A prospective clinical patient study evaluating the effect of increasing anesthetic volume on inferior alveolar nerve block success rate

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Objective: The purpose of this study was to clinically evaluate an anesthetic technique in which a second cartridge was reloaded in a traditional dental syringe and reinjected at the same site in regard to success rate of the attempted inferior alveolar nerve block. During the same appointment, a computer-controlled delivery system was used on the opposite side of the same patient to administer 2 cartridges as well. Successful anesthesia and time efficiency of the traditional syringe and computer-controlled technique were then evaluated and compared. **Method and Materials:** Thirty-five subjects between the ages of 18 and 58 years were randomly assigned to both the traditional syringe delivery system using a standardized 2-cartridge reloading and reinjection technique and a computer-controlled system using a technique whereby the second cartridge was reloaded without having to remove the needle from the injection site. Subjects served as their own controls. Successful anesthesia was achieved when all soft tissues innervated by the inferior alveolar and lingual nerves were nonresponsive to painful stimulation with an explorer as evaluated at 3- and 10-minute intervals following final anesthetic administration. The time necessary to reload the second cartridge for each side was measured, as was the time necessary to deliver the second full 1.8-mL cartridge. **Results:** Two-cartridge delivery with the traditional syringe resulted in a 94.3% success rate at 3 minutes and a 100% success rate at 10 minutes; 2-cartridge delivery with the computer-controlled delivery system resulted in an 80% success rate at 3 minutes and a 91.4% success rate at 10 minutes following final injection. Reloading time for the second cartridge was 11.37 seconds less with the computer-controlled delivery system, but no statistical difference was found between the 2 systems regarding time to deliver the second cartridge. **Conclusions:** The results for the 2-cartridge technique with both systems compare favorably with and surpass the accepted 85% success rate reported in the dental literature with only 1 cartridge. The computer-controlled delivery system did not require needle removal and was more time efficient at reloading than the traditional syringe system. *(Quintessence Int 2007;38:711.e521–526)*

Key words: computer-controlled delivery system, dental anesthesia, inferior alveolar nerve block, local anesthesia, success rate, two-cartridge injection

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Local anesthesia is the most common clinical act performed on a daily basis in the oral cavity. Achieving a predictable and effective outcome requires a series of specific conditions to be met. These conditions are closely interrelated, each building on one another. The clinician's knowledge and ability in addition to anatomic and pharmacologic variability are all factors that play a critical role.

Proper selection and placement of the needle are most important for success in local anesthetic technique.[1,2] All subcuta-

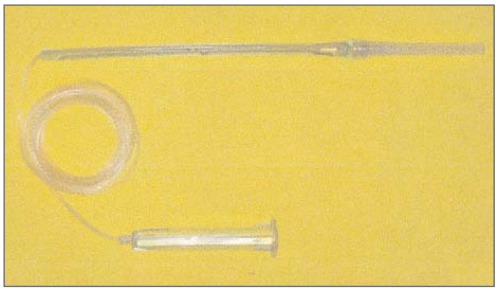

Fig 1 Disposable CompuDent/Wand handpiece with the cartridge holder separated from the handpiece and needle by microtubing.

neous injections require a basic understanding of anatomy that clinicians must master. An additional factor that plays a critical role in achieving anesthesia is adequate drug volume.[3] Sufficient volume of anesthetic solution must be deposited in close proximity to a given target.[4] An inadequate volume is a known risk factor leading to incomplete anesthesia.[1,2]

Clinicians providing local pain control have had to deal with volume limitations since the inception of commercially available products. For example, dental anesthetic cartridges have always been supplied in either a 1.8-mL or a 2-mL volume quantity. The rationale for this relates to the specially designed handheld aspirating syringes used in dentistry. This dates back to the 1920s when Dr Harvey Samuel Cook manufactured and received approval for the first anesthetic cartridge and dental syringe.[5] This volume has become the standard worldwide in dentistry. However, it has yet to be scientifically established if a 1.8-mL cartridge is the ideal volume to be used for achieving 100% success with intraoral nerve blocks.

