Transcutaneous Mandibular Nerve Blocks: Success Rate between Two Techniques and Comparative Evaluation of Local Anesthetic Distribution Using Cone Beam Computerized Tomography with Iodized Contrast

Thesis

Presented in Partial Fulfillment of the Requirements for the Degree of Master of Science in the Graduate School of The Ohio State University

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Abstract

Success rates to achieve profound pulpal anesthesia of the mandibular teeth using the traditional inferior alveolar nerve block technique have been reported by several authors to be 80-85\%\(^{1}\). The Gow-Gates and Akinosi-Vazirani techniques have also been reliable alternatives to achieve inferior alveolar nerve (IAN) anesthesia, through an intraoral approach. The first purpose of this study was to compare the efficacy of two, well-documented, transcutaneous extraoral techniques in their ability to anesthetize the dental pulp of mandibular teeth. The technique described by Kantorowicz delivers local anesthetic within the pterygomandibular space adjacent to the mandibular foramen by passing a hypodermic needle transcutaneously into the submandibular space along the medial aspect of the mandible. Braun’s technique describes the deposition of anesthetic solution near the foramen ovale by inserting a needle along the inferior aspect of the zygomatic arch at its midpoint and marking the distance at which it touches the lateral pterygoid plate. The needle is then brought back to the subcutaneous layer, redirected approximately 30 degrees posteriorly and advanced to the marked depth; at this position anesthesia of the mandibular nerve should be achieved.

The second purpose of the study was to describe the area of distribution and location of the solution. This was done by injecting iohexol contrast medium into a fresh cadaver head specimen, using both techniques and obtaining a cone beam computerized tomographic (CBCT) study of the injected solutions and surrounding regions. The
characterization of anatomic landmarks and fluid boundaries allows for a better understanding of the anatomic location of the injected solution and to better comprehend how the solution is distributed within soft tissues at the time of injection for both the Kantorowicz and Braun techniques.

Following approval from The Ohio State University IRB, 13 ASA I and II patients requiring bilateral mandibular third molar extractions under general anesthesia were enrolled in this study. All patients received bilateral mandibular nerve blocks, one side using the Kantorowicz technique and the other side using the Braun technique. Patients were randomly assigned to one of two groups; group A received the Kantorowicz injection on the right, group B received this technique on the left. The anesthetic used was 3.0mL of 2% Lidocaine with 1:100,000 parts of epinephrine. The pulpal anesthesia success was measured by applying the standardized method described by Vreeland and Reader\textsuperscript{2}. The anesthetic success of both groups was analyzed.

The frequency of success was 84.6\% for both anesthetic techniques; however the sample size was not sufficient to detect statistically significant differences of the parameters observed. It is of clinical significance that both techniques, when compared to the traditional IAN block technique, are able to anesthetize this nerve and achieve pulpal anesthesia.

Both the Kantorowicz and Braun transcutaneous extraoral techniques offer the practitioner of dental medicine an excellent alternative to the frequently used Halstead
technique. Of obvious advantage is the reduced need for patient cooperation: to open their mouth maximally, accurately position their tongue, and keep absolutely still.
Dedication

Dedicated to my loving family and professors, for without you, this journey would have been impossible.
Vita

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tr>
<td>2009</td>
<td>Internship in Oral and Maxillofacial Surgery. The Ohio State University. Columbus, Ohio.</td>
</tr>
<tr>
<td>2009</td>
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<tr>
<td>2010 - present</td>
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Publications

Mainville, G.Furchtgott, N, Ing, S, Allen, C. A rapidly growing mandibular swelling.
JADA 2013; 144 (1) 45-48.

Fields of Study

Major Field: Dentistry
Specialization: Oral and Maxillofacial Surgery

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Introduction

Pain control is one of the greatest challenges in medicine. The International Association for the Study of Pain defines it as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.”

