Efficacy of Maxillary Buccal Infiltration of Articaine for Palatal Anesthesia: A Prospective, Randomized, Crossover Study

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Objective: Although there are conflicting data, several authors have proposed that articaine's molecular properties suggest improved perfusion capabilities over other amide anesthetics. The purpose of this prospective, randomized, crossover study was to evaluate the anesthetic efficacy of palatal soft-tissue anesthesia following a buccal infiltration of 1.8 and 3.6 mL of 4% articaine with 1:100,000 epinephrine.

Methods: One hundred eighteen adults received 1.8 or 3.6 mL of 4% articaine with 1:100,000 epinephrine as a buccal infiltration of the maxillary first molar at 2 separate appointments. Palatal soft-tissue anesthesia was evaluated with a dental explorer. Anesthetic success was defined as the absence of pain with an explorer stick. For the subjects who achieved palatal anesthesia, mapping was conducted over 70 minutes, and the overall area of palatal anesthesia was calculated. The data were analyzed using chi-square tests.

Results: The highest percentage of palatal anesthetic success was 20% for the 1.8-mL volume and 32% for the 3.6-mL volume both at 30 minutes. A statistically significant difference between the 1.8- and 3.6-mL volumes was seen at 40 minutes. There was high variability in area measurements for subjects who achieved palatal anesthesia. The highest area measurements were 92 mm^2 for the 1.8-mL volume at 20 minutes and 113 mm^2 for the 3.6-mL volume at 10 minutes.

Conclusion: Because of the low success rates (20%–32%) and the high variability of the area anesthetized for the subjects who achieved palatal anesthesia, the clinical efficacy of 1.8 or 3.6 mL of articaine via buccal infiltration for palatal anesthesia is of questionable value.

Key Words: Maxillary anesthesia; Articaine; Infiltration; Palatal anesthesia.

Palatal anesthesia is indicated for certain dental procedures that create noxious stimulation of the palatal soft tissues such as maxillary extractions, periodontal surgery, and placement of a rubber dam clamp. Unfortunately, palatal injections have been reported to be painful[1–3] because the palatal tissues are bound tightly to the periosteum.[4]

Due to the pain associated with palatal injections[5] and the supposedly superior perfusion quality of articaine,[6–9] numerous articles have reported on the buccal infiltration of articaine for maxillary extractions to avoid palatal injections.[2,3,10–25] The extraction model has been used to demonstrate efficacy, and some clinical studies involving permanent maxillary molars that used buccal infiltrations of articaine have reported that extractions can be performed without the addition of a palatal injection.[10–15,17,19,20,22–24] However, other studies have found that buccal infiltration of articaine was not effective for palatal anesthesia during extractions.[2,3,16,18,21,25]

If palatal anesthesia were reliably obtained with buccally infiltrated articaine, clinicians could use this approach for many clinical procedures. However, given the conflicting results using an extraction model, buccal infiltration of articaine for palatal anesthesia needs further study before regular implementation for clinical use. In addition, no study has determined if an increased volume of articaine would result in a higher incidence of palatal anesthesia.

The primary objective of this prospective, single-blinded, randomized, crossover study was to evaluate the anesthetic efficacy of 1.8 or 3.6 mL of 4% articaine with 1:100,000

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epinephrine via buccal infiltration for palatal soft-tissue anesthesia. A secondary objective was to measure the area of soft-tissue anesthesia for those subjects who obtained palatal anesthesia to determine the variability of anesthesia.

METHODS

Asymptomatic adult subjects participated in this study. All were in good health as determined by a written health history and oral questioning. Inclusion criteria consisted of adults 18 to 65 years of age with an American Society of Anesthesiologists Physical Status (ASA-PS) classification I or II. Exclusion criteria consisted of allergies to local anesthetics or included preservatives, history of significant medical problems (ASA-PS classification ≥III), recent use of central nervous system depressants (including alcohol or any analgesics, tranquilizers, sedatives, or hypnotics), ongoing pregnancy or lactation, or the inability to give informed consent. The Human Subjects Review Committee approved this study. Written informed consent was obtained from each subject.

