Supplementary local anesthetic injection techniques in dentistry

Niroshani S. Soysa

Abstract
Local anesthesia plays a pivotal role in pain management in dentistry. Local anesthesia is administered by way of infiltration, field blocks and nerve blocks. Infiltration technique is commonly employed in maxilla due to the porous cancellous bone. However, nerve blocks exemplified by inferior alveolar nerve block (IANB) are commonly required in anesthetizing the mandibular teeth due to the thick cortical bone. Consistent anesthesia with IANB is elusive. The literature reveals IANB failure of 33.1% - 71%, which becomes more in teeth having irreversible pulpitis. The data shows that that the anesthesia of mandibular molars with irreversible pulpitis is eight times more than the healthy pulps requiring supplemental injections (with different techniques and/or types of anesthetic) to achieve profound anesthesia. This is an attempt to review the supplementary injection techniques in dentistry which can be used as sole techniques or to complement the IANB.

Introduction
Local anesthesia provides the backbone of pain control in dentistry (1). Local loss of pain in a circumscribed area is important in pre-, intra- and post-operative pain management in various dental procedures such as endodontics, exodontia and periodontal treatments. Local anesthetics include amino esters exemplified by cocaine and procaine and amino amides exemplified by lignocaine and articaine. The basic structure of a local anesthetic agent consists of a lipophilic aromatic ring connected to a hydrophilic amine via an intermediate hydrocarbon chain with an ester or amide linkage. Local anesthetics in dentistry are usually administered by an infiltration, a field block or a nerve block. Infiltration techniques are commonly employed in maxilla because of the porous cancellous bone whereas nerve blocks are needed to achieve anesthesia in mandibular teeth.

Inferior alveolar nerve block (IANB) is one of the frequently used techniques in obtaining anesthesia in mandibular teeth. Inadequate depth and/or duration of an anesthetic to begin or to continue a dental procedure can be defined as anesthetic failure which is a common occurring with IANB and is unavoidable. The IANB has shown a success rate between 43% and 55.6% on healthy first permanent molar pulps using two consecutive electric pulp testing (EPT) readings as an outcome measure (2-5). Other studies using the visual analog scale (VAS) on inflamed molar teeth have revealed success rates between 25% and 75%6-15. The results of these studies are outlined in more detail in Table 1. Local anesthetic failure can occur as a result of certain factors at both ends of the syringe i.e. operator dependent and patient dependent factors16. Use of inappropriate anesthetic and insufficient solution may cause anesthetic failure which can be easily overcome. However, failure due to anatomical factors such as variations in the position of nerves and foramina, accessory nerve supply, abnormal
The course of the nerves and pathological as well as psychological factors may require additional local anesthetic injection techniques.

There are several supplementary injection techniques which can be used as sole technique in pain control, as effective pulpal anesthesia in a single tooth without the aid of other techniques and or in situations where other techniques have failed or as a supplement to a failed conventional technique. These techniques include ‘high blocks’ such as the Gow-Gate nerve block.

