Minimizing the Pain of Local Anesthesia Injection

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Background: Local anesthetic injection is often cited in literature as the most painful part of minor procedures. It is also very possible for all doctors to get better at giving local anesthesia with less pain for patients. The purpose of this article is to illustrate and simplify how to inject local anesthesia in an almost pain-free manner.
Methods: The information was obtained from reviewing the best evidence, from an extensive review of the literature (from 1950 to August of 2012) and from the experience gained by asking over 500 patients to score injectors by reporting the number of times they felt pain during the injection process.
Results: The results are summarized in a logical stepwise pattern mimicking the procedural steps of an anesthetic injection—beginning with solution selection and preparation, followed by equipment choices, patient education, topical site preparation, and finally procedural techniques.
Conclusions: There are now excellent techniques for minimizing anesthetic injection pain, with supporting evidence varying from anecdotal to systematic reviews. Medical students and residents can easily learn techniques that reliably limit the pain of local anesthetic injection to the minimal discomfort of only the first fine needlestick. By combining many of these conclusions and techniques offered in the literature, tumescent local anesthetic can be administered to a substantial area such as a hand and forearm for tendon transfers or a face for rhytidectomy, with the patient feeling just the initial poke. (*Plast. Reconstr. Surg.* 132: 675, 2013.)

Local anesthetic injection is often cited in the literature as the most painful part of minor procedures.[1,2] It is also very possible for all doctors to get better at giving local anesthesia with less pain for patients. The purpose of this article is to illustrate and simplify how to inject local anesthesia in an almost pain-free manner. The information is obtained from reviewing the best evidence, from an extensive review of the literature (from 1950 to August of 2012) and from the experience gained by asking over 500 patients to score injectors by reporting the number of times they felt pain during the injection process. The results are summarized in a logical stepwise pattern mimicking procedural steps of an anesthetic injection—beginning with solution selection and preparation, followed by equipment choices, patient education, topical site preparation, and finally procedural techniques. There are now excellent techniques for minimizing anesthetic injection pain, with supporting evidence varying from anecdotal to systematic reviews. Medical students and residents can easily learn techniques that reliably limit the pain of local anesthetic injection to the minimal discomfort of only the first fine needlestick.[3] By combining many of these conclusions and techniques offered in the literature, tumescent local anesthetic can be administered to

From McMaster University; and Dalhousie University.
Received for publication February 1, 2013; accepted March 6, 2013.

DOI: 10.1097/PRS.0b013e31829ad1e2

Disclosure: *The authors have no financial interest to declare in relation to the content of this article.*

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a substantial area such as a hand and forearm for tendon transfers or a face for rhytidectomy, with the patient feeling just the initial poke.[4–6]

PAIN AND LOCAL ANESTHESIA EXPLAINED

Cutaneous nociceptors provide an important warning system about injury that could endanger the body.[7] Nociceptors consist of pacinian corpuscles (movement-sensitive hair follicle receptors), Ruffini endings (pressure-sensitive), mechanoreceptors, and free-ended nociceptors at the dermal-epidermal border.[7,8] These receptors activate two types of nerve fibers: fast, myelinated fibers, called A-δ fibers; and slow, unmyelinated C fibers.[8] A-δ fibers typically carry the afferent impulses for sharp sensations, whereas unmyelinated C fibers typically carry afferent impulses of dull pain.[7,9] A threshold number of nociceptors is needed to be activated in a confined area of skin to generate a painful impulse.[10] Local anesthetics work by blocking free nerve endings and preventing transmission of painful stimuli. This is accomplished through blocking voltage-gated sodium channels.[11] However, before local anesthetic molecules can provide anesthesia, they must first diffuse through hydrophobic cell membranes into the neurons. Pain from local anesthetic injections occurs with both the insertion of the needle and the infiltration of fluid. The needle puncture activates pacinian corpuscles, mechanoreceptors, and the Ruffini endings, whose afferent impulses are carried along the A-δ fibers to evoke a sharp, acute, pricking pain.[7] Meanwhile, the infiltration of fluid evokes a second type of pain, mainly from polymodal free-end nociceptors, which tends to be a more intense and prolonged pain.[7,9] This second pain is produced from receptors responding to both chemical irritants and the rapid distention of the tissue.[1]