Pulp testing of the maxillary first molar was performed with an electric pulp tester (Analytic Technologies) at each appointment to ensure vitality of the test tooth. In addition, clinical examination guaranteed that the first molar was of free of caries and periodontal disease, although a single occlusal restoration was permitted. Test teeth also had no history of orthodontic treatment or trauma. Clinical examination guaranteed that the palatal mucosa was within normal limits and free of disease.

Subjects randomly received 1 of 2 volumes (1.8 or 3.6 mL) of articaine for buccal infiltration of a maxillary first molar at 2 appointments spaced at least 2 weeks apart. The order of the anesthetic volume administration and the infiltration side (right or left) was randomly determined by assigned 6-digit random numbers (www.random.org). At the first appointment, the subject received a buccal maxillary infiltration of either the 1.8- or 3.6-mL volume of 4% articaine with 1:100,000 epinephrine (Septocaine, Septodont, Inc.) based on the assigned random number. Whichever volume was rendered at the first appointment, the subject was administered the other volume at the same site at the second appointment. All injections were administered by the principal investigator (A.W.), but the subjects were blinded to the injection volume.

Prior to each appointment, the volume of anesthetic was premeasured by the investigator to provide a volume of either 1.8 or 3.6 mL. The appropriate volume was drawn from anesthetic cartridges into a Luer-Loc 5-mL syringe (Becton, Dickinson, and Co). Anesthetic cartridges were checked to ensure that they were not expired. The syringe was preloaded prior to the subject arriving and covered by a patient napkin.

The following protocol was used for the injections. All subjects were placed in the supine position. A 20% benzocaine topical anesthetic was placed for 1 minute at the injection site via cotton swab. A volume of 1.8 or 3.6 mL of 4% articaine with 1:100,000 epinephrine was administered as a standard buccal infiltration of the maxillary first molar using a Luer-Loc 5-mL syringe and a 27-gauge short needle (Monoject; Sherwood Services). The needle was gently inserted into the alveolar mucosa to a depth of 2 to 3 mm and advanced to an approximate depth of the maxillary buccal root apices. A subperiosteal infiltration was not administered. The operator deposited the 1.8-mL volume over 60 seconds while keeping the needle in the mucosa for an additional 30 seconds for subject blinding. The 3.6-mL volume was steadily deposited over 90 seconds. A computer timer (https://www.timeanddate.com/stopwatch/) was used to record the injection time as well as the postinjection times, which started immediately after the injection was completed.

Palatal anesthesia success was defined as absence of pain during the mucosal measurements. The presence versus absence of sharp pain was used as a dichotomous outcome, as it has been used by other authors.[1–3] For the subjects who obtained anesthetic success, the overall area of palatal anesthesia was also calculated. Variability of the mean area measurements were categorized by dividing the maximum area (288 mm^2) into fourths to help demonstrate potential partial and full palatal anesthesia.

For both volumes of anesthetic solution, mapping the area of anesthetized palatal soft tissue using a standard dental explorer was performed at 1, 5, 10, 15, 20, 30, 40, 50, 60, and 70 minutes after completion of the anesthetic injection. The explorer was gently placed on the palatal mucosa starting at a point 3 mm superior to the mid-crown gingival margin of the maxillary first molar without pressure (no pain recording) and then moved slowly superiorly with mucosal pressure until a painful sensation was felt by the subject. This distance was then measured with a periodontal probe and recorded. This same procedure was conducted in the distal and mesial directions from the same mid-crown starting point. The maximum distance for each of the superior, mesial, and distal measurements from the 3-mm starting point was 12 mm. The 12-mm distance was chosen to minimize the time to measure the 3 distances. If pain was felt before the maximum 12-mm distance was reached, that distance was measured and recorded.

The greatest distance area measurements (mm^2) were calculated for each subject (superior × [mesial + distal]). The total number and percentage of subjects who achieved palatal anesthesia for each time and for each volume were calculated by adding the area measurements for the total number of subjects who achieved anesthesia at each time point. To better quantify variability, area measurements were categorized by dividing the maximum area into fourths to help demonstrate potential partial and full palatal anesthesia. The maximum area measurement was 288 mms^2 ([12 mm mesial + 12 mm distal] × 12 mm superior). The resulting area categories were inadequate anesthesia (3–72 mm^2), low partial anesthesia (73–144 mm^2), medium partial anesthesia (145–216 mm^2), and adequate anesthesia (217–288 mm^2). The value range for adequate anesthesia (217–288 mm^2) would be expected to ensure the greatest success for palatal anesthesia or for the additional injection of local anesthesia. Partial palatal anesthesia would be expected with low partial anesthesia (73–144 mm^2) and medium partial anesthesia (145–216 mm^2) values, while inadequate palatal anesthesia (3–72 mm^2) values would be expectedly unpredictable.