Albert Neimann, a German chemist, was the first to extract cocaine in its pure form in 1859. Richard John Hall and William Stewart Halsted were the first to use cocaine to perform regional blocks, and described the currently used infraorbital and inferior alveolar nerve (IAN) blocks. Side effects of cocaine are well known and include cardiac stimulation, peripheral vasoconstriction, excitation of the central nervous system (CNS), and physical and psychological dependence. The synthesis of an ester called procaine (Novocaine) by Alfred Einhorn in 1904 and the later development of lidocaine (Xylocaine) in the 1940s by the Swedish pharmaceutical company Astra. This was the first amide local anesthetic, synthetized by Nils Lofgren, which displaced the use of cocaine. The use of modern synthetic local anesthetics has become a crucial element of dental and surgical practices.

It is of utmost importance to achieve profound pulpal anesthesia during the majority of dental procedures. The traditional intraoral technique described by Halstead to anesthetize the IAN calls for deposition of the anesthetic at an anatomic location close to the mandibular foramen. Success rates to achieve profound pulpal anesthesia of the
mandibular teeth using this technique, which is the one traditionally taught at dental
schools around the world, have been reported by several authors to be 80-85%\textsuperscript{1}.

The Gow-Gates and Akinosi-Vazirani techniques, described in 1973 and 1977
respectively, have also been reliable alternatives to achieve IAN anesthesia, through an
intraoral approach.\textsuperscript{7,8} However, experimental studies have failed to show that either
technique is superior to the traditional one.\textsuperscript{9}

This study had two purposes. The first one was to compare the efficacy of two, well-
documented, transcutaneous extraoral techniques in their ability to anesthetize the dental
pulp of mandibular teeth. The technique described by Kantorowicz delivers local
anesthetic within the pterygomandibular space adjacent to the mandibular foramen by
passing a hypodermic needle transcutaenously into the submandibular space along the
medial aspect of the mandible. Braun’s technique describes the deposition of anesthetic
solution near the foramen ovale by inserting a needle along the inferior aspect of the
zygomatic arch at its midpoint and marking the distance at which it touches the lateral
pterygoid plate. The needle is then brought back to the subcutaneous layer, redirected
approximately 30 degrees posteriorly and advanced to the marked depth; at this position
anesthesia of the mandibular nerve should be achieved.

These techniques could be part of the armamentarium used by dental practitioners to
provide treatment comfortably in the mandibular arch.
The second purpose of this investigation was to describe the area of distribution and location of the solution injected into a fresh cadaver head specimen for both transcutaneous techniques. This was done by injecting contrast medium into the specimen and obtaining a cone beam computerized tomographic study. This characterization of anatomic landmarks may allow a better understanding of the anatomic location of the injected solution and to more completely comprehend the distribution of anesthetic solutions within the anatomical spaces involved with both the Kantorowicz and Braun techniques.
Review of Literature

Local Anesthetics

Local anesthetics produce an electrical conduction block in peripheral nerves by decreasing the permeability of the sodium (Na+) channels within their membranes. This will inhibit initiation and propagation of impulses, inhibiting pain or sensation. Two chemical classes of local anesthetics are available currently: aminoesters and aminoamides. They are metabolized primarily by plasma estearases and hepatic cytochrome P450-like enzymes, respectively.

Systemic toxicity involves undesirable effects mainly for the cardiovascular and central nervous systems. Therefore, use of local anesthetics for regional anesthesia requires an excellent understanding of the patient’s clinical condition, quality of local anesthesia required, anatomy of the region, and proper drug selection and dosing.

Basic Pharmacology: Chemical Structure and Features

All injectable local anesthetics are composed of three structural domains: aromatic residue, intermediate chain, and amino terminus (Figure 1). The aromatic portion is lipophilic and allows the drug to penetrate lipid-rich nerve sheaths and nerve membranes. The intermediate portion allows for spatial separation of the lipophilic and hydrophilic portions, dividing local anesthetics into two chemical classes: esters (-COO-) and amides (-NHCO-). The amino terminus is the hydrophilic portion, which allows for solubility of the drug within the fluid vial and interstitial fluid.5,10
Pharmacokinetics of Local Anesthetics

The esters are metabolized primarily by plasma pseudocholinesterases. A byproduct of this metabolism is the formation of para-aminobenzoic acid (PABA), which is responsible for the development of allergic responses in sensitive individuals. Another
substance that was also found to produce allergic reactions was methylparaben. Its structure is similar to that of an ester and it was used as a preservative in amide local anesthetic solutions. \(^1\)\(^5\) Today, this preservative is only found in multidose vials.