### Table 1. Success rates of conventional inferior alveolar nerve block (IANB)

<table>
<thead>
<tr>
<th>Local anesthetic used in IANB</th>
<th>Outcome measure</th>
<th>Pulpal status</th>
<th>No. of participants</th>
<th>Success rate</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>4% articaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>40</td>
<td>53%</td>
<td>Mikesell et al., (2005)²</td>
</tr>
<tr>
<td>2 ml, 2% lignocaine + 1:80,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>31</td>
<td>55.6%</td>
<td>Kanaa et al., (2006)³</td>
</tr>
<tr>
<td>3.6 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>40</td>
<td>53%</td>
<td>Goldberg et al., (2008)⁴</td>
</tr>
<tr>
<td>1.7 ml, 4% articaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>35</td>
<td>43%</td>
<td>Jung et al., (2008)⁵</td>
</tr>
<tr>
<td>4% articaine + 1:100,000 adrenaline 2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>72</td>
<td>24% 23%</td>
<td>Claffey et al., 2004⁶</td>
</tr>
<tr>
<td>1.8 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>15</td>
<td>60%</td>
<td>Remmers et al., (2008)⁷</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>97</td>
<td>36%</td>
<td>Aggarwal et al., (2010)⁸</td>
</tr>
<tr>
<td>4% articaine + 1:100,000 adrenaline 2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>52 52</td>
<td>75% 69.2%</td>
<td>Poorni et al., (2011)⁹</td>
</tr>
<tr>
<td>1.7 ml 4% articaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>100</td>
<td>26%</td>
<td>Rogers et al., (2014)¹⁰</td>
</tr>
<tr>
<td>1.8 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>20</td>
<td>10%</td>
<td>Monteiro et al., (2015)¹¹</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>156</td>
<td>62.8%</td>
<td>Zain et al., (2016)¹²</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>375</td>
<td>28%</td>
<td>Fowler et al., (2016)¹³</td>
</tr>
<tr>
<td>2% lignocaine + 1:80,000 adrenaline</td>
<td>NAS</td>
<td>Carious/periodontally affected</td>
<td>50</td>
<td>58%</td>
<td>Venkat Narayan et al., (2017)¹⁴</td>
</tr>
<tr>
<td>4% articaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>199</td>
<td>25%</td>
<td>Shapiro et al., (2018)¹⁵</td>
</tr>
</tbody>
</table>
Supplementary local anesthetic injection techniques in dentistry

(GGNB)19 and Vazirani-Akinosi technique20, intraosseous anesthesia techniques such as periodontal ligament injection21, intraseptal injection and intraosseous injection22. Intrapulpal injection can be used when the other techniques have failed. Table 2 lists the various indications of supplemental techniques. Mandibular infiltration technique has received a considerable attention in recent past because of the availability of agents with superior diffusibility such as articaine23. In addition, there are several clinical trials which have carried out to see the feasibility of using infiltration technique to anesthetize mandibular molars as an alternative for IANB.

Table 2. Indications of supplemental injection techniques

<table>
<thead>
<tr>
<th>Supplemental injection technique</th>
<th>Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Procedures on multiple teeth in one mandibular quadrant</td>
</tr>
<tr>
<td></td>
<td>Procedures on the buccal periodontium anterior to the first molar</td>
</tr>
<tr>
<td></td>
<td>Procedures on the lingual periodontium</td>
</tr>
<tr>
<td></td>
<td>Pulpal anesthesia involving one or two teeth in a quadrant</td>
</tr>
<tr>
<td></td>
<td>One or two teeth in both quadrants</td>
</tr>
<tr>
<td></td>
<td>When soft tissue anesthesia is unwanted</td>
</tr>
<tr>
<td></td>
<td>In the presence of any contraindications for regional block injections</td>
</tr>
<tr>
<td></td>
<td>Diagnosis of pulpal pain in teeth</td>
</tr>
<tr>
<td></td>
<td>Adjunct in partial anesthesia of block injection</td>
</tr>
<tr>
<td></td>
<td>Pain control in soft tissue and osseous periodontal treatment</td>
</tr>
<tr>
<td></td>
<td>Hemostasis in soft tissue and osseous periodontal treatment</td>
</tr>
<tr>
<td>Intraosseous injection</td>
<td>Pain control for dental procedures involving a single tooth or multiple teeth in a quadrant</td>
</tr>
<tr>
<td>Intrapulpal injection</td>
<td>Pain control for endodontic procedures due to inadequate anesthesia by other techniques</td>
</tr>
</tbody>
</table>

1. The Gow-Gates nerve block (GGNB)

This technique was described by the Australian dental practitioner George Albert Edwards Gow-Gates in 1973 who had been practicing the technique for about 30 years 19. The Gow-Gates injection anesthetizes the inferior alveolar, lingual, mental, incisive, auriculotemporal, mylohyoid and buccal nerves (in 75% of the patients). This is because the injection blocks the nerves at a point that is proximal to their division into inferior alveolar, buccal, and lingual nerves24. GGNB has many advantages over the IANB. Approximately 10-15% of the inferior alveolar nerve block injections are aspiration positive25, whereas with the GGNB it is 2%. In addition, higher success rate and the absence of problems with accessory sensory innervation to the mandibular teeth are other added advantages of this technique.