An a priori power analysis was performed using a SASS program to determine the number of subjects. Using a repeated-measures design, the power of the chi-square test to detect a difference of ±19 percentage points in anesthetic success required 70 subjects to have 80% power and a 2-sided type 1 error of .05.

The data were analyzed statistically using SASS. Comparisons between the 2 volumes of articaine regarding palatal anesthetic success (i.e., no response to the dental explorer) were analyzed nonparametrically using chi-square tests with Bonferroni-adjusted *P* values. Comparisons were considered significant at $P < .05$.

RESULTS

A total of 118 subjects participated in this study with an average age of 27 years and a range of 20 to 44 years. A total of 236 injections were given. The current study included 66 female and 52 male subjects.

Regarding palatal anesthesia success, the 1.8- and 3.6-mL volumes demonstrated low success rates from 1 to 20 minutes (7%–19% and 4%–30%, respectively), demonstrating a relative slow onset of palatal anesthesia (Table 1; Figure 1). The highest percentage of anesthetic success was 20% for the 1.8-mL volume at 30 minutes and 32% for the 3.6-mL volume at 30 minutes which indicates low success rates overall. Aside from the success rates at 40 minutes, there were no significant differences in palatal anesthesia success between the 2 volumes. The 3.6-mL volume had a significantly higher rate (30% vs 11%) of successful palatal anesthesia than the 1.8-mL volume at 40 minutes ($P < .05$). Declining rates of palatal anesthesia were noted with both volumes after 30 minutes (Figure 1).

For the 20% to 30% who experienced palatal anesthesia, the highest mean areas of palatal anesthesia calculated were 92 mm^2 at 20 minutes for the 1.8-mL volume and 113 mm^2 at 10 minutes for the 3.6-mL volume (Table 1; Figure 2). The highest area measurement for adequate anesthesia (217–288 mm^2) category was 27% for 3.6-mL volume and 18% for 1.8-mL volume (Table 2; Figure 3). The greatest number and percentage of area measurements were in the inadequate anesthesia (3–72 mm^2) category for both the 1.8- and 3.6-mL volumes (Table 2; Figure 3).

Table 1. Success Rates and Mean Areas of Palatal Anesthesia Over Time[a]

	1.8-mL volume		*3.6-mL volume*		
Times (min)	*Success, No. (%)*	*Area (mm^2)*	*Success, No. (%)*	*Area (mm^2)*	*P value*
1	8 (7)	3	5 (4)	49	>.05
5	15 (13)	41	15 (13)	97	>.05
10	18 (15)	75	22 (19)	113	>.05
15	22 (19)	80	31 (26)	98	>.05
20	22 (19)	92	35 (30)	94	>.05
30	24 (20)	75	38 (32)	92	>.05
40	13 (11)	75	35 (30)	73	<.05[b]
50	19 (16)	64	29 (25)	78	>.05
60	13 (11)	32	27 (23)	70	>.05
70	12 (10)	35	22 (19)	59	>.05