Due to their low allergenicity, amide local anesthetics are currently the local anesthetic of choice. However, amides undergo hepatic metabolism\(^1\) and should be used with caution in patients with impaired or decreased liver function.

The pH of the solution and the soft tissues affect the pharmacodynamics of local anesthetics. pKa values for injectable local anesthetics range from 7.7 to 8.9. Therefore, these weak bases exist in two forms at physiological pH ranges: free base (neutral form) and cationic form (positively charged). The free base will be the lipophilic form that penetrates neural tissue, the cationic form is thought to be responsible for preventing sodium ions from effectively passing through the sodium channels.\(^1\)

Lidocaine has a pKa of 7.8 at a pH of 7.4. In these conditions, according to the Henderson-Hasselbach equation, 71% of it will be found in a cationic form and 29% as a free base. It’s time of onset will then be 2-4 minutes. (Table 1)\(^5\)
Mechanism of Action of Local Anesthetics

Local anesthetics achieve the blockage of nerve impulses by inhibiting the normal function of voltage-sensitive Na\(^+\) channels after they cross the lipid membrane of peripheral nerves. This will prevent the noxious stimuli from reaching the brain and producing the sensation of pain.\(^5\)

As the influx of Na\(^+\) into the excitable nerve membrane is blocked, the action potential is slowed down, reducing the rate of rise in the depolarization phase.\(^{11}\) The action potential is then blocked.

Table 1. Relationship Between pKa, Ionization, and Local Anesthetic Onset at a pH of 7.4. (from Fonseca RJ. Oral and Maxillofacial Surgery. 2nd Ed. Chapter 3, 35-55. St. Louis: Elsevier Inc; 2009.)

<table>
<thead>
<tr>
<th>Drug</th>
<th>pKa</th>
<th>% Cationic</th>
<th>% Free Base</th>
<th>Onset Time (Min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mepivacaine</td>
<td>7.7</td>
<td>67</td>
<td>33</td>
<td>2–4</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>7.8</td>
<td>71</td>
<td>29</td>
<td>2–4</td>
</tr>
<tr>
<td>Prilocaine</td>
<td>7.8</td>
<td>71</td>
<td>29</td>
<td>2–4</td>
</tr>
<tr>
<td>Articaine</td>
<td>7.8</td>
<td>71</td>
<td>29</td>
<td>2–4</td>
</tr>
<tr>
<td>Etidocaine</td>
<td>7.9</td>
<td>76</td>
<td>24</td>
<td>2–4</td>
</tr>
<tr>
<td>Bupivacaine</td>
<td>8.1</td>
<td>83</td>
<td>17</td>
<td>5–8</td>
</tr>
<tr>
<td>Propoxycaine</td>
<td>8.9</td>
<td>97</td>
<td>3</td>
<td>9–14</td>
</tr>
<tr>
<td>Procaine</td>
<td>8.9</td>
<td>97</td>
<td>3</td>
<td>14–18</td>
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</table>
**Potency of Local Anesthetics**

Lipid solubility (hydrophobicity) of a local anesthetic appears to be related to its intrinsic potency. Increased lipid solubility permits the anesthetic to penetrate the nerve membrane (which itself is 90% lipid) more easily. Local anesthetics with greater lipid solubility produce more effective conduction blockade at lower concentrations (lower percentage solutions or smaller volumes deposited) than do the less lipid-soluble local anesthetics.\(^1\) Table 2 depicts relative conduction-blocking potency of common local anesthetics.\(^{12}\)