In GGNB the target area is the lateral aspect of the anterior portion of the condyle, just inferior to the insertion of the lateral pterygoid muscle. The injection is performed while the patient opens the mouth comfortably widely as possible to rotate and translate the condyle forward. The condyle is palpated with the fingers of the non-dominant hand while the cheek is retracted with the thumb. The extraoral landmarks are the intertragic notch and the labial commissure of the same side. Beginning from the contralateral canine, the needle is positioned so that a puncture point is made approximately at the location of the distobuccal cusp of the maxillary second molar26.
A 25-gauge long needle is inserted slowly to a depth of 25-30 mm; the endpoint is inferior and lateral to the condylar head. The injection must not be performed unless bone is contacted to ensure proper needle placement. After the needle is withdrawn 1-2 mm, the clinician aspirates and injects the LA contents.

The GGNB has shown a success rate between 38% and 83.9% on healthy first permanent molar pulps using two consecutive EPT readings as an outcome measure. Other studies using the VAS on inflamed molar teeth have revealed success rates between 12.5% and 87.5%. The results of these studies are outlined in more detail in Table 3.

### Table 3. Success rates of Gow-Gates nerve block (GGNB)

<table>
<thead>
<tr>
<th>Local anesthetic used in IANB</th>
<th>Outcome measure</th>
<th>Pulpal status</th>
<th>No. of participants</th>
<th>Success rate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>162</td>
<td>83.9%</td>
<td>Hung et al., (2006)27</td>
</tr>
<tr>
<td>3.6 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>40</td>
<td>53%</td>
<td>Goldberg et al., (2008)4</td>
</tr>
<tr>
<td>1.8 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>Healthy FPM</td>
<td>32</td>
<td>12.5%</td>
<td>Kohler et al., (2008)28</td>
</tr>
<tr>
<td>1.8 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>Healthy FPM</td>
<td>32</td>
<td>87.5%</td>
<td></td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>40</td>
<td>87.5%</td>
<td>Sherman et al., (2008)29</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>97</td>
<td>52%</td>
<td>Aggarwal et al., (2010)8</td>
</tr>
<tr>
<td>3.6 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>125</td>
<td>35%</td>
<td>Click et al., (2015)30</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>40</td>
<td>50%</td>
<td>Ghoddusi et al., (2018)31</td>
</tr>
</tbody>
</table>

2. **Vazirani-Akinosi closed-mouth mandibular block**

This technique was described by Joseph Akinosi in 1977 and Vazirani described a similar technique in 1960. This block injection anesthetizes the inferior alveolar, lingual, incisive, mental and mylohyoid nerves. This injection is especially indicated in patients with trismus because it is performed while the jaw is in the physiologically resting position. This block provides ipsilateral anesthetization of the mandibular teeth from the third molar to the midline, the buccal mucoperiosteum, soft tissues anterior to the mental foramen, the body of the mandible and lower part of the ramus, the PDL, lingual mucous membrane and periosteum, anterior part of tongue (2/3rd), floor of

---

Niroshani S. Soysa
the mouth and the skin and subcutaneous tissues of the chin and lower lip\textsuperscript{26}.

The technique is performed with the patient placed supine or semi-seated. The operator palpates the coronoid notch and then opens out the soft tissues of the cheek and upper vestibule. A 25-gauge long needle is inserted parallel to the maxillary occlusal plane at the height of the maxillary buccal vestibule. The bevel should be oriented away from the bone of the mandibular ramus so that deflection occurs toward the ramus\textsuperscript{26}. The depth of penetration is approximately half the mesiodistal length of the ramus, which is about 25 mm in adults. The depth of insertion will vary with the anteroposterior size of the patient’s ramus. Since there’s no bony end points the Vazirani-Akinosi injection is performed “blindly”\textsuperscript{26}.

This block injection has several advantages including reduced risk of positive aspiration as well as hematoma formation compared to that of an IANB as the inferior alveolar (IA) artery and vein are farther away from the injection site than they are with the IANB. It is also less traumatic than the GGNB as the latter requires wide mouth opening for the entire duration of the technique. However, unlike other techniques the Vazirani-Akinosi technique lacks bony landmarks\textsuperscript{24,26}.