On the other hand, a multicartridge technique when used with a conventional side-loading aspirating syringe may have undesirable consequences stemming from the need to have to withdraw the needle to replace the anesthetic cartridge. This seemingly innocuous reloading procedure dictates a subsequent puncture of the oral tissues. Each needle penetration into the oral cavity produces some insult to the tissue involved.[2] Tissue damage as well as potential for trismus, hematoma, intravascular needle placement, and nerve trauma are all associated risks with the direct inferior alveolar nerve block technique.[6] With the extra handling during cartridge reloading, the clinician also increases the risk of an inadvertent, self-inflicted needle stick[7] unless 2 separate traditional syringes are prepared prior to injections. Lastly, syringe withdrawal and cartridge reloading incorporates time inefficiency into the procedure of local anesthesia administration.

In 1997 the CompuDent/Wand (Milestone Scientific) was introduced to the dental profession.[8,9] This microprocessor-controlled device permits the control of pressure and volume during the delivery of the anesthetic solution and accommodates a conventional local anesthetic cartridge holder that is physically connected to the disposable handpiece, on which a Luer-lock needle is attached by a microtubing 60 inches in length.[10] Therefore, once the needle is inserted at the injection site, it can remain in place as the first cartridge is removed and the second cartridge is inserted into the cartridge holder, attached to the top of the drive unit, which is at a distance (Fig 1). The traditional syringe would require an in-mouth changing of cartridges in order not to remove the needle from the soft tissues, which is impractical.

This computer-controlled system is activated by a foot-control rheostat that automates the delivery of the local anesthetic and automatically aspirates on demand. The drive unit advances the plunger at a precise rate with a fail-safe pressure limit, thereby eliminating the variability of the thumb-operated plunger needed in a traditional syringe delivery system.[11]

The purpose of this study, therefore, is twofold: first, to evaluate if adding a second 1.8-mL cartridge to the injection site would increase the success rate of the inferior alveolar nerve block and lingual nerve infiltration techniques as compared to the accepted 85% success rate of the inferior alveolar nerve block[2]; second, to evaluate the possible advantages of a computer-controlled delivery system in which the second cartridge was reloaded and the anesthetic delivered without removing the needle from the injection site during dental local anesthesia.

Both the traditional syringe and the test computer-controlled syringe were compared while performing direct approach alveolar nerve block and lingual nerve infiltration techniques. Time efficiency as well as inferior alveolar nerve block and lingual nerve infiltration success were objectively evaluated. Patients were monitored and evaluated during and after local anesthetic administration for systemic abnormalities and local and regional reactions.

Table 1 Age and gender (n = 35)

	n	%
Gender		
Men	14	40.0
Women	21	60.0
Age		
≤ 20	6	17.1
21–30	24	68.6
31–40	0	0.0
41–50	3	8.6
51–60	2	5.7
61–65	0	0.0

METHOD AND MATERIALS

Between May and June 2003, 35 subjects participated in this clinical study. Participants had to be between 18 and 65 years of age, in good general health, and have no contraindications to the use of topical and local anesthetics. There were no gender, race, or ethnic restrictions. Pregnant or lactating women were not eligible for this study. Subjects included 21 women and 14 men whose mean chronologic age was 26.6 ± 10.1 years (range 18 to 58 years) (Table 1).

The study protocol was approved and granted permission to proceed by the Human Research Ethics Committee of the University of Montreal. Each subject's medical history was reviewed, and each subject was subsequently given an information sheet describing the procedures involved in this study. All subjects signed a detailed informed consent form. No subject had previously received a CompuDent/Wand injection, but all had previously experienced a traditional syringe injection without any untoward reactions either locally or systemically. No subject had previously received any type of dental treatment from the practicing clinician in this study.

The same clinician used a standardized approach for all dental injections. The anesthetic used was 3% mepivacaine hydrochloride (Scandonest, Septodont Canada) without vasoconstrictor at 70°F (21°C). Each subject received, via the direct approach technique for the inferior alveolar nerves and infiltration technique for the lingual nerves, 2 cartridges of 1.8 mL delivered with the traditional syringe on 1 side and the computer-controlled syringe apparatus on the other.