**Lidocaine**

Lofgren and Lundqvist in Sweden synthesized lidocaine in 1943; it was later introduced clinically in 1947. It is a tertiary amide derivative of diethylamino-acetic acid. It has become one of the most widely used local anesthetics across the world. In concentrations of 0.5-2% it produces a rapid onset of intense motor and sensory nerve blockade. Higher concentrations (5%) were used for spinal anesthesia until reports of transient radicular irritation suggested these concentrations may be neurotoxic.\(^{13}\) However, there is laboratory data suggesting that even lower concentrations may result in neurotoxicity, although there are no data to support this in humans.\(^{14}\)

It has low protein binding properties; therefore it has intermediate duration of clinical activity, as shown in Table 3. It was the anesthetic of choice for this study because of its great track record of safety. It has, however, been reported to have caused a fatality even
in the controlled environment of clinical research.\textsuperscript{15}

\textbf{Inferior Alveolar Nerve Anatomy}

The Trigeminal Nerve, Cranial Nerve V, is the largest cranial nerve, composed of a small motor root and a large tripartite sensory root. It is clinically relevant to dentistry because among its functions is to provide the majority of sensory innervation from the teeth, bone, and soft tissues within the oral cavity. This study’s particular interest lies in the inferior alveolar nerve (IAN), which is a terminal branch of the mandibular division (V3) of this cranial nerve.\textsuperscript{1}

The mandibular division of CN V (V3) is the largest branch of the Trigeminal Nerve. It has a large sensory root and the small motor root, which exit the base of the skull along through the foramen ovale (Fig. 2), and travel inferiorly together as one nerve trunk that enters the infratemporal fossa. It then branches in three areas: an undivided nerve, anterior and posterior divisions.\textsuperscript{1}
The IAN is the largest branch of the mandibular division (Figure 3). It descends medial to the lateral pterygoid muscle and lateroposterior to the lingual nerve, to the region between the sphenomandibular ligament and the medial surface of the mandibular ramus, where it enters the mandibular foramen and follows the mandibular canal, located within the pterygomandibular space. It is always accompanied by the inferior alveolar artery.\textsuperscript{1}
The pterygomandibular space (Figure 4) is bounded anteriorly by the buccal space, posteriorly by the parotid gland and fusion of the parotidomasseteric fascia. Its lateral aspect is the ascending ramus of the mandible with its medial boundary being the medial pterygoid muscle. The superior border is the pterygoid muscle and the inferior border is the inferior border of the mandible. The pterygogmandibular space contains the lingual, mylohyoid and inferior alveolar nerves as well as the inferior alveolar artery, vein, and the sphenomandibular ligament.17

Figure 3. Sensory Innervation of the Mandibular Teeth. (from Norton, N. Netter’s Head and Neck Anatomy for Dentistry. 2nd Ed. Philadelphia, PA: Elsevier Saunders; 2012)
Regional Techniques to Anesthetize the Inferior Alveolar Nerve

*Halstead Technique or Inferior Alveolar Nerve Block*

This is the most frequently used and possibly the most important injection technique in dentistry. It anesthetizes the inferior alveolar nerve and often the lingual nerve. This technique calls for an intraoral injection; the patient must keep their mouth open wide throughout the entire procedure. After identifying the coronoid notch, pterygomandibular
raphe, and occlusal plane of the mandibular posterior teeth, the needle is aligned at the level of the premolars from the contralateral side at a height of injection 6-10mm above the occlusal plane. The insertion point is ¾ the anteroposterior distance from the coronoid notch back to the deepest part of the pterygomandibular raphe. The needle is advanced until bone is encountered, which is approximately 20-25mm deep. Aspiration follows, and the local anesthetic solution is delivered.¹ Figure 5 depicts the location of the injection site. Figure 6 depicts the area anesthetized by an inferior alveolar nerve injection.

