New options of palatal and block anesthesia of the mandible with the use of computer-controlled local anesthesia devices (CCLAD)

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*Streszczenie*

*Większość pacjentów stomatologicznych oczekuje bezbolesnych zabiegów i braku nieprzy- jemnych doznań związanych z utrzymywaniem się efektu znieczulenia. Znieczulenie miej- scowe jest stosowane w przeważającej liczbie zabiegów stomatologicznych, dając pacjentom poczucie bezpieczeństwa i eliminując ból, a lekarzowi zapewniając większy komfort i często możliwość bardziej efektywnej pracy. Stosowanie systemów do komputerowego podawania znieczuleń (CCLAD) pozwala na uzyskanie skuteczniejszej anestezji poprzez udoskonalenie dotychczasowych technik i wprowadzenie nowych.*

*Abstract Most dental patients expect painless dental procedures, as well as no unpleasant sensations associated with maintaining the effect of anesthesia.*

*Local anesthesia accompanies most of the procedures performed in the dental office, giving the patient a sense of security and relief from pain sensations, as well as for a dentist more comfort and often the possibility of more effective work.*

*The use of systems for computer controlled local anesthesia allows to obtain more effective anesthesia by improving the techniques used so far and introducing new ones.*

**Hasła indeksowe: systemy do komputerowego podawania znieczuleń (CCLAD), znieczulenie przewodowe, znieczulenia podniebienne**

**Key words: computer controlled local anesthesia devices (CCLAD), block anesthesia, palatal injections**

According to literature in the field, the problem of pain and the attendant avoidance of dental visits affects 42.5 to 73.4% of the population (1). The failure of local anesthesia in dental care may have many different causes. Some have to do with the anatomical features of the patient, such as untypical anatomical structure, bone density, additional or cross innervation, as well as active inflammation at the injection site. An important role is also played by psychological and emotional factors and the patient's refusal to cooperate with the dentist. Other possible causes may include the wrong choice of injection technique, drug, or dose, as well as intravascular delivery (1, 2). Effective maxillary anesthesia is usually not difficult to achieve, except in the case of rare anatomical anomalies and diseases. The very structure of the maxilla, where tooth roots are lined with low-density bone (with the exception of first molars and medial incisors), ensuring relatively easy access to large nerve trunks, contributes to the high success rate of local anesthesia (c. 95%, as reported in literature) (2). Only palatine nerve blocks are less well-tolerated by patients and more difficult to perform effectively and painlessly.

In the mandible, the most common technique of inferior alveolar nerve block anesthesia is only effective in 80-85% of all cases (1, 2). This may be due to the structure of the mandible, i.e. the high density of the buccal alveolar lamella (which rules out supraperiosteal and infiltration anesthesia), great anatomical diversity in nerve pathways, and limited access to the inferior alveolar nerve. As reported in literature, injections fail and must be delivered again to achieve the desired level of anesthesia in every one in five patients (2). For this reason, clinical success may depend on knowing many different available techniques.

**CCLAD systems allow to perform atraumatic anesthesia where traditional methods may involve difficulties with pain management.**

Computer-controlled local anesthesia devices are fitted with a pen-grip handle that allows for the stable and precise monitoring of needle position throughout the procedure (3). In accordance with accepted ergonomic principles, the diameter of the handle should be equivalent to 1-2 pencils; this ensures an easy grip that does not require increased muscle tension. Its weight should be balanced in a way that makes it easy to hold close to the needle, so as to improve needle position control and facilitate the use of the bi-rotational insertion technique, which will minimize the risk of needle deflection and boost the effects of anesthesia (fig. 1).

Needle deflection is produced by the resultant forces that act on the bevel as the needle moves through the tissue. The longer the needle and the deeper it is inserted, the greater the deflection of its tip (the needle must travel a longer distance, which increases the risk of tip displacement and drug delivery in a random direction). The deflection is also greater for thinner needles, because their size makes them less resilient to withstand the deflecting force.

Fig. 1 Pen grip on a Calaject handle

In conventional techniques (traditional syringe, carpule), which rely on a thumb hand grip, the force acting on the bevel during insertion is perpendicular to the path of the needle and causes the needle to deflect in the direction opposite to that of the bevel. The initial position of the bevel, oriented toward the surface of the epithelium at a 45° angle, may be reversed as the needle travels through the tissue. A deflection of 4 mm, as described in literature, may compromise the efficacy of block anesthesia (4).

The introduction of CCLAD systems, along with special injection and delivery techniques (e.g. bi-rotational insertion, pre-injection, or anesthetic pathway), has allowed to minimize needle deflection and avoid associated anesthetic failure (3).