SOLUTION PREPARATION FOR MINIMAL PAIN

Lidocaine and Epinephrine

This article focuses on lidocaine with epinephrine, as it has remained the most widely used local anesthetic combination since its introduction in 1948.[12] Although articaine is now becoming popular in the dental world,[13–16] 300 million yearly doses of lidocaine and epinephrine are still injected in dental offices in the United States.[17] In fact, it is the widespread dental use of lidocaine and epinephrine in dental offices that has cemented the safety of those two medications. Only 702 cases of adverse events from lidocaine injections were reported in the 33 years between 1964 and 1997.[18]

Benefits of adding epinephrine to lidocaine include minimized bleeding, longer duration of action of the local anesthetics, and higher safe dosage tolerances because of less vascular diffusion. In addition, epinephrine's blanching effect on the skin provides a useful visual indicator of the extent of the anesthetized area.

There is level II evidence that a single subcutaneous injection in the midline of the phalanx with lidocaine and epinephrine finger blocks provides pain relief for 10 hours, whereas they only last 5 hours with lidocaine without epinephrine.[19] In addition, the myth that lidocaine with epinephrine is contraindicated in fingers has been dispelled.[20–24]

Buffer the Lidocaine and Epinephrine

Lidocaine 1% with 1:100,000 epinephrine has been found to have a pH of 4.2, which is 1000 times more acidic than physiologic pH.[25] According to the literature, the use of sodium bicarbonate to buffer lidocaine with epinephrine has been studied extensively. Although some trials have not shown any diminution of injection pain with buffering,[26,27] the majority of studies have shown significant pain reduction.[28–31] A recent meta-analysis and systematic review concluded that lidocaine buffered with 10:1 sodium bicarbonate was associated with a statistically significant pain reduction compared with unbuffered lidocaine.[32] A 2010 Cochrane review also supports the use of buffering lidocaine with epinephrine.[33] The proper concentration of bicarbonate that is required to properly buffer the solution and effectively raise the solution pH to a physiologic 7.4 is a 1:10 ratio of 8.4% sodium bicarbonate to 1% lidocaine with 1:100,000 epinephrine.[25]

Local anesthetics work by blocking nerve transduction but must first diffuse into the nerve. At a physiologic pH, more lidocaine molecules are in an unionized state.[11] Buffering local anesthetic accelerates the passage of more uncharged molecules through lipophilic cell membranes, producing a faster time of onset.[1,11] A common concern with buffering revolves around stability or shelf life of the buffered solutions.[31] Acidic solutions are used to increase the solubility and stability of local anesthetics, which are weak bases.[11] However, most of the concerns relate to decreasing the stability and efficacy of the epinephrine and not the lidocaine.[11] Buffered lidocaine with epinephrine does not decrease its anesthetic efficacy.[29] Buffering lidocaine with epinephrine causes only a 25

percent decrease of the epinephrine concentration per week. The senior author (D.H.L.) buffers his lidocaine with epinephrine on the day of use.

Fortunately, buffering is simple. Ten-milliliter syringes can actually hold 11 ml of fluid, and 20-ml syringes can hold 22 ml.[25] Drawing up 1 ml of 8.4% sodium bicarbonate and then filling the syringe with 10 ml of lidocaine, for a total volume of 11 ml, provides a simple method to achieve the desired 10:1 ratio. Sodium bicarbonate is also inexpensive. It is readily available as a 8.4% solution in 50-cc bottles in Canada at a cost of less than Can$5.