Figure 5. Location of the Injection Site for an Inferior Alveolar Nerve Block. (from Norton, N. Netter’s Head and Neck Anatomy for Dentistry. 2nd Ed. Philadelphia, PA: Elsevier Saunders; 2012)
Kantorowicz Technique

This technique to anesthetize the IAN is an extraoral, transcutaneous method where the patient is required to maintain their mouth closed throughout the procedure. The skin overlying the inferior border of the mandible along the antegonial notch was prepped with an alcohol wipe. A 25-gauge spinal needle was inserted along the medial aspect of the mandibular ramus (Figure 7). The insertion point was measured to be 1.0-1.5cm anterior to the angle of the mandible, parallel to the posterior border of the mandibular ramus and 45mm deep. Aspiration was performed and 3mL of anesthetic delivered within the pterygomandibular space.\textsuperscript{18}
This technique is also a closed-mouth, extraoral, transcutaneous procedure to anesthetize the IAN (Figure 8). Its purpose is to deliver the anesthetic in the temporal fossa, near the foramen ovale. The first step is to identify the midpoint of the zygomatic arch, then the skin is prepped with an alcohol wipe. The needle is inserted perpendicular to the skin and
along the inferior aspect of the zygomatic arch. The initial guide to the correct depth is achieved when the bone of the lateral pterygoid plate is encountered; the needle is then marked with a sterile marker at this depth. The needle is then partially withdrawn but not removed out of the skin, it is reangulated posteriorly through an angle of 60 degrees, making an angle of 30 to the skin anterior to the point of needle insertion. It is then advanced until it reaches the marked depth. At this point, the needle is considered to be just anterior to the foramen ovale. To ensure that the needle is not intravascular a routine aspiration in two planes is performed. (An initial aspiration is followed by a secondary aspiration after the needle tip has been rotated through 90 degrees.) This is particularly important due to the close proximity of internal carotid artery. If both are negative then 3mL of local anesthetic is delivered. 19
Cone-Beam Computed Tomography (CBCT)

Cone-beam machines emit an x-ray beam shaped like a cone rather than a fan as in conventional computed tomography (CT). After this beam passes through the patient, the remnant beam is captured on an amorphous silicon flat panel or image intensifier/charge-coupled device (CCD) detector. The beam diameter ranges from 4 to 30 cm and exposes the head in one pass around the patient capturing from 160 to 599 basis images. These
images are used to compute a volume from which planar or curved reconstructions can be extracted in any orientation. Voxels are isotropic and can be as small as 0.125 mm.20

3-D images of bone or soft tissue surfaces can also be generated. In dentistry the most common indications for cone-beam imaging are assessment of the maxilla and mandible for placement of dental implants, evaluation of the temporomandibular joints for osseous degenerative changes, examination of teeth and facial structures for orthodontic treatment planning, evaluation of the proximity of lower wisdom teeth to the mandibular nerve prior to extraction, and evaluation of teeth and bone for signs of infections, cysts, or tumors.20

Cone-beam images have largely replaced conventional tomography for these tasks. The effective dose from cone-beam imaging is 0.2 microSv. In contrast, a traditional CT Head will deliver 2.0 microSv on average, which is a significantly higher dose of radiation for the patient..21

Interpreting cone-beam images can be very challenging: there is lack of a soft tissue window, precise Hounsfield units are not given, and higher image noise is sometimes present.22
Iohexol (Omnipaque®)

Organic iodine compounds block x-rays as they pass through the body, thereby allowing body structures containing iodine to be delineated in contrast to those structures that do not contain iodine. Iohexol (Omnipaque®) is an effective non-ionic, water-soluble contrast agent which is used in myelography, arthrography, nephroangiography, arteriography, and other radiographic procedures. It has a very low systemic toxicity.

The degree of opacity produced by these compounds is directly proportional to the total amount (concentration and volume) of the iodinated contrast agent in the path of the x-rays.

