at the SB center). There was a statistically significant difference between the success rates of mild and severe preoperative pain groups ($P = .03$, odds ratio = 2.67, 95% confidence interval = 1.093 to 6.504; Table 3). Overall, the success rate was 25% (46 of 177 patients). Patients with severe preoperative pain experienced significantly more solution deposition pain than other groups ($P < .05$).

The correlation plot between the absolute values of preoperative and intraoperative pain scores is shown in the Figure. There was a positive correlation coefficient between the 2 values ($r = .2$ at SGT and $r = .4$ at SB).

DISCUSSION

The combined success rate in the present study was 25%. This was comparable with previous studies evaluating 1.8–2.2mL of 2% lidocaine in patients with symptomatic pulpitis but was significantly less than studies evaluating asymptomatic patients.^{2–4,12–15} Patients with symptomatic irreversible pulpitis present with lower pain thresholds and increased response to nociceptive stimuli.¹⁶ The alteration and/or modulation of signal processing is a contributing factor to this hyperalgesia and allodynia.^{1,5} At the peripheral level, inflammatory mediators activate and potentiate the activity of certain receptors such as TTX-resistant channels and TRPV1 channels.^{17,18} The TRPV1 channels are activated by either direct stimulation or posttranslational modulation by arachidonic acid metabolites.^{17,18} The local acidosis, which is present as a sequel of pulpal inflammation, directly activates the

Table 2. Anesthetic Success Rate Obtained in Different Experimental Groups

	Mild Preoperative Pain (%)	Moderate Preoperative Pain (%)	Severe Preoperative Pain (%)
Successful anesthesia obtained at SGT center	9 of 30 patients (30%)	7 of 29 patients (24%)	3 of 27 patients (11%)
Successful anesthesia obtained at SB center	11 of 30 patients (37%)	10 of 31 patients (32%)	6 of 30 patients (20%)

Table 3. Logistic Regression Analysis of the Combined Anesthetic Success Rates of Both Centers

	Mild vs Severe	Mild vs Moderate	Moderate vs Severe
Odds ratio	2.68	1.264	2.108
95% confidence interval	1.093 to 6.504	0.581 to 2.750	0.851 to 5.221
Z statistics	2.156	0.593	1.613
Significance level	$P = .03$	$P = .554$	$P = .107$

TRPV1 activity.¹⁹ The sensitization of TRPV1 channels may lead to reduction in the firing threshold of the channel activation (from 42°C to body temperature).^{1,19,20} This will lead to spontaneous and/or pulsating pain. The TTX-resistant channels and TRPV1 channels are difficult to anesthetize, and they make the nerve less sensitive to commonly used local anesthetic agents.¹ This can explain the peripheral mechanism behind the reduction in the success rate of anesthesia in patients with symptomatic pulpitis as compared with asymptomatic pulpitis.

In the present study, the effect of amount/severity of preoperative pain on anesthetic efficacy was evaluated as “success” or “failure” during endodontic management of symptomatic mandibular molars using 1.8 mL of 2% lidocaine with 1 : 200,000 epinephrine. The amount of preoperative pain affected the anesthetic success rates (which was measured as no or mild pain during endodontic procedures) in the mild versus severe preoperative pain groups. There was a weak positive correlation between the absolute preoperative pain scores and intraoperative pain scores. The results imply that patients with active pain associated with symptomatic irreversible pulpitis have a poor success rate and that the failure rate increases with an increase in the severity of preoperative pain. The patients with severe preoperative pain had the lowest success rates in the present study. This effect can be explained by peripheral and central nociceptive sensitization. The inflammation and continuous barrage of nociceptor stimuli can lead to sensitization of dorsal horn wide-dynamic-range neurons; in other words, they produce central sensitiza-

tion.^{21–23} Central sensitization produces an exaggerated central nervous system response to even gentle peripheral stimuli, leading to hyperalgesia.^{20,21} Woolf²⁴ reported that application of brief, low-frequency burst-of-action potentials by the activation of nociceptors increased the synaptic efficacy in nociceptive neurons in the dorsal horn of the spinal cord. The author also noted that central sensitization remained active even after the end of conditioning stimuli or that it may require only a very low level of nociceptor inputs to sustain it. Khan et al²⁵ evaluated mechanical pain thresholds in patients with irreversible pulpitis and compared the values with their contralateral teeth. The authors reported that the mechanical pain thresholds of teeth with irreversible pulpitis were reduced by 77% compared with contralateral control teeth. Moreover, the normal teeth contralateral to the symptomatic teeth had lower mechanical thresholds than those observed in healthy volunteers, suggesting the activation of central sensitization.²⁵

In the present study, patients with severe preoperative pain presented with significantly higher solution deposition pain than other test groups. Overall, almost 74% of patients had moderate to severe solution deposition pain. McCartney et al¹⁶ retrospectively analyzed 102 inferior alveolar nerve block in patients with irreversible pulpitis, using 1.8–2.2 mL of 2% lidocaine with 1 : 100,000 epinephrine. The authors reported that 66% to 73% of patients experienced moderate to severe pain during solution deposition. Although several studies evaluating the solution deposition pain in healthy volunteers have reported a much lower incidence of moderate to severe pain, the higher incidence of pain in

Linear correlation chart between Heft-Parker visual analog scale value of preoperative pain and intraoperative pain. (a) Center SGT ($r = .2$). (b) Center SB ($r = .4$).

the present study could be attributed to the preoperative pain/anxiety of the patients.^{25–27}

In conclusion, the amount of preoperative pain affects the anesthetic success of inferior alveolar nerve block of 1.8 mL of 2% lidocaine with 1 : 200,000 epinephrine. There was a positive correlation between the values of preoperative pain and intraoperative pain.