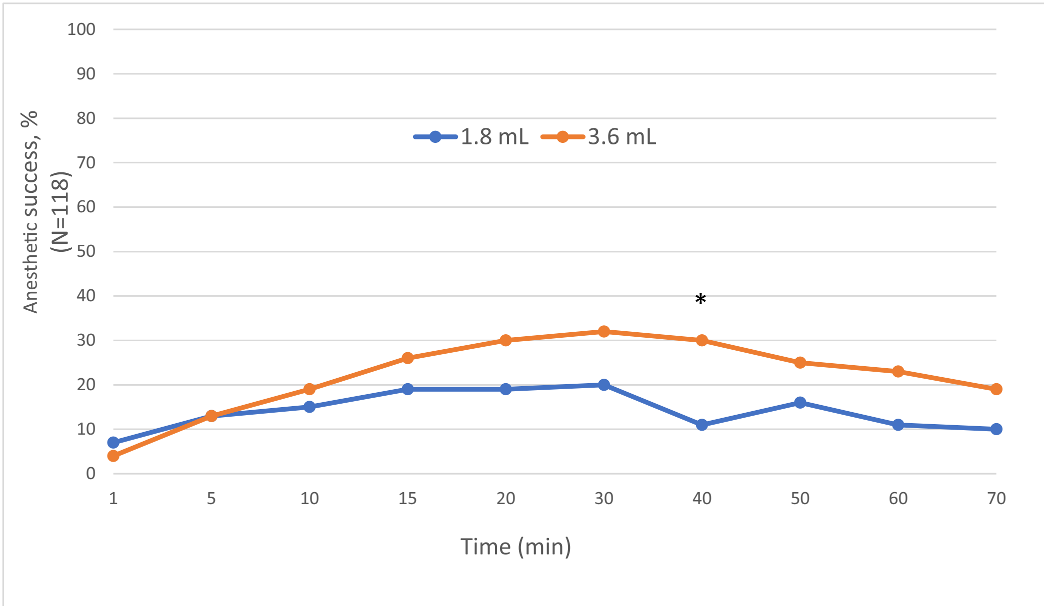
[a] N = 118 total study participants.
[b] Statistically significant difference ($P < .05$) between the 2 anesthetic volumes for success.

DISCUSSION

Regarding the primary objective of palatal anesthesia success, the current study was able to demonstrate that some degree of palatal soft-tissue anesthesia can be obtained from a buccal infiltration of 4% articaine with 1:100,000 epinephrine using either 1.8- or 3.6-mL volumes (Table 1; Figure 1). The 3.6-mL volume resulted in a statistically higher anesthetic success rate at 40 minutes. However, these results likely lack clinical relevance since the success rates were so low.

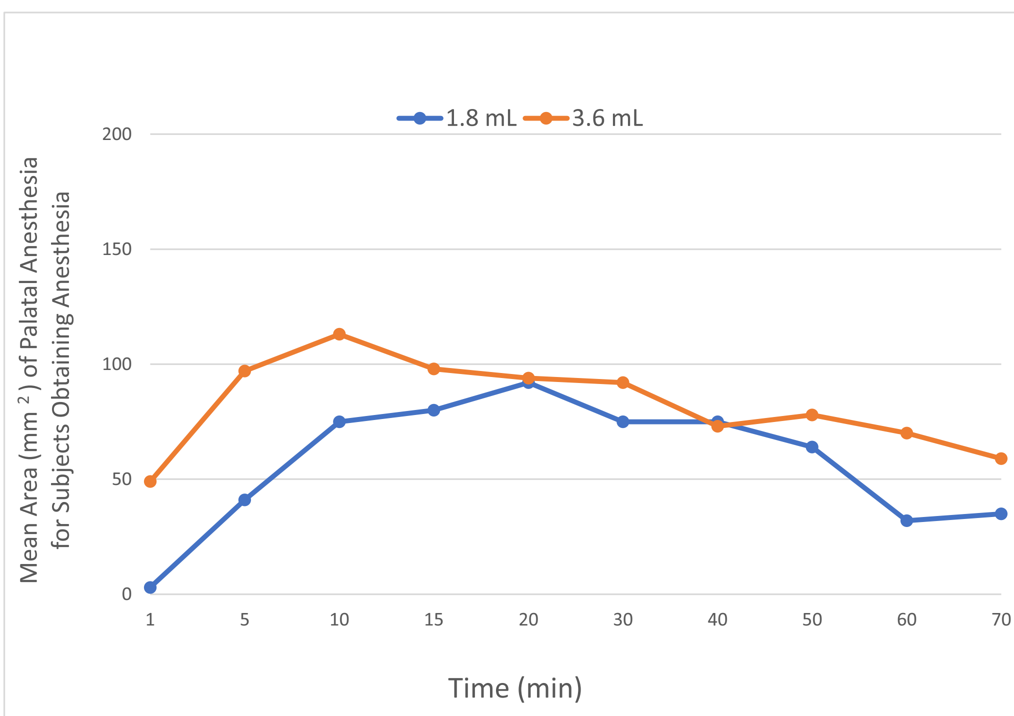
Because both the 1.8- and 3.6-mL volumes demonstrated low anesthetic success rates from 1 to 20 minutes and peak soft tissue anesthesia occurred at 30 minutes (Figure 1), the clinical efficacy of a 1.8- or 3.6-mL buccal infiltration of articaine for palatal anesthesia would be problematic in terms of rapid onset. Previous studies measured the onset of palatal anesthesia after buccal infiltration of articaine and found that onset occurred within 8 to 10 minutes.[3] However, some studies that measured anesthesia by mucosal stimulation (mucosal sticks) similarly to the methods used in this study found pain at 8 to 10 minutes.[2,3,14,15] Furthermore, teeth extraction had higher failure rates due to palatal pain.[3] Some authors recommended checking for palatal anesthesia with mucosal sticks before extractions.[3] In contrast to palatal anesthesia, maxillary molar pulpal anesthesia is usually obtained within 5 minutes following a buccal infiltration.[26] The current study found more time would be required for diffusion of a buccal articaine formulation to the palatal tissues. Therefore, buccal infiltration of