The Vazirani-Akinosi technique has shown a success rate of 27\% on healthy first permanent molar pulps using two consecutive EPT readings as an outcome measure\textsuperscript{4}. Other studies using the EPT or VAS on inflamed molar teeth have revealed success rates between 16\% and 60\%\textsuperscript{8,30,33}. The results of these studies are outlined in more detail in Table 4.

3. Periodontal ligament injection
(Intraligamentary injection)

Periodontal ligament injection (PDL) technique which had been named as periodontal injection had been used in early 20\textsuperscript{th} century (1912-1923). This technique was later abandoned due to the possibility of blood-borne infection and septicemia\textsuperscript{17}. With the advent of devices which enabled easy injection, this technique began to gain its due credit in 1980\textsuperscript{s}\textsuperscript{21}. Periodontal ligament injection is commonly used in mandibular arch because several atraumatic techniques such as supraperiosteal/infiltration can be easily employed in single-tooth pulpal anesthesia of maxillary teeth. The most attractive feature of this technique is that it provides pulpal and soft tissue anesthesia of a single tooth without the extensive soft tissue anesthesia of a regional block. Moreover, anesthesia of a single tooth in both mandibular quadrants is possible with this technique\textsuperscript{18}. Since this injection avoids the

<table>
<thead>
<tr>
<th>Local anesthetic used</th>
<th>Outcome measure</th>
<th>Pulpal status</th>
<th>No. of participants</th>
<th>Success rate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.6 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>40</td>
<td>27%</td>
<td>Goldberg et al., (2008)\textsuperscript{4}</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS IP</td>
<td>97</td>
<td>41%</td>
<td>Aggarwal et al., (2010)\textsuperscript{8}</td>
<td></td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS IP</td>
<td>125</td>
<td>16%</td>
<td>Click et al., (2015)\textsuperscript{10}</td>
<td></td>
</tr>
<tr>
<td>2.2 ml, 2% lignocaine + 1:80,000 adrenaline</td>
<td>EPT IP</td>
<td>30</td>
<td>60%</td>
<td>Sharma et al., (2018)\textsuperscript{31}</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Success rates of Vazirani-Akinosi technique
residual soft tissue anesthesia, this is indicated in children in whom self-inflicted trauma is possible. This injection can be used in patients in whom block anesthesia is contraindicated such as hemophiliacs. Using this injection technique identification of a localized mandibular pain in a tooth is also possible. PDL injection can be used as an adjunct in failed conventional anesthesia.

However, PDL injection should not be performed if the injection area is infected and inflamed and in primary teeth of children with their primary tooth buds present. The injection can be performed using either conventional or specialized syringes such as STA system. A needle is inserted (27 gauge short) with the bevel toward the tooth through the gingival sulcus apically at 30° to the long axis of the tooth (Figure 1) on the mesio-buccal (or mesio-lingual) aspect of the root. The needle is inserted until a resistance is felt which is similar in nature to that of nasopalatine injection and the needle is wedged between the tooth and the crestal bone in the tooth to be anesthetized. It is important that the needle is in contact with the tooth the entire time. A minimal dose of 0.2 ml of anesthesia (per root) is injected under back-pressure over a 20 second period.

![Figure 1. Insertion of needle of periodontal ligament injection is performed at 300 to the long axis of the tooth until a resistance is felt. Needle insertion should be along the root to avoid tissue damage.](image)

![Figure 2. Diagrammatic representation of periodontal ligament injection.](image)

![Figure 3. Area anesthetized by a periodontal ligament injection includes the tooth, lingual and buccal periosteum.](image)
injection might cause discomfort during injection and post injection pain) which reaches the pulpal nerve supply by entering the cancellous bone through natural perforations in the socket wall, but not by travelling down the length of the ligament (Figure 2).