Warm the Local Anesthetic

A recent systematic review and meta-analysis conducted in 2011[34] concluded that warming of anesthetic fluid significantly reduces the pain of injection whether the solution is buffered or not. When compared head to head, the relative benefit of warming is smaller than that of buffering.[31,35] Studies consistently show that the combination of warming and buffering a solution provides the least painful injection[31,36,37] and has no effect on the duration of anesthesia.[31]

There are two popular postulated mechanisms of action for warming injection solution. The first is that cold temperatures stimulate more nociceptor fibers. The second is that as the temperature increases, local anesthetic molecules diffuse faster across cell membranes, producing a quicker time of onset.[34]

EQUIPMENT FACTORS TO REDUCE INJECTION PAIN

Use a Smaller Diameter Needle for Injection

Many studies have shown pain reduction with smaller needle diameters.[2,7,38,39] A well-designed randomized controlled trial using an automated injection device to standardize injection parameters demonstrated a significant decrease in pain reported with 30-gauge needles than with 25-gauge needles.[2] Use of a 27- to 30-gauge needle, if possible, is recommended.[1,5] The use of a smaller gauge needle also forces the injector to slow the rate of injection, which has also been shown to decrease the pain experienced. The authors routinely use 30-gauge needles in the face and 27-gauge needles in the hand and trunk.

Use Fresh Needles: Repeated Needle Use Dulls the Tip and Increases Pain

Pain of needle insertion has been related to the sharpness or bluntness of needle bevels.[40] Using separate needles for drawing up and injection significantly reduced pain intensity of needle insertion.[41] A sharper needle reduces the force required to puncture the skin.[38] This activates fewer nerve fibers, reducing temporal stimulation of afferent nociceptor fibers and thus minimizing pain.

PATIENT PREPARATION TO DECREASE INJECTION PAIN

The Patient Can Look Away

Visual feedback may be of importance. In one study,[42] a video screen suspended above participants' hands depicted one of the following: an untouched hand, or a cotton swab or a needle poking a virtual hand. An electrode was used on the participants' fingers to deliver a shock either above or below an individual's predetermined pain threshold. Although there was no significant difference between a visual cue of the painful (needle) and nonpainful stimulus (cotton swab), there was a significantly lower relative pain perception when a nontouched hand was shown, despite the intensity of the shock. The authors concluded that looking away (simulated by the untouched hand) may decrease pain perception.

Distraction

Given that anxiety appears to play a role in pain perception,[1,43–46] it is not surprising that there is evidence that distraction methods such as listening to music,[47] task distraction,[48] blowing away the pain (pediatrics),[47] and conversation distraction[1] may decrease the pain. A 2008 systematic review examined psychological interventions to reduce needle-related pain in children and adolescents.[49] It concluded that distraction, suggestion of minimal pain, patient positioning, and nurse coaching all appear to decrease perceived or reported pain.

STRATEGIES TO DECREASE THE PAIN OF THE NEEDLE PUNCTURE

Consider Topical Anesthetic Creams and Cooling with Ice

Topical creams such as a eutectic mixture of local anesthetics are often used to anesthetize needle puncture sites. Eutectic mixture of local anesthetics is a topical oil water emulsion of 2.5% prilocaine and 2.5% lidocaine.[50] Eutectic mixture of local anesthetics creams significantly reduce the pain of venous cannulation.[8,51] Eutectic mixture of local anesthetic creams are commonly

used for superficial dermatological procedures with successful results.[50]

Their main drawback is that they must be applied for a long time on the skin to be effective. A total of 90 to 120 minutes is required for the eutectic mixture of local anesthetic cream to reach its maximum effect.[52] Studies have shown that the penetrating depth of the anesthesia is 3 mm at 60 minutes[8,53] and more than 5 mm after 90 to 120 minutes.[8]

Applying ice before needle insertion has been found to reduce pain in many trials.[54–56] Ice is frequently used in dental practice to dull the pain of needle insertion into mucosa.[55,57] In the mucosa of the palate, ice provided more effective pain reduction, decreased application time requirement, greater ease of application, and avoidance of displeasing taste when compared with eutectic mixture of local anesthetic creams.[57] The results of a study comparing the efficacy of eutectic mixture of local anesthetic topical anesthesia and the application of ice before cutaneous needle insertion showed that the eutectic mixture of local anesthetic provided better pain control but was hindered by the slow onset, whereas ice was inexpensive, fast-acting, and readily available, and still produced statistically significant pain reduction.[54]

Consider Tactile Distraction: Vibration, Pinch, Stretch, Touch, and Pressure

Tactile distraction in the area of needle insertion (Fig. 1) can also be used to reduce pain. Fast myelinated fibers can effectively "close the pain gate" if a new stimulus such as pressure or touch is perceived near the pain source.[1] Other forms of stimulation, such as pinching, stretching, pressing, or tapping near needle insertion sites have also been described to reduce perceived pain.[50,58] The use of vibration in dental procedures has shown to decrease the pain of needle insertion.[55,59] The stimuli increase the "sensory noise" perceived by the brain in the area of the needlestick. This is the mechanism that explains why rubbing a stubbed toe seems to dissipate some of the pain.