The randomized crossover design allowed the computer-controlled test injection to be given on 1 side and 2 injections with the traditional aspirating syringe to be given on the other side. Thus, 17 subjects received the computer-controlled test injection on the right side and 18 subjects received the test injection on the left side. This distribution was also applied to the traditional syringe injections. The sequence for the right and left sides was randomized.

The time necessary to reload the second cartridge for each side as well as the time necessary for the delivery of the second full 1.8-mL cartridge were accurately measured by a research assistant using a stopwatch. Profoundness of anesthesia was subjectively verified 3 and 10 minutes after the injections. A Keller pulse oximeter (Keller Medical Specialties Products) was used to record blood pressure, oxygen saturation, and pulse of each subject at 8 distinct times during the procedure: at preinjection baseline, immediately postinjection, and at 5-minute intervals for the following 30 minutes.

For both the test and traditional techniques, a 25-gauge, 1.5-inch needle was used. A blinded examiner analyzed the collected data with chi-square analysis for dichotomous variables and *t* test for continuous variables. All analyses, including mean scores and percentages, were carried out using the SPSS analytic software version 11.1 (SPSS). Comparisons were deemed statistically significant at $P < .05$.

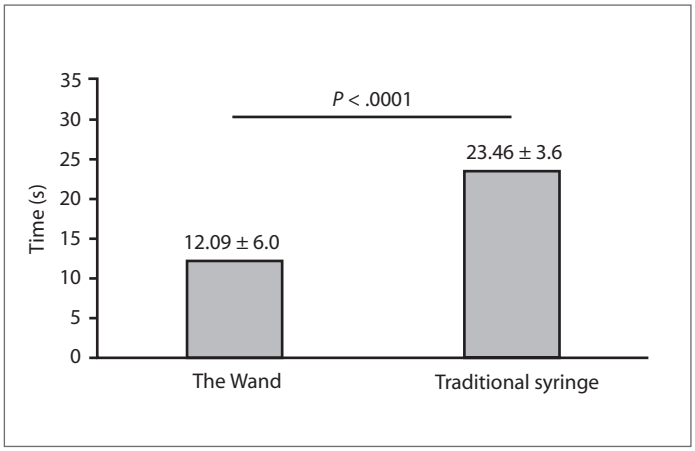

Fig 2 Mean time necessary to reload a second cartridge.

RESULTS

A total of 105 injections were performed, 35 (17 on the right, 18 on the left) with the test computer-controlled syringe and 70 (36 on the right, 34 on the left) with the traditional syringe. There were more traditional injections than test injections because the needle and syringe had to be removed to allow for cartridge reload prior to reinjection. None of the subjects experienced untoward local, regional, or systemic reactions during or after the procedures.

The mean time necessary to withdraw the traditional syringe and reload a second cartridge was compared to the mean time necessary to reload a second cartridge on the cartridge holder of the test computer-controlled syringe. Figure 2 shows the difference measured between the 2 techniques. The time to reload the test computer-controlled technique was 11.37 seconds less ($P < .0001$) than the time needed for the traditional technique. This was statistically significant. However, the difference in the mean time for the second cartridge to be delivered for both the test and traditional techniques was not statistically significant ($P < .36$). Results are presented in Table 2.

Since no dental treatment was scheduled, anesthesia of the soft tissues innervated by the inferior alveolar and lingual nerves was objectively evaluated using a dental explorer at 3- and 10-minute intervals following the last cartridge injection.