Same procedure is performed on the distal side if the tooth is multi-rooted. Rapid onset is an attractive feature of this technique and the procedure may commence after 30 seconds. This will give rise to anesthesia of the bone, soft tissue, pulp and apical tissues of the area of injection (Figure 3). The success of the technique relies that it is injected against a resistance and no solution flows back to the patient’s mouth. The PDL injection success rate varies between 74-86% as reported by several studies on healthy first permanent molar pulps using two consecutive EPT readings as an outcome measure35-41 (Table 5). The success rate of the anesthesia is varied depending on the volume of LA used. A meta-analysis conducted in 2014 shows that PDL injection is neither superior nor inferior compared to that of IANB42. In certain instances as in the distal aspect of mandibular 2nd and 3rd molars, needle may need to be bent to insert into the PDL space. The duration of pulpal anesthesia is inconsistent and it is reported that lignocaine with 1:100,000 adrenaline may provide pulpal anesthesia of 5-55 minutes whereas, lignocaine with 1:50,000 adrenaline may vary between 0-67 min. However, the duration of anesthesia provided by intraligamental injections may be adequate for procedures such as cavity preparation, pulpectomy and extractions, whereas advanced restorative procedures may require a second injection17.

Even though PDL injection is considered to be a single-tooth anesthetic technique the solution may spread to the adjacent areas and anesthetize the adjoining teeth as well. The presence of a vasoconstrictor increases the success rate of this

<table>
<thead>
<tr>
<th>Local anesthetic used</th>
<th>Outcome measure</th>
<th>Pulpal status</th>
<th>No.</th>
<th>Success rate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Mandibular first premolar</td>
<td>19</td>
<td>79%</td>
<td>Moore et al., (1987)35</td>
</tr>
<tr>
<td>3.6 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>40</td>
<td>79%</td>
<td>White et al., (1998)36</td>
</tr>
<tr>
<td>0.8 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>28</td>
<td>79%</td>
<td>Edwards and Head, (1989)37</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline 4% articaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>51</td>
<td>74% 86%</td>
<td>Berlin et al., (2005)38</td>
</tr>
<tr>
<td>0.4 ml of 4% articaine with 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Maxillary lateral incisor</td>
<td>27</td>
<td>55.6%</td>
<td>Biočanin et al., (2011)39</td>
</tr>
<tr>
<td>0.4ml, 0.6 ml and 0.8 ml of 4% articaine with 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Mandibular premolar</td>
<td>27</td>
<td>50%, 63.3%, 70%</td>
<td>Biočanin et al., (2013)40</td>
</tr>
</tbody>
</table>
technique rather than the type of local anesthetic agent. Furthermore, success rate is more with procedures such as exodontia than endodontic treatment. PDL injection is very effective in causing anesthesia in incisors than other teeth. Success rate is less with mandibular third molar than mandibular first molar and in canines and lateral incisors. Insufficient perforations in that particular area may explain the poor success rate with lateral incisors.

4. Intraseptal injection

Intraseptal injection is used to anesthetize a single tooth or multiple teeth on one quadrant. This requires diffusion of the local anesthetic solution through the cancellous bone (spongy) to reach the dental plexus of nerves innervating the tooth/teeth providing osseous and soft tissue anesthesia. The technique is easily employed in scaling and root planing and surgical flap procedures due to the anesthesia and hemostasis brought by this injection. This technique is similar to the PDL injection hence has many advantages such as lack of extensive soft tissue anesthesia, e.g., lip and tongue anesthesia, atraumatic with minimal bleeding during surgical procedures, useful in infected and inflamed periodontal tissues, rapid onset and lack of postoperative complications. However, similar to PDL injection this technique has the disadvantage of short duration of pulpal anesthesia.

Site of injection of intraseptal technique is at the center of the interdental papilla next to the tooth to be anesthetized. Usually a 27 gauge short needle with the bevel oriented towards the apex of the tooth is inserted at a 45-degree angle to the long axis of the tooth and at a 90-degree angle to the gingiva (Figure 4). Topical anesthesia can be applied at the site of penetration and a few drops of anesthetic are injected as the needle enters the soft tissue. Needle should be advanced until the bone is reached. The needle may be advanced 1 to 2 mm into the interdental septum and a minimal dose of 0.2 to 0.4 mL of anesthetic over a period of 20 seconds is injected. This will provide anesthesia of the bone, soft tissue and root structure of the area of injection. Success rates of intraseptal anesthesia have ranged from 25%-90% depending on how the success was measured (extractions, restorative procedures, and experimental monitoring with an electric pulp tester) (Table 6). The intraseptal technique has shown to have a success rate between 25% and 35% on healthy first permanent molar pulps using EPT readings as an outcome measure. Other studies using the VAS show success rates between 29% and 90% on lateral incisor, premolars and molars.