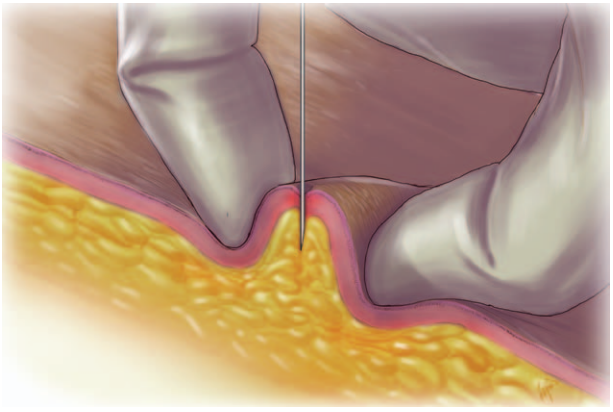

Fig. 1. If the skin is loose, it can be gently pinched in the area into which the fine needle will be inserted. This provides both tactile distraction and tension to facilitate needle insertion.

Inject into Subcutaneous Fat if There Is an Open Wound

When confronted with a laceration or a post-Mohs surgical defect, injection of local anesthetic into the subcutaneous fat has been shown to significantly reduce the perceived pain when compared with injections into the intact adjacent skin.[60,61] This may be explained by the higher concentration of nerve endings in dermis than in subcutaneous fat.

Insert the Needle Perpendicular to the Skin

Needle puncture pain can be minimized by inserting the needle at 90 degrees (Fig. 2). Most pain nerve endings are found within the dermis, like the leaves on a tree, with the larger branches and trunks in the fat. By penetrating the skin at 90 degrees (instead of 45 degrees), the needle passes through fewer pain fibers.[50] A level II evidence study of 65 subjects receiving two injections standardized to rate, volume, temperature, and pH found a statistically significant difference in pain reduction with 90-degree versus 45-degree needle insertions.[62]

STRATEGIES TO DECREASE THE PAIN OF THE LOCAL ANESTHETIC INJECTION

Stabilize the Syringe Holding Hand to Minimize Needle Movement

Unintentional needle wobbling movement increases the pain felt by patients until the needle puncture site is numb.[63] A simple technique to decrease movement during injection is to stabilize the syringe holding hand with fingers propped on the skin, similar to techniques used during microsurgery (Fig. 3). Using stabilized hands has been shown to improve needle bevel control.[63] If the syringe holding hand is not stabilized, the patient will feel every little needle movement until the needle site is numb.

Inject Subdermally Instead of Intradermally

Although studies show that injecting intradermally can induce anesthesia more rapidly than

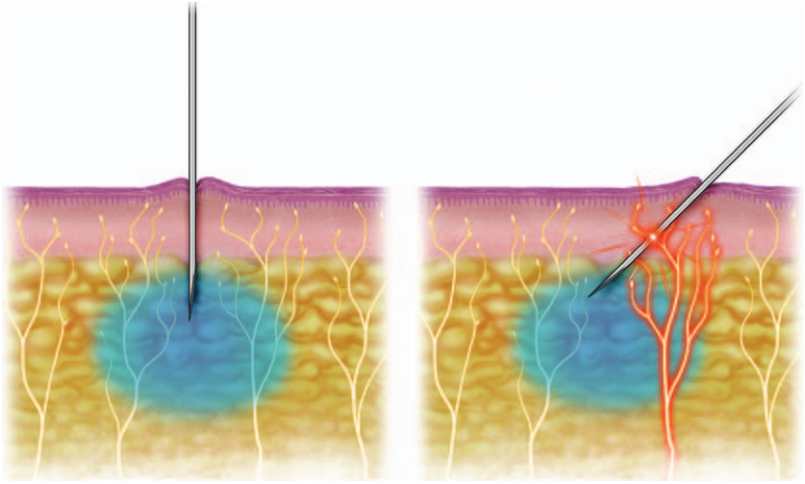

Fig. 2. Fewer nerve fibers are irritated and the pain is less when the needle is inserted at 90 degrees, as opposed to the more painful 45 degrees.