Figure 1. Palatal Anesthesia Success Rates Over Time.



The highest success rate was 20% for the 1.8-mL volume at 30 minutes and 32% for the 3.6-mL volume at 30 minutes. The only significant difference in success between the 2 volumes occurred at 40 minutes (11% and 30%, respectively; $P < .05$). Declining success was seen after 30 minutes with both volumes. *$P < .05$.

Figure 2. Mean Area (mm^2) of Palatal Anesthesia Over Time.



The highest mean area measurements for those who reported palatal anesthesia were 92 mm^2 at 20 minutes for the 1.8-mL volume and 113 mm^2 at 10 minutes for the 3.6-mL volume.

Table 2. Variability of Palatal Anesthesia

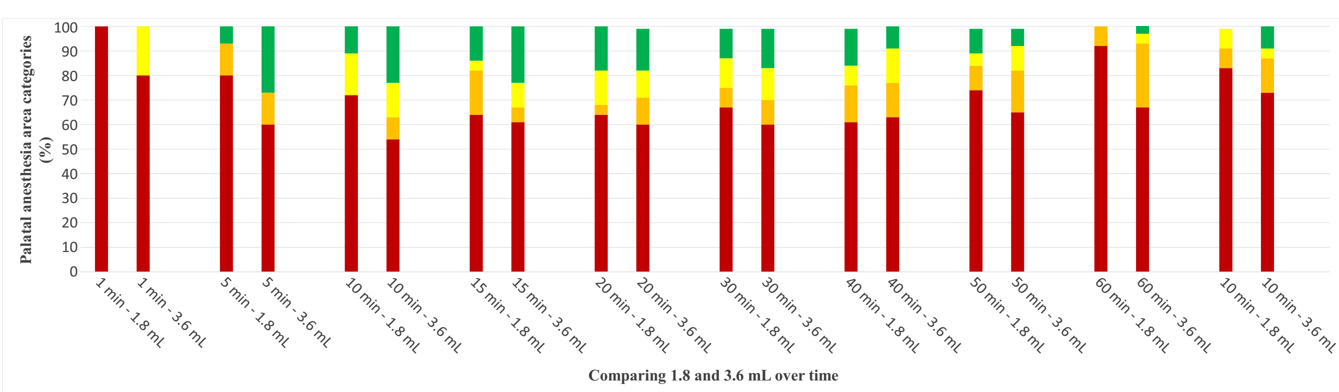
Times	*Volume group*[a]	*Inadequate anesthesia (3–72 mm²), No. (%)*	*Low partial anesthesia (73–144 mm²), No. (%)*	*Medium partial anesthesia (145–216 mm²), No. (%)*	*Adequate anesthesia (217–288 mm²), No. (%)*
1 min	1.8 mL, n = 8	8 (100)	0 (0)	0 (0)	0 (0)
	3.6 mL, n = 5	4 (80)	0 (0)	1 (20)	0 (0)
5 min	1.8 mL, n = 15	12 (80)	2 (13)	0 (0)	1 (7)
	3.6 mL, n = 15	9 (60)	2 (13)	0 (0)	4 (27)
10 min	1.8 mL, n = 18	13 (72)	0 (0)	3 (17)	2 (11)
	3.6 mL, n = 22	12 (54)	2 (9)	3 (14)	5 (23)
15 min	1.8 mL, n = 22	14 (64)	4 (18)	1 (4)	3 (14)
	3.6 mL, n = 31	19 (61)	2 (6)	3 (10)	7 (23)
20 min	1.8 mL, n = 22	14 (64)	1 (4)	3 (14)	4 (18)
	3.6 mL, n = 35	21 (60)	4 (11)	4 (11)	6 (17)
30 min	1.8 mL, n = 24	16 (67)	2 (8)	3 (12)	3 (12)
	3.6 mL, n = 38	23 (60)	4 (10)	5 (13)	6 (16)
40 min	1.8 mL, n = 13	8 (61)	2 (15)	1 (8)	2 (15)
	3.6 mL, n = 35	22 (63)	5 (14)	5 (14)	3 (9)
50 min	1.8 mL, n = 19	14 (74)	2 (10)	1 (5)	2 (10)
	3.6 mL, n = 29	19 (65)	5 (17)	3 (10)	2 (7)
60 min	1.8 mL, n = 13	12 (92)	1 (8)	0 (0)	0 (0)
	3.6 mL, n = 27	18 (67)	7 (26)	1 (4)	1 (4)
70 min	1.8 mL, n = 12	10 (83)	1 (8)	1 (8)	0 (0)
	3.6 mL, n = 22	16 (73)	3 (14)	1 (4)	2 (9)