Figure 4. Diagrammatic representation of intraseptal injection.

Figure 5. Area anesthetized by an intraseptal injection includes bone, buccal soft tissues and root structure of area of injection.
5. **Intraosseous injection**
The technique was described in 1975 by B. Lilienthal and it enjoys a resurgence of popularity due to the availability of specialized delivery systems such as Stabident, X-tip and IntraFlow. Usually before the procedure, the gingiva at the injection site is anesthetized by applying a topical anesthetic and then infiltrated with 0.2 ml of a local anesthetic agent until blanching is visible. The point of perforation is in the attached gingiva at a point 2 mm apical where two imaginary lines at right angles are bisected each other. The horizontal line runs along the buccal gingival margins of the teeth while the vertical line runs through the distal interdental papilla. If the point happens to be on reflected mucosa a point coronal to it should be selected to make the perforation, otherwise perforation in the alveolus may not be able to visualize later. Perforator attached to a slow-speed hand piece is pushed until it reached the bone and then the hand piece is activated and advanced with a pecking motion until a characteristic ‘give’ or a lack of resistance is felt. Then the perforator is removed and the 1.0 ml of anesthetic is injected with a 27 gauge short needle over a minimum of 2 min period (Figure 5). This gives a rapid onset of action with a duration of 15-30 minutes and provides anesthesia of the bone, soft tissue and root structure of the area of injection. Infected or inflamed tissue due to active periodontal disease, inadequate attached gingiva and interradicular bone and difficulty in perforating cortical bone are some of the limitations of this technique. Requirement of a smaller dose, minimal anesthesia of adjacent soft tissues compared to that of infiltration and nerve blocks and the greater success rate in failed conventional techniques are some of the advantages of IO technique. However, there are some disadvantages of this technique including post-injection pain, possible damage to the teeth (penetration of teeth), requirement of specialized equipment and difficulty in placing the anesthetic needle. Furthermore, the technique is somewhat

<table>
<thead>
<tr>
<th>Local anesthetic used</th>
<th>Outcome measure</th>
<th>Tooth involved</th>
<th>No. of participants</th>
<th>Success rate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8 ml of 4% articaine with 1:100.000 adrenaline</td>
<td>EPT</td>
<td>Maxillary lateral incisor</td>
<td>27</td>
<td>77.8%</td>
<td>Biočanin et al., (2011)</td>
</tr>
<tr>
<td>0.4 ml, 0.6 ml and 0.8 ml of 4% articaine with 1:100.000 adrenaline</td>
<td>EPT</td>
<td>Mandibular premolar</td>
<td>30</td>
<td>73%, 90%, 90%</td>
<td>Biočanin et al., (2013)</td>
</tr>
<tr>
<td>1.4 ml of 4% articaine with 1:100.000 adrenaline</td>
<td>FPM</td>
<td>Healthy FPM</td>
<td>100</td>
<td>32%</td>
<td>Berlin et al., (2017)</td>
</tr>
<tr>
<td>1.4 ml of 2% lignocaine with 1:100.000 adrenaline</td>
<td>VAS</td>
<td>Maxillary lateral incisors</td>
<td>35</td>
<td>76%</td>
<td>Bromic et al., (2010)</td>
</tr>
<tr>
<td>0.8 ml of 2% lignocaine with 1:100.000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>73</td>
<td>29%</td>
<td>Webster, Jr et al., (2016)</td>
</tr>
</tbody>
</table>

Table 6. Success rates of intraseptal technique
difficult than the infiltration anesthesia. The success rate of this technique as with PDL injection is greatly influenced by the presence of vasoconstrictors\textsuperscript{24}. However, this may cause palpitations in patients due to the entry of catecholamines into the circulation\textsuperscript{42}. This disadvantage may be overcome by using the recommended minimal doses and by avoiding vasoconstrictors in the solution.

The success rate of IO technique is between 45\% and 100\% in healthy first permanent molar pulps using EPT readings as an outcome measure\textsuperscript{22, 49-53} (Table 7). Other studies using the VAS show success rates between 87\% and 93.5\%\textsuperscript{7,54} (Table 7).