REFERENCES

1. Hargreaves KM, Keiser K. Local anesthetic failure in endodontics: mechanisms and management. *Endod Topics*. 2002;1:26–39.
2. 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;30:568–571.
3. Aggarwal V, Jain A, Debipada K. Anesthetic efficacy of supplemental buccal and lingual infiltrations of articaine and lidocaine following an inferior alveolar nerve block in patients with irreversible pulpitis. *J Endod*. 2009;35:925–929.
4. Lin JY, Cheng YC, Chen JY, et al. Increased spinal prodynorphin gene expression in reinflammation-associated hyperalgesia after neonatal inflammatory insult. *BMC Neurosci*. 2010;11:139.
5. Ji RR, Xu ZZ, Gao YJ. Emerging targets in neuroinflammation-driven chronic pain. *Nat Rev Drug Discov*. 2014;13:533–548.
6. Jänig W. Sympathetic nervous system and inflammation: a conceptual view. *Auton Neurosci*. 2014;182:4–14.
7. Honda K, Kitagawa J, Sessle BJ, et al. Mechanisms involved in an increment of multimodal excitability of medullary and upper cervical dorsal horn neurons following cutaneous capsaicin treatment. *Mol Pain*. 2008;4:59.
8. Arqueta-Figueroa L, Arzate-Sosa G, Mendieta-Zeron H. Anesthetic efficacy of articaine for inferior alveolar nerve blocks in patients with symptomatic versus asymptomatic irreversible pulpitis. *Gen Dent*. 2012;60:e39–e43.
9. Henry M, Reader A, Beck M. Effect of penicillin on postoperative endodontic pain and swelling in symptomatic necrotic teeth. *J Endod*. 2001;27:117–123.
10. Yoldas O, Topuz A, Isçi AS, Oztunc H. Postoperative pain after endodontic retreatment: single- versus two-visit treatment. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2004;98:483–487.
11. Heft MW, Parker SR. An experimental basis for revising the graphic rating scale for pain. *Pain*. 1984;19:153–161.
12. Sampaio RM, Carnaval TG, Lanfredi CB, Ratto Tempestini Horliana AC, Rocha RG, Tortamano IP. Comparison of the anesthetic efficacy between bupivacaine and lidocaine in patients with irreversible pulpitis of mandibular molar. *J Endod*. 2012;38:594–597.
13. Kreimer T, Kiser R II, Reader A, Nusstein J, Drum M, Beck M. Anesthetic efficacy of combinations of 0.5 mol/L mannitol and lidocaine with epinephrine for inferior alveolar nerve blocks in patients with symptomatic irreversible pulpitis. *J Endod*. 2012;38:598–603.
14. Dou L, Luo J, Yang D. Anaesthetic efficacy of supplemental lingual infiltration of mandibular molars after inferior alveolar nerve block plus buccal infiltration in patients with irreversible pulpitis. *Int Endod J*. 2013;46:660–665.
15. Foster W, Drum M, Reader A, Beck M. Anesthetic efficacy of buccal and lingual infiltrations of lidocaine following an inferior alveolar nerve block in mandibular posterior teeth. *Anesth Prog*. 2007;54:163–169.
16. McCartney M, Reader A, Beck M. Injection pain of the inferior alveolar nerve block in patients with irreversible pulpitis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2007;104:571–575.
17. Park CK, Kim K, Jung SJ, et al. Molecular mechanism for local anesthetic action of eugenol in the rat trigeminal system. *Pain*. 2009;144:84–94.
18. Matsuura S, Shimizu K, Shinoda M, et al. Mechanisms underlying ectopic persistent tooth-pulp pain following pulpal inflammation. *PLoS One*. 2013;8:e52840.
19. Patwardhan AM, Scotland PE, Akopian AN, Hargreaves KM. Activation of TRPV1 in the spinal cord by oxidized linoleic acid metabolites contributes to inflammatory hyperalgesia. *Proc Natl Acad Sci U S A*. 2009;106:18820–18824.
20. Gibbs JL, Hargreaves KM. Neuropeptide Y Y1 receptor effects on pulpal nociceptors. *J Dent Res*. 2008;87:948–952.
21. Song Y, Li HM, Xie RG, et al. Evoked bursting in injured Aβ dorsal root ganglion neurons: a mechanism underlying tactile allodynia. *Pain*. 2012;153:657–665.
22. Quinn KP, Dong L, Golder FJ, Winkelstein BA. Neuronal hyperexcitability in the dorsal horn after painful facet joint injury. *Pain*. 2010;151:414–421.
23. Fehrenbacher JC, Loverme J, Clarke W, Hargreaves KM, Piomelli D, Taylor BK. Rapid pain modulation with nuclear receptor ligands. *Brain Res Rev*. 2009;60:114–124.
24. Woolf CJ. Central sensitization: implications for the diagnosis and treatment of pain. *Pain*. 2011;152:S2–S15.
25. Khan AA, Owatz CB, Schindler WG, Schwartz SA, Keiser K, Hargreaves KM. Measurement of mechanical allodynia and local anesthetic efficacy in patients with irreversible pulpitis and acute periradicular periodontitis. *J Endod*. 2007;33:796–799.
26. Kanaa MD, Meechan JG, Corbett IP, Whitworth JM. Speed of injection influences efficacy of inferior alveolar nerve blocks: a double-blind randomized controlled trial in volunteers. *J Endod*. 2006;32:919–923.
27. Malamed SF, Tavana S, Falkel M. Faster onset and more comfortable injection with alkalized 2% lidocaine with epinephrine 1:100,000. *Compend Contin Educ Dent*. 2013;34:10–20.