[a] Total number of subjects at each time with palatal anesthesia after 1.8 or 3.6 mL.

articaine is unlikely to result in predictable palatal anesthesia success to permit completion of dental treatment or a supplemental palatal injection without further discomfort in a timely fashion.

Numerous articles have reported on the buccal infiltration of articaine to avoid palatal injections for maxillary extractions.[2,3,10–25] The extraction model has been used to demonstrate efficacy, and some clinical studies involving permanent maxillary molars that used buccal infiltrations of articaine have reported that extractions can be performed without the addition of a palatal injection.[10–15,17,19,20,22–24] However, other studies have found buccal infiltration of articaine was not effective for palatal anesthesia during extractions.[2,3,16,18,21,25] The current study would support the findings of previous studies[2,3,16,18,21,25] that palatal anesthesia was not effectively achieved with buccally infiltrated articaine. Local anesthesia requirements for an uncomplicated extraction, which may take approximately 4 to 5 minutes to complete, are likely different from those of other dental procedures (e.g., restorative, endodontic, and periodontal treatment) that take more time. Palatal anesthesia has been reported to occur within 5 to 10 minutes following buccal infiltration of articaine for extractions.[3] In endodontics and periodontics, palatal surgery may require

Figure 3. Palatal Anesthesia Variability.



The highest area measurement for adequate anesthesia (217–288 mm²) was 27% for 3.6-mL volume and 18% for 1.8-mL volume. The greatest number and percent of area measurements were in the inadequate anesthesia (3–72 mm²) category for both the 1.8-mL and 3.6-mL volume.

60 to 90 minutes of anesthesia. Application of a rubber dam clamp for restorative dentistry and endodontics may need palatal anesthesia for 45 to 60 minutes. Therefore, an extended duration of palatal soft-tissue anesthesia has greater relevance in periodontics, endodontics, and restorative dentistry.

The anatomical challenges of obtaining palatal anesthesia from a buccal infiltration can be difficult.[2,3,16,18,21,25] The thickness of the buccal cortical plate and the maxillary cancellous bone and the rate of anesthetic diffusion can all be contributing factors in determining palatal anesthesia success. According to a study evaluating the relationship between bone thickness within dental implant sites in all quadrants, the posterior maxilla had a mean cortical bone thickness of 0.72 ± 0.19 mm and a cancellous bone grayscale value of 388 ± 206.[27] The thicknesses of the maxillary posterior cortical and cancellous bone were the smallest out of all the quadrants, so it could be assumed that this would be the site to observe the most anesthetic perfusion.[27] Anesthetic diffusion has limited capability to be quantifiably measured. A study by Ozeç et al.[28] used magnetic resonance imaging (MRI) to visually evaluate anesthetic solutions at sites of buccal infiltrations of 4% articaine. Visual evaluation of the MRI did not show any changes indicating local anesthetic reaching the palatal region; thus, further qualitative measures of palatal anesthesia are indicated.

