A comparison of ropivacaine and lidocaine with epinephrine for intraligamentary anesthesia

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Objective. The purpose of this study was to compare the efficacy of 2 different concentrations of ropivacaine with lidocaine containing epinephrine for intraligamentary anesthesia.
Study design. Ethical approval was obtained and a randomized, double-blind, cross-over volunteer investigation was conducted. Twenty-four volunteers had intraligamentary injections of 2% lidocaine with 1:80,000 epinephrine, 0.75% ropivacaine, or 1% ropivacaine at the upper lateral incisor and lower first bicuspid teeth. The response of the test teeth to electrical pulp testing and the reaction of the gingiva to sharp probing were assessed up to 29 minutes after injection. Injection discomfort and side effects were also recorded. Data were analyzed by using the chi-square test and analysis of variance.
Results. Lidocaine with epinephrine was more successful than the ropivacaine solutions in obtaining pulpal anesthesia (chi-square = 12; $P < .002$) and produced longer-lasting pulpal ($F = 21$; $P < .001$) and soft tissue ($F = 16$; $P < .001$) anesthesia. Injection discomfort and incidence of side effects were similar between solutions, and none produced serious adverse effects.
Conclusion. Lidocaine with epinephrine is more effective than ropivacaine as an intraligamentary anesthetic.
(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002;93:469-73)

The efficacy of intraligamentary anesthesia is determined by a number of factors.[1] An important aspect is the choice of anesthetic. One important feature of the anesthetic solution is the presence of a vasoconstrictor such as epinephrine.[2-4] Gray et al[2] reported that lidocaine with epinephrine was effective as an anesthetic in 91.6% of periodontal ligament injections, but without the vasoconstrictor, the success rate was only 42%. Kim[3] noted that the concentration of epinephrine used also affected the efficacy of 2% lidocaine during intraligamentary anesthesia. When the vasoconstrictor was present as a 1:100,000 solution, 81% success was observed compared with 88% success obtained by using a 1:50,000 concentration. Kaufman et al[4] reported that pulpal anesthesia ranged from a mean of 1.05 minutes with 2% lidocaine to 27.05 minutes when 2% lidocaine containing 1:50,000 epinephrine was used.

It has been suggested that the administration of epinephrine by the intraligamentary method should be avoided in some patients, such as those with severe cardiac disease.[5] This technique of anesthesia is an intraosseous injection,[6] and systemic effects are equivalent to those of intravascular injection.[7] Therefore, an epinephrine-free solution that is effective in intraligamentary anesthesia would be a useful addition to the dental local anesthetic armamentarium. An anesthetic with intrinsic vasoconstrictive action might be a possibility. Ropivacaine, which is a relatively recent addition to the local anesthetic armamentarium, has vasoconstrictive properties.[8] Some studies have shown that the addition of a vasoconstrictor to ropivacaine does not improve anesthetic efficacy or duration compared with use of the drug alone.[9]

The objective of the present study was to investigate the efficacy of 2 concentrations of ropivacaine as an intraligamentary anesthetic. Lidocaine with epinephrine was used as the "gold standard" for comparative purposes.

MATERIAL AND METHODS

A stochastic simulation was performed to assess sample size according to expected success rate. Combinatorial reasons dictated that the sample size be a multiple of 12, and it was concluded that an injection success rate in the region of 90% dictated a sample size of 24.

Ethical approval was obtained, and 24 healthy subjects (12 men, 12 women) volunteered. Each volunteer was seen on 2 occasions for intraligamentary injections at least 2 weeks apart. Subjects were also seen the day after injection to assess any postinjection problems. Each anesthetic was used on 32 teeth (16 upper incisors and 16 lower bicuspids).

The protocol at each injection visit was the same. The pulpal response of an upper lateral incisor and a lower first bicuspid tooth were measured on an Analytical Pulp Tester (Analytic Technology, Redmond, Wash). In addition, the response of the attached gingiva buccal to the test teeth to sharp probing with a 25-gauge needle was assessed. After

Supported by a grant from AstraZeneca.
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Received for publication Jun 6, 2001; returned for revision Sep 3, 2001; accepted for publication Oct 15, 2001.