Two-cartridge delivery with the traditional syringe resulted in a 94.3% success rate at 3 minutes and a 100% success rate at 10 minutes. Two-cartridge delivery with the computer-controlled test syringe resulted in an 80.0% success rate at 3 minutes and a 91.4% success rate at 10 minutes. Success was interpreted as complete anesthesia of all of the soft tissues innervated by the inferior alveolar and lingual nerves. All but the 3-minute interval with the computer-controlled test syringe compare very favorably with the 85% success rate accepted in the literature for the inferior alveolar nerve block.[2]

DISCUSSION

As recommended in the literature and to prevent local and systemic untoward reactions, a minimum of 60 seconds for delivery of a 1.8-mL anesthetic solution during an intraoral nerve block is necessary.[2] The clinician administered the anesthetic solution slowly with the traditional syringe technique, and for the test computer-controlled technique the device precisely controlled the flow rate, thereby allowing a constant flow rate to be maintained even when different soft tissue resistances were encountered. The time required to deliver the second 1.8-mL cartridge with the traditional syringe was 59.71 ± 8.0 seconds versus 58.06 ± 7.0 seconds with the test computer-controlled syringe, a finding that was not statistically significant ($P < .36$).

This study demonstrates a statistically significant reduction in the time needed to reload a second cartridge, 12.09 ± 6.0 seconds with the computer-controlled device versus 23.46 ± 3.5 seconds with the traditional syringe ($P < .0001$). This is possible because the first cartridge is removed and the second cartridge is placed into the cartridge holder attached to the top of the

Table 2 Time measured for different subject variables

Variables	Injection method		
	Test	Traditional	*P* value
Time (sec) to reload a second cartridge in the syringe or the cartridge holder	12.09 ± 6.0	23.46 ± 3.5	< .0001*
Time (sec) to deliver a second full 1.8-mL cartridge	58.06 ± 7.0	59.71 ± 8.0	< .36
Anesthesia success rate			
3 minutes	80.0%	94.3%	
10 minutes	11.4%	5.7%	< .13†
Not completed	8.6%	0.0%	

*Statistically significant.
† Chi-square.

computer drive unit located a distance away from the operator and patient. Therefore, it may be concluded that time inefficiency is incorporated during syringe withdrawal for a cartridge reload with the traditional syringe technique as compared to the test computer-controlled syringe technique (see Table 2).

The test computer-controlled syringe technique does not require needle removal and reinsertion, thereby reducing the risk of soft tissue trauma during needle reinsertion or self-inflicted needle stick during withdrawal and reloading of cartridges.[2,6,7,12–15] However, there were no diagnosed local, regional, or systemic complications in any of the patients or any observed needle sticks delivered to the clinician with either technique.

Two-cartridge delivery with the traditional technique resulted in a success rate of 94.3% at the 3-minute interval and 100% at the 10-minute interval following the administration of the second cartridge. This compares quite favorably with and surpasses the accepted 85% success rate achieved generally with the inferior alveolar nerve block technique. Two-cartridge delivery with the test computer-controlled technique resulted in a success rate of 80.0% at the 3-minute interval and 91.4% at the 10-minute interval. The latter result also compares quite favorably with and surpasses the accepted success rate of 85% for the inferior alveolar nerve block.

CONCLUSIONS

1. The success rate of the inferior alveolar nerve block using the direct approach with the traditional syringe technique is significantly improved up to 94.3% at the 3-minute interval and 100% at the 10-minute interval as well as to 91.4% with the computer-controlled syringe technique at the 10-minute interval following injection of 2 standard 1.8-mL local anesthetic cartridges at the same site. These results compare quite favorably with and surpass the accepted success rate of 85% for the inferior alveolar nerve block in general. Therefore, to enhance such success, the clinician should consider the administration of 2 1.8-mL cartridges to the same site. Further clinical prospective patient study is required to support this conclusion.
2. The test computer-controlled syringe technique is statistically more time efficient regarding the removal of the first cartridge and reloading of the second cartridge when compared with the traditional syringe technique.
3. The total time required for administration of the full second cartridge did not differ significantly between the traditional syringe and test computer-controlled syringe system.
4. The test computer-controlled syringe system does not require removal of the needle and syringe from the injection site in order to reload the second cartridges.

This allows not only for increased time efficiency, as mentioned above, but may also decrease the risk of soft tissue damage to the patient and/or the clinician, which is always a possibility when introducing a long needle into soft tissues during an inferior alveolar nerve block and lingual nerve infiltration.

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