It can be used for intrathecal injection to examine the subarachnoid space, or as an intravascular injection to opacify vessels in their path of flow, allowing visualization of the internal structures until significant hemodilution occurs.23

It is absorbed through the bladder via intravesical instillation and renally excreted without undergoing significant metabolism, deiodination, or biotransformation occurs. Its intrathecal half-life is 3.4 hours, intravascular is approximately 2 hours with normal renal function.24

Omnipaque® 300 mg/ml syringe is approximately $1.08/ml, making it an ideal contrast solution for the radiographic portion of this study.
Hypothesis

The null hypothesis for this study is that there is no difference between success rates of mandibular pulpal anesthesia and mandibular gingival anesthesia when using the Braun or Kantorowicz transcutaneous extraoral techniques.
Materials and Methods

For the clinical portion of this study, thirteen adult volunteers, 7 men and 6 women, participated in this study. The ages of the subjects ranged from 19 to 59 years of age. Based on clinical written histories and oral questioning, the subjects’ physical status had been previously determined to be either ASA I or ASA II, according to the American Society of Anesthesiologists’ physical status classification system. The study was approved by The Ohio State University Human Subject Review Committee and written consent was obtained from each subject.

An equal number of right and left sides were tested in this study. Following the methodology described by Vreeland and Reader\textsuperscript{2} with minor modifications, the first permanent mandibular molar and canine on each side were chosen as the test teeth, with the permanent maxillary lateral incisors used as a negative control. The testing of the maxillary lateral incisors ensured that the electric pulp tester (Parkell Pulp Vitality Tester. Parkell, Inc. Edgewood, New York 11717) was functioning properly, and that the patient would respond positively during postoperative testing. Clinical and panoramic x-ray examination indicated that the teeth that would be tested did not have caries, large restorations, or endodontic therapy.

Subjects included in this study had a prior surgical consultation with an Oral and Maxillofacial Surgery Resident and were scheduled to undergo extraction of both
mandibular third molars under general anesthesia. On the day of the surgery, written and verbal consent to participate in the study were obtained from the volunteers.

Prior to the induction of general anesthesia it was confirmed that all teeth to be used in this study were vital. Each tooth was isolated and dried with gauze. Colgate toothpaste (Colgate-Palmolive Company, New York 10022) was used as an electrolyte. The pulp-tester tip was placed on the facial surface of the tooth and activated. The patient was asked to raise his or her hand to communicate the initial sensation in the tooth. A sharp dental explorer was used for alveolar mucosal sticks. With gentle pressure on the mucosa apical to the tested teeth, the subject would indicate when they felt a sharp sensation.

Each subject had been randomly assigned to receive the Kantorowicz technique on the right side or the left side. The Braun technique would be given on the unassigned side. After general anesthesia had been induced, each subject’s skin was prepped with three alcohol wipes and a sterile skin-marking pen was used to mark the patient’s anatomic landmarks according to the Kantorowicz or Braun techniques described before in this document. The needle to be used for the Kantorowicz technique was marked at 4.5cm to determine the correct depth of insertion for this technique. Then, the subjects were injected on each side with 3mL of 2% lidocaine with 1:100,000 epinephrine (Cook Waite, Manufactured by Carestream Health Inc. by Novocol Pharmaceutical of Canada Inc., Cambridge Ontario, Canada), using the methodology described previously. This solution was obtained from single use dental cartridges, without preservative, and drawn
from these vials with an 18-gauge needle in a 5mL sterile disposable syringe. The 18g needle was then replaced with, a 25G x 3-1/2 BD Spinal Needle with Quincke Type Point (BD Medical Systems, Franklin Lakes, NJ, USA) which was then used for the injection techniques being studied. A new syringe and needle was used for each side.

After emergence from general anesthesia, the subjects were transferred to the Postoperative Anesthesia Care Unit for monitoring. This is where postoperative testing took place. This was done in less than 60 min of having received the injections. The same testing procedures were done; electric pulp testing and mucosal pinprick. The blocks were considered to be successful if there was no response to pinprick stimulation and electric pulp tester readings achieved an 80 reading.

Additionally, the subjects were shown a Visual Analogue Scale to rate their postoperative pain.

To eliminate inter-operator variability, the author NF, a senior Oral and Maxillofacial Surgery Resident, performed all the injections. Due to the lack of a constant research assistant who was able to be present for both preoperative and postoperative testing, the author NF also performed these tasks.