1079-2104/2002/$35.00 + 0 **7/15/121390**
doi:10.1067/moe.2002.121390

Table I. Anesthetic success and duration

Drug	*% Teeth with pulpal anesthesia after first injection*	*% Teeth with pulpal anesthesia at any time*	*Mean duration (min) of pulpal anesthesia (upper/lower 95% confidence limits)*	*Mean duration (min) pin-prick anesthesia (upper/lower 95% confidence limits)*
Lidocaine/epinephrine	72	94	15.9 (13.0:18.8)	20.2 (17.7:22.7)
Ropivacaine 0.75%	22	56	4.7 (1.9:7.6)	12.2 (9.7:14.7)
Ropivacaine 1.0%	34	75	3.6 (0.7:6.4)	10.84 (8.3:13.4)

baseline readings, intraligamentary anesthesia was administered to the upper lateral incisor. A 30-gauge needle fitted to an intraligamentary syringe was used. The mesiobuccal and distobuccal aspects of the tooth each received 0.18 mL of solution. The local anesthetic injected was either 2% lidocaine with 1:80,000 epinephrine (AstraZeneca, Södertälje, Sweden), 0.75% ropivacaine, or 1% ropivacaine (AstraZeneca). The operator and the subject were blinded to the identity of the solution injected.

Immediately after the injection, the subject indicated the degree of discomfort resulting from the injection by rating the experience on a 100-mm Visual Analogue Scale with end points of "no pain" and "worst pain imaginable." At 1 and 2 minutes after injection, the pulpal and soft tissue responses were recorded. If pulpal anesthesia was not achieved at 2 minutes, then another 0.18 mL of the same solution was injected at the mesiobuccal aspect of the tooth. Pulpal anesthesia was considered present when the maximum stimulus from the pulp tester (80 μA) did not produce pain in the tooth. Pulpal and soft tissue responses were further recorded every minute until 29 minutes after the injection or until baseline responses were reached (whichever occurred sooner). Once recordings on the upper lateral incisor were completed, an identical regimen was performed on a lower first bicuspid.

Soft tissue anesthesia was measured as absence or presence of pain when the gingiva was probed with a 25-gauge needle.

In addition, the subject was questioned with respect to any subjective feeling of numbness in the tooth and any adverse effects recorded. The following day the subject was reviewed and any adverse effects noted. Data were analyzed by using the chi-square test and analysis of variance.

RESULTS

The mean age of the subjects was 21.75 years (range, 20-28 years). The results of pulpal and soft tissue anesthesia are shown in Table I and Figures 1 and 2. Figures 1 and 2 show the duration and success of pulpal and soft tissue anesthesia in all teeth and included reinjection. The duration of anesthesia in teeth successfully anesthetized the first time after lidocaine with epinephrine was slightly longer than that shown in Table I, it being 18.5 minutes (95% confidence limits 13.5 and 23.5). When anesthesia was successful after initial injections with 0.75% and 1.0% ropivacaine, the mean duration of anesthesia was 1.3 and 1.2 minutes, respectively. There was no difference in successful anesthesia between the upper lateral incisor and the lower first bicuspid (Table II; chi-square = 1.1; $P > .5$). Similarly, the duration of pulpal anesthesia did not differ among the teeth ($F = 1.9$; $P = .17$). The lidocaine solution was more successful in producing pulpal anesthesia (chi-square = 12; $P < .002$) and produced longer-lasting anesthesia than did the ropivacaine solutions ($F = 21$; $P < .001$). The 2 concentrations of ropivacaine did not differ significantly in their efficacy (Fig 1).

Lidocaine with epinephrine produced long-lasting soft tissue anesthesia ($F = 16$; $P < .001$; Fig 2). However, there were no differences in the occurrence of soft tissue anesthesia; this was achieved in the gingiva around all but 2 test teeth (one after 1.0% ropivacaine and one after lidocaine with epinephrine).

All solutions produced subjective feelings of numbness; this was reported in 28 teeth (87.5%) injected with 0.75% ropivacaine, in 26 teeth (81.3%) that received 1.0% ropivacaine, and in 31 teeth (96.9%) that received lidocaine with epinephrine. There was no difference among anesthetic solutions in this regard (chi-square = 3.9; $P = .14$). The reported injection discomfort did not vary among the different solutions ($F = 0.46$; $P = .6$). The mean ± SD Visual Analogue Scale score for each solution was as follows: ropivacaine 0.75%, 35 ± 20 mm; ropivacaine 1.0%, 36 ± 21 mm; and lidocaine with epinephrine, 40 ± 20 mm. All adverse effects were minor and had spontaneously resolved at the 24-hour review. They are listed in Table III.