### Table 7. Success rates of intraosseous (IO) technique

<table>
<thead>
<tr>
<th>Local anesthetic used</th>
<th>Outcome measure</th>
<th>Pulpal status</th>
<th>No. of participants</th>
<th>Success rate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>40</td>
<td>53%</td>
<td>Coggins et al., (1996)\textsuperscript{22}</td>
</tr>
<tr>
<td>1.8 ml, 2% lignocaine + 1:100,000 adrenaline 1.8 ml, 3% mepivacaine</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>42</td>
<td>74%</td>
<td>Replogle et al., (1997)\textsuperscript{49}</td>
</tr>
<tr>
<td>1.5 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>20</td>
<td>95%</td>
<td>Chamberlain et al., (1997)\textsuperscript{50}</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>41</td>
<td>93%</td>
<td>Gallatin et al., (2003)\textsuperscript{51}</td>
</tr>
<tr>
<td>1.4 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>55</td>
<td>100%</td>
<td>Jensen et al., (2008)\textsuperscript{52}</td>
</tr>
<tr>
<td>4% articaine + 1:200,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>32</td>
<td>93.5%</td>
<td>Cabasse et al., (2010)\textsuperscript{53}</td>
</tr>
<tr>
<td>1.8 ml, 2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>15</td>
<td>87%</td>
<td>Remmers et al., (2008)\textsuperscript{7}</td>
</tr>
<tr>
<td>4% articaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>60</td>
<td>87.5%</td>
<td>Idris et al., (2014)\textsuperscript{54}</td>
</tr>
</tbody>
</table>

6. **Intrapulpal injection**

Intrapulpal injection involves administration of local anesthetic into the coronal part of the pulp chamber or root canal under pressure (Figure 6). When injecting to enable snug fit, it may be necessary to make a small opening in the chamber by a bur. Therefore, this injection can be performed in the presence of a pulpal exposure (surgically or pathologically)\textsuperscript{55}. If an opening is already present needle should be inserted to fit snugly into the canal. Injection can be made with a 25/27 gauge short/long needle. A small amount of solution, i.e. 0.2 ml is adequate to anesthetize the tooth. This amount is hardly able to give rise to any systemic effects. Intrapulpal technique may cause pain for a brief period but
it invariably provides profound anesthesia and adequate duration of action to permit extirpation of the pulpal tissues and instrumentation in endodontic treatments. However, this injection is used as a second line injection in the event of a failure of a conventional technique because of the pain. The anesthetic solution may spread mainly to the apex of the injected root and a small amount to the adjacent roots of a multi-rooted tooth necessitating injection into each root for adequate anesthesia.

Studies have shown that intrapulpal anesthesia can be obtained by injecting saline instead of local anesthetic solution\textsuperscript{17}. A critical point in intrapulpal injection is that the injection should be performed under pressure. Therefore, if a large opening is present, it is necessary to obliterate the opening with gutta-percha. This will prevent the leakage of solution.

7. Mandibular infiltration
Unlike in maxilla local anesthesia in the mandible is mainly achieved by way of nerve blocks including Halsted inferior alveolar nerve block injection. Nerve block techniques are difficult than the infiltration technique and have the added disadvantages such as possible nerve damage and anesthetic failure due to accessory nerve supply. There are several randomized controlled trials which have carried out to see the feasibility of using infiltration anesthetic technique in adult mandibular posterior teeth as well as the feasibility of using mandibular infiltration as a supplemental method to an failed inferior alveolar nerve block injection.

The success rate of buccal infiltration technique is between 38.7\% and 82\% in healthy first permanent molar pulps using EPT readings as an outcome measure\textsuperscript{5,56-59} (Table 8). Other studies using the VAS show success rates between 29\% and 76.9\% \textsuperscript{60,10-13,15} (Table 8). Many studies show that the efficacy is more with the 4\% articaine than the 2\% lignocaine\textsuperscript{10,57,60} whereas Shapiro et al., showed a comparable efficacy between the two agents\textsuperscript{15}. From the foregoing it is apparent that splitting of dose between buccal and lingual aspects has no advantage suggesting that accessory nerve supply from the lingual aspect is not important and the infiltration through the mental foramen mimicking a modified MINB might be the reason for the anesthesia observed in mandibular molar area\textsuperscript{61}. The mandibular infiltration anesthesia observed with articaine might be due to the effective diffusibility due to the thiophene ring in the articaine than the benzene ring in other anesthetic agents. However, a recent published systematic review revealed that inferior alveolar nerve block alone gives 14-39\% success rate whereas with supplementary infiltration the local anesthesia can be significantly increased to a success rate of 50-65\%\textsuperscript{62}. They further showed that none of the techniques gives a 100\% success rate\textsuperscript{62}.