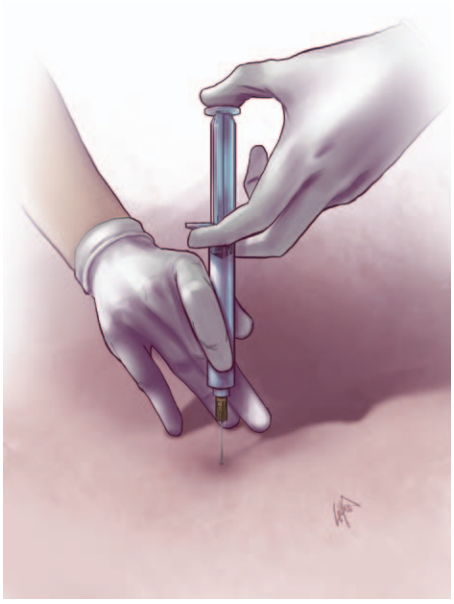

Fig. 3. Stabilize the needle by pinching the syringe between the index finger and thumb while resting it on an outstretched long finger. This provides three-point fixation with the syringe and the fingers on the skin, minimizing needle movement. If the syringe holding hand is free in the air and is not stabilized on the skin, the patient feels every little needle movement until the local anesthetic has numbed the needle insertion site.

subcutaneous injection,[1] a level II evidence study showed that injecting intradermally produces more pain.[64] Stretching of the dense nociceptor-rich dermal tissue activates more pain fibers than stretching of the loose subcutaneous tissue. Pain can be minimized by injecting just beneath the dermis into the subcutaneous tissue (Fig. 4). Using the tree analogy, injecting beneath the dermis blocks the dermal nerves beneath the leaves at the trunk level.[64,65] By injecting just beneath the dermis into the subcutaneous tissue, injection pain can be minimized (Fig. 4). An easy method to determine whether the injection is intradermal is to look for immediate whitening, tightening, or peau d'orange appearance of the skin.[64]

Inject a Small Subdermal Bleb and Then Pause

To minimize the pain of needle movement and infiltration, immediately following needle insertion, inject the first 0.2 to 0.5 ml so you can see a subcutaneous wheal, and then pause[1,4,50] (Fig. 5). This gives time for the local anesthetic to numb the needle insertion site, which can take up to 45 seconds. It is useful to ask the patient to tell you when the "pain of the needle is *all* gone" before proceeding. Patients will feel movement of the needle until the needle site is numb. After the pain is all gone, inject an additional 2 cc without moving the needle at all. Then you can proceed to tilt the needle parallel to the skin and inject slowly in an antegrade fashion as described below.

Inject Very Slowly

Pain is greater with rapid injections.[45,50,64,66] Slowing the rate of injection can make the injection "virtually painless."[1,4] The pain of infiltration is from activated skin nociceptors[1] responding to rapid distention and stretching of the tissue. Slowing injection rates facilitates "accommodation" of nerve endings, and provides time for the anesthetic to diffuse and block the nerve transduction of the stimulated fibers. A study using a computer-assisted injection concluded that slower injection rates produced less pressure and less pain.[45]