DISCUSSION

Although ropivacaine has been well investigated, there are few published studies in the medical literature on the effect of ropivacaine after intraoral injection. One study has reported that ropivacaine is effective in obtaining pulpal anesthesia after maxillary infiltration.[10] This study used ropivacaine in the 0.5% concentration. The concentration of the drug used in medicine

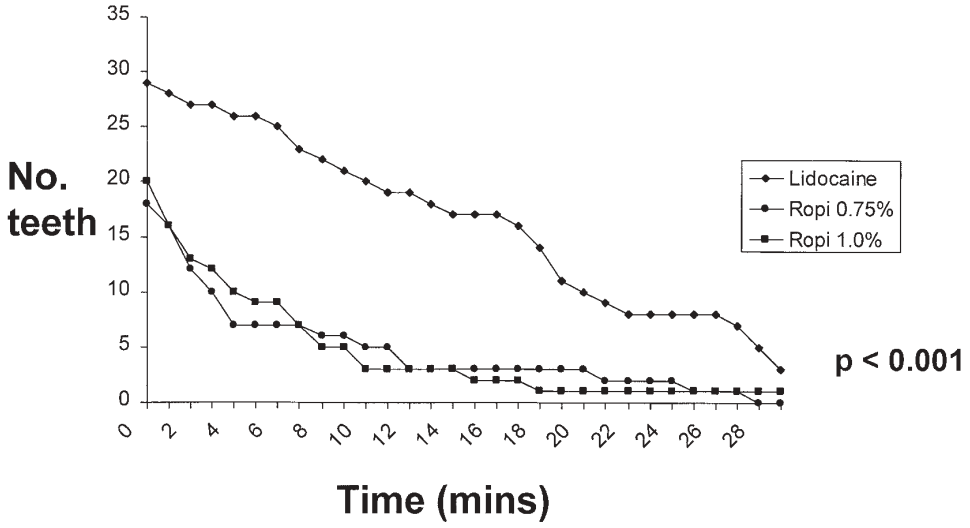

Fig 1. The duration of pulpal anesthesia versus time for the 3 local anesthetic solutions.

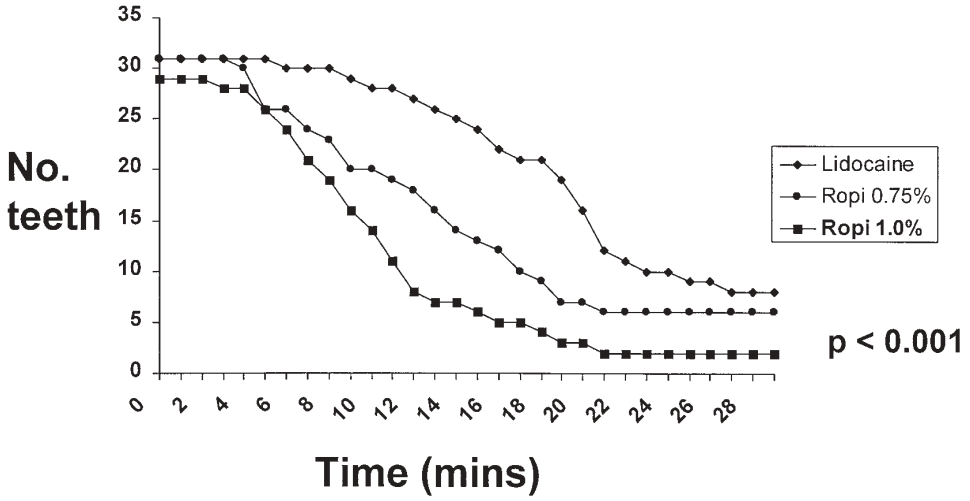

Fig 2. The duration of soft tissue anesthesia versus time for the 3 local anesthetic solutions. The soft tissue tested was the attached gingiva buccal to the test tooth.

is 0.5% to 1.0%.[9,11] Ropivacaine is unusual in that it is not a racemic mixture but is the pure *s*-isomer. An important feature of ropivacaine is that it has some vasoconstrictive properties.[8] However, a number of studies have shown that successful intraligamentary anesthesia is dependent on the presence of a vasoconstrictor-containing solution.[2-4]

Ropivacaine is similar in structure to bupivacaine and, like the latter drug, is a long-acting agent. Ropivacaine has fewer cardiovascular and central nervous system toxicities than does bupivacaine.[12] A number of studies comparing the efficacy of longer-acting local anesthetic agents such as etidocaine,[13] mepivacaine,[14] or bupivacaine[4] with lidocaine for intraligamentary anesthesia have concluded that success is related more to the concentration of the vasoconstrictor used than to the anesthetic agent used. However, McLean et al[15] found that bupivacaine with epinephrine produced longer-lasting pulpal anesthesia than lidocaine with epinephrine. Schleder et al[14] found 3% mepivacaine more effective than 2% lidocaine (41.9% success and 13.8% success, respectively) when injected into the periodontal ligament of human mandibular premolars. However, both solutions were significantly less effective than 2% lidocaine with 1:100,000 epinephrine (86.7% success).