Regarding the mean area of palatal anesthesia obtained, the maximum mean area measurements were 92 mm^2 for the 1.8-mL volume and 113 mm^2 for the 3.6-mL volume (Table 1; Figure 2). In comparison, these values would be less than half the area of a No. 15 scalpel blade, which would not be enough area of anesthesia to cover the overlying greater palatine nerve or enough of an area to likely permit completion of a surgical procedure. However, the area measurements were assessed only in subjects who achieved successful palatal anesthesia. Therefore, while the area anesthetized varied following buccal infiltration of 1.8 or 3.6 mL of articaine, palatal anesthesia did occur. The key aspect is that buccal infiltration of articaine is unlikely to be sufficiently reliable to forgo a conventional palatal injection for most dental procedures.

The highest range of area measurements (acceptable anesthesia, 217-288 mm^2; Table 2; Figure 3) would provide an area of palatal anesthesia similar to that recorded by Crump et al[1] using the combination of a periodontal ligament (PDL; 0.4 mL) injection and palatal infiltration (0.9 mL) with 2% lidocaine with 1:100,000 epinephrine. While impressive, it must be remembered that a total of only 20% to 30% of the 118 subjects recorded palatal anesthesia at all, and of those, most area percentages were in the low, inadequate anesthesia range (Table 2; Figure 3). The other 70% to 80% of subjects recorded no palatal anesthesia.

We chose the area of the first molar mid-crown point of the palate because if this area was anesthetized, we could administer additional anesthesia to provide a larger area of palatal anesthesia. Crump et al.[1] demonstrated a large area of palatal anesthesia using an infiltration of 0.9 mL of 2% lidocaine with 1:100,000 epinephrine at this mid-palatal site. In addition, the 0.9-mL volume may allow diffusion of the local anesthetic solution at or near the greater palatine foramen. Unfortunately, because of the low anesthetic success rates and the peak onset of soft-tissue anesthesia being 20 to 30 minutes, an additional infiltration at this mid-crown point would potentially be painful.

New techniques for achieving palatal anesthesia remain an area of interest for a very clear reason: palatal injections are reported to be painful.[1–3] Attempts to reduce palatal injection pain using topical anesthetic and or pressure anesthesia,[29–32] computer-assisted anesthesia,[29] and cold application[32] still result in a 32% to 38% incidence of moderate pain upon needle insertion. In addition, these methods would not be effective for reducing the pain of depositing the anesthetic solution.[1] Moderate to severe pain from depositing the anesthetic solution into the palatal soft tissues may be experienced 42% to 69% of the time.[1,29]

Because of the low success rates of palatal anesthesia in the current study, a possible solution to palatal anesthesia was shown in a recent study demonstrating significantly reduced pain from palatal infiltration by providing PDL anesthesia (0.4 mL of 2% lidocaine with 1:100,000 epinephrine) into the mid-palatal sulcus of the maxillary first molar and then administering a palatal injection (0.9 mL of 2% lidocaine with 1:100,00 epinephrine) into the blanched collar around the PDL molar site.[1] That study compared the combination injection to a routine palatal injection (0.9 mL of 2% lidocaine with 1:100,000 epinephrine) and found the combination PDL injection + palatal infiltration significantly decreased moderate to severe needle insertion pain from 65% to 1% ($P < .0001$) and significantly reduced moderate to severe solution deposition pain from 65% to 2% ($P < .0001$).[1]

CONCLUSION

Because of the low success rates (20%-32%) and the high variability of the area anesthetized for the subjects who achieved palatal anesthesia, the clinical efficacy of 1.8 or 3.6 mL of articaine administered via buccal infiltration is of questionable value for producing reliable palatal anesthesia.

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