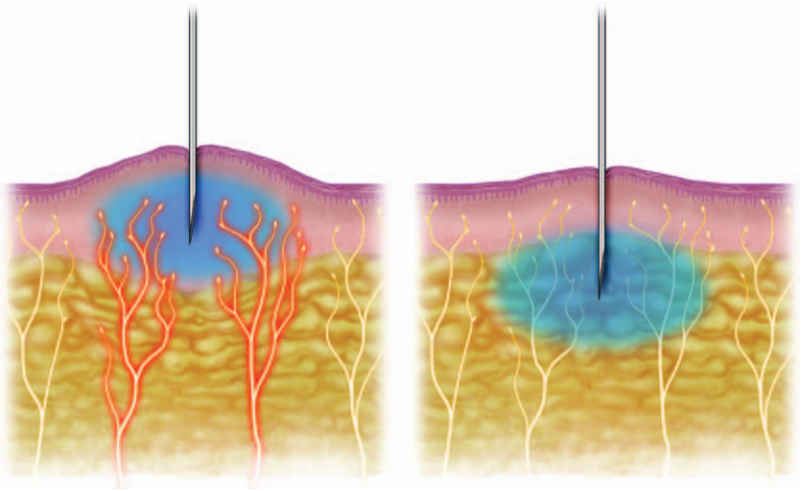

Fig. 4. Injecting subdermally is less painful than injecting intradermally. The nerves are knocked out at their source at the trunk and branch level, rather than in the leaves of the neural tree.

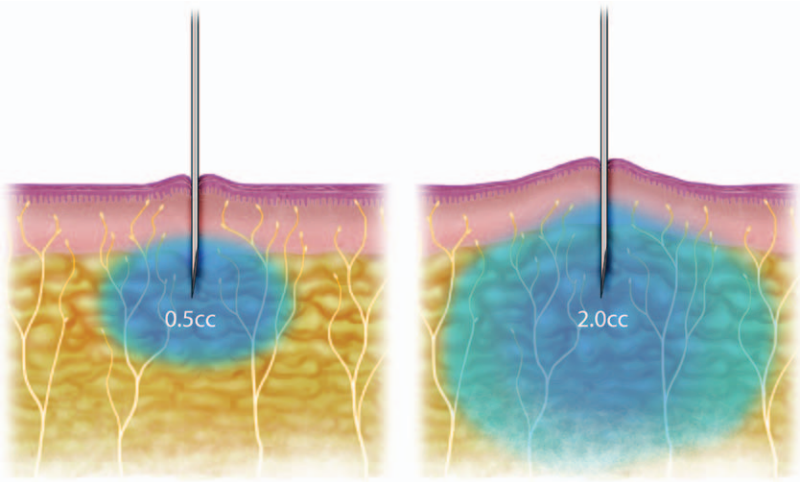

Fig. 5. Inject an initial subcutaneous 0.2- to 0.5-ml bleb and then pause. Wait 15 to 45 seconds until you are reassured by the patient that "the pain of the needle is *all* gone." Then, proceed to inject an additional 2 ml very slowly without moving the needle.

Another study of dorsal penile blocks showed less pain with slower injections.[66] Using a smaller gauge needle has the benefits listed earlier, but also forces the injector to slow down.

Keep the Local Anesthetic Wheal 10 mm ahead of the Needle Tip

Keeping a good volume of antegrade injection of local anesthetic ahead of the sharp needle tip and giving that local anesthetic time to work is key. During injection, the phrase "blow slow before you go, blow slow before you go" is repeated silently by medical students and residents who scored highly in a recent study evaluating minimal pain local anesthetic injections.[3]

Very large areas can be anesthetized with the patient feeling only the initial poke if a wheel of 10 mm of visible or palpable local anesthetic is always kept in front of the needle tip as it is slowly but gradually advanced.[5] The wheal can often be palpated through the skin with the other hand (Fig. 6). Most importantly, never let the needle get into unanesthetized nerves ahead of the local anesthetic (Fig. 7).