Synopsis
Failure rates in obtaining anesthesia with IANB led to the development of supplemental techniques in achieving profound anesthesia

---

Figure 6. Diagrammatic representation of intraosseous injection.
<table>
<thead>
<tr>
<th>Local anesthetic used in IANB</th>
<th>Outcome measure</th>
<th>Pulpal status</th>
<th>No. of participants</th>
<th>Success rate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>31</td>
<td>38.7%</td>
<td>Meechan et al., (2006)56</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>60</td>
<td>57%</td>
<td>Robertson et al., (2007)57</td>
</tr>
<tr>
<td>1.7 ml 4% articaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>35</td>
<td>54%</td>
<td>Jung et al., (2008)5</td>
</tr>
<tr>
<td>1.8 ml 4% articaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>31</td>
<td>64.5%</td>
<td>Corbett et al., (2008)58</td>
</tr>
<tr>
<td>1.7 ml 4% articaine + 1:100,000 adrenaline</td>
<td>EPT</td>
<td>Healthy FPM</td>
<td>29</td>
<td>62.1%</td>
<td>Kwon et al., (2014)59</td>
</tr>
<tr>
<td>4% articaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>Failed IANB in IP</td>
<td>51</td>
<td>71%</td>
<td>Ashraf et al., (2013)60</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>Failed IANB in IP</td>
<td>51</td>
<td>29%</td>
<td></td>
</tr>
<tr>
<td>1.7 ml 4% articaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>Failed IANB in IP</td>
<td>100</td>
<td>62%</td>
<td>Rogers et al., (2014)60</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>Failed IANB in IP</td>
<td>204</td>
<td>42%</td>
<td>Monteiro et al., (2015)61</td>
</tr>
<tr>
<td>1.8 ml 4% articaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>30</td>
<td>40%</td>
<td>Zain et al., (2016)62</td>
</tr>
<tr>
<td>4% articaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP</td>
<td>156</td>
<td>76.9%</td>
<td>Fowler et al., (2016)63</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>IP FPM</td>
<td>204</td>
<td>42%</td>
<td></td>
</tr>
<tr>
<td>4% articaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>Failed IANB in IP</td>
<td>199</td>
<td>61%</td>
<td>Shapiro et al., (2018)65</td>
</tr>
<tr>
<td>2% lignocaine + 1:100,000 adrenaline</td>
<td>VAS</td>
<td>Failed IANB in IP</td>
<td>293</td>
<td>66%</td>
<td></td>
</tr>
</tbody>
</table>

Table 8. Success rates of mandibular buccal infiltration technique

especially in the mandible. Though higher blocks show more promising effects than the IANB, they require more expertise and skill. Intraosseous anesthesia is useful in achieving single tooth anesthesia without extensive anesthesia common with conventional blocks. Although all techniques have some advantage over the traditional IANB, none is without the disadvantages and contraindications. The superior diffusibility of articaine enables it to be used in mandibular infiltration. However, so far not a single systematic review or a meta-analysis is able to find a 100% effective technique due to the differences in the clinical trials suggesting that
clinical trials conducted to show the efficacy of the supplementary techniques require a standard methodology so that studies can be compared meaningfully. However, with the foregoing it can be delineated that with the availability of a number of alternative anesthetic techniques the mandibular IANB will become passé.

Acknowledgement
The author would like to thank Mr. Kosala Kithsiri Jayasingha for contributing to figures 2 and 3.

References


29. Sherman MG, Flax M, Namerow K, Murray PE. Anesthetic efficacy of the Gow-Gates injection and maxillary infiltration with


60. Ashraf H, Kazem M, Dianat O, Noghrehkar F.
Supplementary local anesthetic injection techniques in dentistry