For the radiographic portion of this study, a fresh cadaveric specimen’s head was harvested and within an hour immediately taken to the Department of Oral Radiology of the College of Dentistry at The Ohio State University. It was preoperatively scanned with a CBCT Scanner (Imaging Sciences International ICAT Platinum Dental X-Ray). It was
then injected on the right with the Kantorowicz technique and on the left with the Braun technique. 3mL of contrast medium (Omnipaque® Distributed by GE Healthcare Inc. Princeton, NJ 08540 U.S.A.) was used on each side. The right side received a concentration of 300mg/mL and the left side 150mg/mL).

Results

The sample size of 13 subjects for the clinical portion of this study does not allow for the null hypothesis to be accepted or rejected since there is insufficient data for declaring a clinically or statistically significant difference between the Kantorowicz and Braun techniques. This study is able, however, to report a frequency of success to achieve mandibular pulpal anesthesia and gingival anesthesia anterior to the premolar region that is equal for both techniques. This frequency of success is 84.6%.

All preoperative measurements with the electric pulp tester indicated vitality of control teeth (numbers 7, 10, 19, 22, 27, 30) and appropriate sensation of the gingival tissues (buccal and lingual to teeth 7, 10, 19, 22, 27, 30).

Postoperative measurements with the electric pulp tester and pinprick sensation were intact in the non-anesthetized maxillary teeth 7 and 10, as expected.

The postoperative response of the mandibular teeth to the electric pulp tester and for the gingival pinprick testing was identical for both techniques. Of 13 subjects, two failed to have anesthesia with the Braun Technique, and two failed to have anesthesia with the Kantorowicz Technique. All subjects denied being in pain in the acute postoperative period, VAS = 0.
The radiographic portion of this study has interesting results as well. Figure 9 shows the steps taken to anesthetize the specimen head on the right side with the Braun technique. Figure 10 shows the Kantorowicz technique being used on the left side of the specimen.

Figure 9. Braun Sequence Technique to Anesthetize Fresh Specimen Head with Contrast.

Figure 10. Kantorowicz Technique to Anesthetize Fresh Specimen Head with Contrast.
The following CBCT images in Figure 11 are 3-D reconstructions depicting the preoperative view of the right mandible and postoperative views after the injection of contrast medium with Kantorowicz technique. They show how the solution is deposited in the right pterygomandibular space, near the medial aspect of the neck of the mandibular condyle. It is a very clear image where the contrast lights up the scanned images.
Figure 11. Preoperative and Postoperative 3-D Reconstruction Images of CBCT obtained for Kantorowicz Technique Distribution of Contrast of Cadaveric Specimen Head.
Figure 12 depicts the left side of the specimen, where the preoperative view of the mandible and postoperative views after the injection of contrast medium with the Braun technique are shown. They show how the solution is deposited in the left temporal space, near the foramen ovale and medial to the neck of the left mandibular condyle. Comparatively speaking, it is harder to visualize the contrast medium within the space than the images obtained for the right side.
Figure 12. Preoperative and Postoperative 3-D Reconstruction Images and Single Slices of CBCT obtained for Braun Technique Distribution of Contrast of cadaveric specimen head.
Figure 13 shows a comparison between both sides after injection, demonstrating how Omnipaque® concentrations differ in their appearance in a CBCT set of images.

Figure 13. Comparison of postoperative images for both right and left sides of the cadaveric specimen head. Omnipaque® 300mg/mL was used on the right side, Omnipaque® 150mg/mL was used on the left side.
Discussion

In medicine, local anesthetic blocks of the face, mouth and jaws are routinely accomplished using extraoral approaches for the application of local anesthetic solutions. For example, otolaryngologists, perhaps the most closely related surgical area to dentistry, frequently use extraoral approaches for local anesthesia in and around the maxilla and mandible. In dentistry, however, for surgical treatment of significant portions of the mandible, restorative dental procedures, periodontal surgery or the like, the routine teaching of dental students has been to rely solely on the use of intraoral injections.

The inferior alveolar nerve (IAN), which provides sensory innervation to the mandibular teeth, gingival tissues anterior to the premolars, and lower lip and chin is the nerve studied in this research project.