Reinsert the Needle Only within 1 cm of the Blanched Skin Border

If a very large area is being anesthetized, such as in a forearm tendon transfer or a facial rhytidectomy, the needle will have to be withdrawn

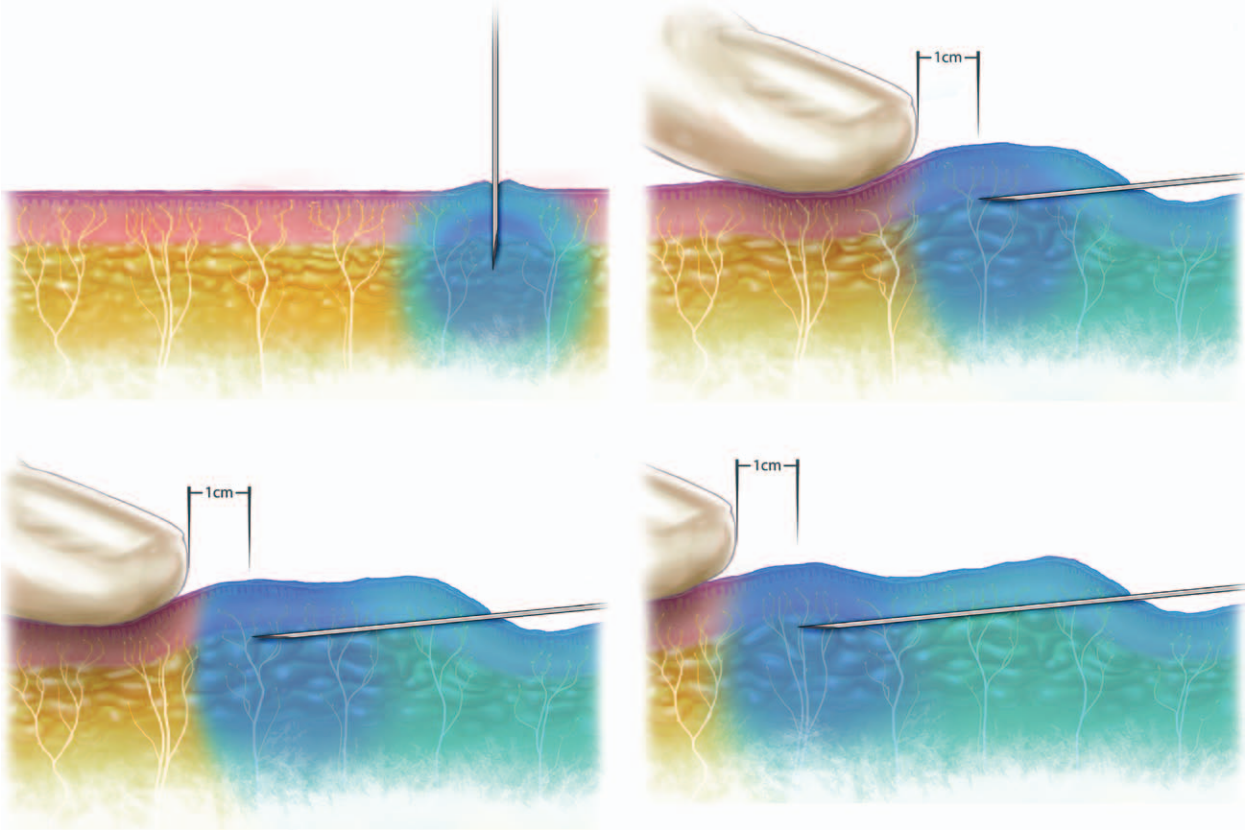

Fig. 6. Illustrations for minimal pain local anesthetic injection. (*Above*, *left*) Insert the needle perpendicular to the skin, inject a small bleb subcutaneously, and wait 15 to 45 seconds (as shown in previous figures). (*Above*, *right* and *below*) Keep tumescent local anesthetic 10 mm in front of the needle bevel while advancing under the dermis. The other hand can be used to palpate the extent of the tumescence ("blow slow before you go").

and reinserted more than once to anesthetize the whole area. The needle should always be reinserted within 1 cm of blanched skin to ensure that there is functioning epinephrine, and therefore functioning lidocaine, at the needle reinsertion site. In this way, the needle can be reinserted countless times in a totally pain-free fashion.