The results of the present investigation show that ropivacaine can produce anesthesia of the pulp and adjacent soft tissue when injected into the periodontal ligament. However, this anesthetic effect is inferior to

Table II. Number of teeth with anesthetic failure at 2 minutes

Teeth	*Solution*		
	Ropivacaine 0.75% (n = 32)	*Ropivacaine 1.0% (n = 32)*	*Lidocaine/ epinephrine (n = 32)*
Upper lateral incisor	11	10	4
Lower first bicuspid	14	11	5
Total	25	21	9

Table III. Adverse events

Adverse event	*Ropivacaine 0.75% (n = 11)*	*Ropivacaine 1.0% (n = 5)*	*Lidocaine/epinephrine (n = 12)*
Palpitations	1	0	1
Bleeding mucosa	1	0	0
Dizziness	0	0	2
Nausea	0	0	1
Pain in tooth	7	4	7
Tender tooth	2	0	0
Pulsing sensation	0	0	1
Tingle in feet	0	1	0

that of lidocaine with epinephrine in terms of obtaining pulpal anesthesia when injected through this route. The results support the findings of previous studies that have shown that vasoconstrictor-free solutions have poor efficacy in obtaining pulpal anesthesia compared with those containing epinephrine when injected into the periodontal ligament.

Studies of the effect of epinephrine on the duration of soft tissue anesthesia after intraoral injection show inconsistent results. Previous investigations[16,17] studying both infiltration and regional block intraoral injections have shown that the duration of oral soft tissue anesthesia is not affected by the addition of a vasoconstrictor such as epinephrine to local anesthetic solutions. Oikarinen et al[16] showed that the addition of epinephrine to 3% mepivacaine injected into the maxillary buccal sulcus in the bicuspid area did not influence the duration of soft tissue anesthesia. Hersh et al[17] reported no difference in the duration of lip and tongue anesthesia between epinephrine-free and epinephrine-containing local anesthetics after inferior alveolar block injections in volunteers. However, Meechan et al[18] showed that the addition of epinephrine to lidocaine solutions increased the duration of soft tissue anesthesia after palatal injections. Similarly, Kennedy et al[10] reported that the addition of epinephrine to 0.5% ropivacaine increased the duration of lip numbness after maxillary infiltration. The results of the present study show that the epinephrine-containing solution provided longer-lasting gingival anesthesia than epinephrine-free solutions when injected by using the intraligamentary method.

The vasoconstrictive properties of ropivacaine alone are not as profound as epinephrine-containing solutions. A study of the amount of blood loss during reduction mammoplasty showed decreased hemorrhage control when ropivacaine was used as infiltration anesthesia compared with that obtained with a solution of bupivacaine with 1:200,000 epinephrine.[19] The results of the present study suggest that vasoconstrictive properties of ropivacaine are not sufficient to make the drug alone acceptable as an intraligamentary injection. It is important to stress that the current study does not offer any information concerning the relative effectiveness of lidocaine and ropivacaine alone for pulpal anesthesia. The addition of epinephrine to ropivacaine 0.5% solutions has been shown to increase the duration of pulpal anesthesia after maxillary infiltration injection. However, the rate of anesthetic success did not differ among the ropivacaine alone and the epinephrine-containing ropivacaine solutions.[10] Whether the addition of epinephrine to the ropivacaine solutions used in the present investigation would increase the occurrence of pulpal anesthesia after intraligamentary injection merits investigation.

The choice of local anesthetic solution may influence the amount of discomfort produced during intraoral injection.[10,16] Such variations may be caused by differences in pH. Epinephrine-containing solutions have a lower pH than epinephrine-free anesthetics. In the present investigation the discomfort produced by ropivacaine was similar to that obtained with a solution of lidocaine with epinephrine when injected by using the intraligamentary method.

The adverse effects produced by ropivacaine were similar to those found after the intraligamentary injection of lidocaine with epinephrine. All were minor and reversed spontaneously, suggesting that ropivacaine may be injected safely by the intraligamentary method.

CONCLUSION

Ropivacaine alone in the concentration range 0.75% to 1.0% is not as effective as 2% lidocaine with 1:80,000 epinephrine in obtaining pulpal anesthesia when injected as an intraligamentary anesthetic. The adverse effects of ropivacaine are similar to those produced by lidocaine with epinephrine after intraligamentary injection and are minor and reversible.

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