As discussed in the introduction, the intraoral technique for the traditional inferior alveolar nerve block failure rate is 15-20%. This is mainly due to the variability in the anatomy of the nerve before it enters the mandibular foramen within the ramus of the mandible and the necessity of the patient to maintain their mouth wide open and still, with their tongue immobile while being injected.

A previous investigation at The Ohio State University by Kapitan et al, which compared the traditional inferior alveolar nerve block with the transcutaneous extraoral Kantorowicz technique, showed that subjects preferred to receive the latter technique,
particularly the more anxious ones. It also determined that both techniques were equally as effective.  

In this study, although the desired sample size was not achieved to determine statistical significance in order to show conclusive results for which extraoral technique, Kantorowicz or Braun, was more successful to achieve pulpal anesthesia; the authors were able to observe a clinically acceptable frequency of adequate pulpal anesthesia with either technique. This frequency is reported as 84.6%, which is comparable to the success rate for the traditional intraoral IAN block.

The main limitation to obtain a larger sample size for this study, which was approved to be 80 subjects by the IRB, was found to be the lack of ASA I or II adult patients who were undergoing third molar extractions under general anesthesia. The patient population that was seen in the Oral and Maxillofacial Surgery Resident Clinic at The Ohio State University College of Dentistry during the period where this study was conducted that received this type of procedure, was mostly under the age of 18, had some degree of developmental delay, did not have all of their mandibular teeth present to perform postoperative testing, or did not want to participate in the study due to apprehension about participating in research.

The second part of this study’s purpose was to describe the distribution and anatomic location of contrast medium injected using both the Kantorowicz and Braun techniques.
into a fresh cadaver specimen head after being scanned with a cone beam computer
tomography.

After reviewing the currently available literature, it is a novel enterprise to be able to
interpret with reliability the distribution of contrast mediums for target localization in
CBCTs. To the author’s knowledge, only two groups have reported using iodinized
contrast-enhanced CBCTs for localizing brain and liver tumors in humans and maxillary
tumors in a dog. 26, 27

For the second part of this study, a preoperative standard CBCT imaging was performed
for a fresh cadaveric specimen head. The specimen was set-up in a closed mouth position
and contrast-enhanced CBCT imaging with Omnipaque® 300 mg/mL was injected on the
right side using the Kantorowicz technique on the right side and Omnipaque®
150mg/mL.

The CBCT images were reconstructed in the iCAT®, Osirix MD® and Anatomage®
systems for analysis of DICOM images. It was interesting to experiment with two
different concentrations of the Omnipaque® solution because it demonstrated how
important it is to maintain the 300mg/mL solution as it will appear very clearly and
consistently throughout the images. The 150mg/mL solution was barely detectable, to the
point where the exact location and distribution of the solution is unable to be determined
with the same accuracy as if the higher concentration were used.
Also of interest is the fact that both Kantorowicz and Braun techniques will deposit local anesthetic solution within the pterygomandibular space and temporal space, respectively. This is exactly the purpose of these techniques and they are validated not only clinically but radiographically with the imaging provided in this study. The distribution of the iodized contrast medium shows how the solution is deposited within the region where the IAN lies medial to the mandibular condyle and ramus.

Although there are limitations because it is not possible to observe a soft tissue window in a CBCT, this technique can open an entire line of research for evaluating pathological conditions within the maxillofacial region such as highly angiogenic entities, fluid-filled osseous defects, or cystic spaces.
Conclusions

In conclusion, this study showed that the transcutaneous extraoral techniques by Kantorowicz and Braun are comparable in their ability to achieve pulpal anesthesia of the mandibular teeth when clinically compared to the traditional intraoral IAN block technique. The author is unable to provide with statistically significant data to determine if there is a difference with the use of either technique due to a small sample size.

The use of contrast-enhanced CBCT for evaluation of distribution and location of the solution after injections of a fresh cadaveric specimen head demonstrated that the desired concentration of iohexol must be 300mg/mL in order to be clearly visible in the imaging study. Additionally, it is shown in the imaging obtained that both injection techniques are able to deposit the solution in the desired anatomical spaces to anesthetize the IAN.
References