Ask All Patients to Score Their Injection Pain

For the past 5 years, the senior author (D.H.L.) has had each patient score the number of times pain was felt during the injection process of injections performed by himself and those performed by over 200 learners. In a study published in 2012, 25 consecutive learners injected patients who scored the learners by recording the number of times they felt pain during the injection process. Patients felt only the first poke of the first needle ("hole in one") for 75 percent of the learners, and had two episodes of pain ("eagle") during the injection process for 25 percent of the learners.[3]

The senior author asks his patients to score him each time he injects local anesthesia for any purpose. Each patient is an opportunity to learn how to inject with less pain. The most common reason that learners cause pain are injections that are too fast, with failure to allow the antegrade injection to numb the nerves before advancing the needle.

CONCLUSIONS

A video demonstrating many of the aforementioned techniques and providing patient testimonials is available. (**See Video, Supplemental Digital Content 1**, which is a technique demonstration and testimonials for an almost painless local anesthetic injection, ***http://links.lww.com/PRS/A830***. Demonstration and discussion of proper injection technique, including tips regarding speed, timing, location, blanching, and volume of local anesthetic injection are included. Also included are testimonials from nine patients anesthetized for nasal reconstructions, carpal tunnel releases, and blepharoplasties. A separate video, demonstrating the technique of the

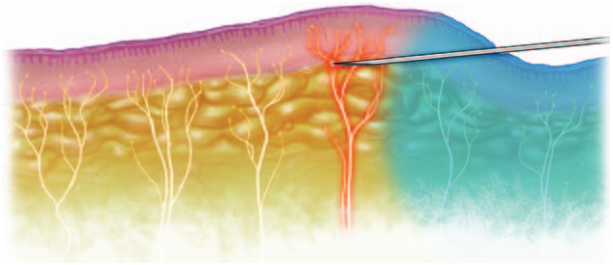

Fig. 7. Do not jab the needle tip ahead of the injected local anesthetic. The needle bevel will contact unanesthetized nerve endings and cause pain.

Video 1. Supplemental Digital Content 1 is a technique demonstration and testimonials for an almost painless local anesthetic injection, ***http://links.lww.com/PRS/A830***.

carpal tunnel injection, is available at Lalonde DH. "Hole-in-one" local anesthesia for wide-awake carpal tunnel surgery. *Plast Reconstr Surg.* 2010;126:1642–1644.) To decrease the pain of local anesthetic injection, consider (1) buffering lidocaine and epinephrine with 8.4% bicarbonate; (2) warming the local anesthetic; (3) distracting the patient or the area of injection; (4) using 27- or 30-gauge needles; (5) stabilizing the syringe to avoid needle wobble; (6) injecting 0.5 cc perpendicularly subdermally and pausing until the patient says the needle pain is gone; (7) injecting an additional 2 cc before moving the needle, and then moving antegrade very slowly with 1 cm of local always palpable or visible ahead of the needle; (8) reinserting needles within 1 cm of blanched areas; and (9) learning from each patient you inject by asking them to score you.

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Q: Level of Evidence grading is new to me as an author (or reviewer). Are there resources to help me determine the LOE for my paper?

A: There are numerous resources in a variety of formats available to you as an author or reviewer. Those resources include:

- *PRS* Information for Authors (http://journals.lww.com/plasreconsurg/Pages/InformationforAuthors.aspx)
- ASPS LOE Grading Recommendations Table (see Table 1)
- PRS Evidence-Based Medicine Article Collections
  - "Evidence-Based Medicine: How-To Articles" collection (http://journals.lww.com/plasreconsurg/pages/collectiondetails.aspx?TopicalCollectionId=24
  - "Evidence-Based Medicine: Outcomes" collection (http://journals.lww.com/plasreconsurg/pages/collectiondetails.aspx?TopicalCollectionId=19)
- Author Tutorial: ASPS "Evidence-Based Medicine and the Critical Appraisal Process" (give PRS, ASPS, and Enkwell web addresses)
- Reviewer Tutorial: ASPS "Reviewing Concepts in Study Design and Critical Appraisal" (give PRS, ASPS, and Enkwell web addresses)
- See the companion article "The Levels of Evidence and their role in evidence-based medicine" article in this issue.

Additional Level of Evidence and Evidence-Based Medicine training is available at the ASPS and ASAPS annual meetings. We encourage you to register and sign up for these training courses.