The **bi-rotational insertion technique (BRIT)** bears resemblance to rotational movements used in endodontics and acupuncture. The operator rotates the needle as it is inserted into the tissues, which means that the bevel constantly changes its direction, allowing to minimize or eliminate the perpendicular force acting on the needle. Rotation enables contact between the sharp cutting edge of the needle and the tissue along the entire circumference of the injection site. This allows to deliver the anesthetic to the tissue at a site closest to the nerve and at a concentration necessary to achieve the anesthetic effect.

In addition, the use of BRIT and CCLAD allows to reduce the force required or the needle to be inserted deep into the tissue. Thanks to needle rotation, the resultant forces are oriented toward the insertion path, which makes the needle easier to guide with much less effort and involves fewer unpleasant sensations for the patient.

Using the BRIT improves the injection technique and minimizes the adverse effects of needle deflection. It is also a less traumatic delivery method from the perspective of the patient (3).

In the **Pre-injection technique** (fig. 2 4), pressure is applied to the tissue at the injection site, while the needle is caulked on the surface of the epithelium by an applicator or a special instrument. The pressure is designed to facilitate the delivery of the anesthetic from the epithelial surface, as the solution is gradually pressed into adjacent tissues. The cotton applicator prevents excess fluid from leaking and stabilizes the needle. With the bevel oriented toward the surface of the epithelium at an angle of 45°, the solution is delivered at a slow rate of 0.5 ml/ min and the pressure is maintained for 8-10 seconds. The procedure causes local ischemia and ensures surface anesthesia, which makes further needle insertion and drug delivery painless. However, the patient should be informed of the possible sensation of a strong, blunt, but tolerable pressure (gate control theory). Pressure anesthesia should be maintained for as long the needle travels through the tissues, until it is pulled out. CCLAD systems guarantee successful delivery by ensuring fine-tuned pressure adapted to patient anatomy, which allows to overcome tissue resistance and successfully diffuse the anesthetic (3). Traditional syringes are usually less effective, as the drug often leaks out or the pressure is too great, which causes considerable patient discomfort after treatment.

Fig. 2 Cotton swab pressure applied to the injection site (pre-injection technique)

Fig. 3 Drop of anaesthetic at the needle tip (pre-injection technique)

Fig. 4 Pre-injection technique

In the **anesthetic pathway technique** used with the CCLAD system, the needle is inserted into the tissue gradually, delivering the anesthetic at a very slow rate. A drop of the solution is first squeezed out onto the tip of the needle; the tip is then positioned at an angle of 45° (see – pre-injection technique, fig. 3, 4) and gently pressed against the surface of the epithelium. This ensures an initial surface anesthesia of the injection site. After 20 seconds, the needle is gently inserted into the tissue and simultaneously rotated. The rotational movement improves tissue penetration and drug diffusion. The needle is inserted at a rate of 1-2 mm per 4-6 seconds, delivering the anesthetic at a preset speed (fig. 5, 6).

When performed with a traditional syringe, the anesthetic pathway technique often leads to tissue slackness and/or excessive needle insertion speed. The tension and pressure applied to the tissue and the rate at which the needle travels are more difficult to control.

Using CCLAD for mandibular block anesthesia

Successful and predictable anesthesia of mandibular bones and molar teeth requires a nerve block injection. Supraperiosteal techniques commonly used in maxillary teeth are not very effective in this region. The mandible bone is made up of thick, compact lamellae that impede the diffusion of externally deposited anesthetics and block access to the nerve that runs within the mandibular canal, inside the bone. The extraosseous pathway of the mandibular nerve can be accessed for anesthetic purposes mainly in the pterygomandibular space. Most mandibular block techniques rely on an intraoral route to the pterygomandibular space via injection into the anterior buccal muscle (5, 6).

Fig. 5 Anaesthetic pathway technique

Fig. 6 Anaesthetic pathway technique

Pterygomandibular space is rich in blood and lymphatic vessels, fibrous connective tissue, and muscle and lymphatic tissue, which requires special caution during anesthesia. Fibrous tissue impedes the diffusion of the anesthetic, especially if the needle is positioned too low. Intramuscular injections are often unsuccessful and may cause post-operative trismus. Delivering the anesthetic to the parenchyma of the parotid gland, on the other hand, may lead to temporary facial paralysis (facial nerve paralysis) (6,7).

Block anesthesia with traditional methods is reported to have a success rate of 80% (5). If anesthesia fails due to anatomical differences that impede successful drug delivery, alternative methods should be tried out instead of repeated injections with the same technique (8).

Alternative methods, which can be used if the inferior alveolar nerve block fails, include:

1. PDL anesthesia (to anesthetize the pulp of the target tooth).
2. Intraosseous injections (to anesthetize the bones and soft tissues, mainly in the vicinity of molars)
3. Intraseptal injections (mandibular bones and soft tissues)
4. Subperiosteal injections (incisors, sometimes premolars)
5. Mental nerve block (soft tissues anterior to the first molar)
6. Incisive nerve block (the buccal soft tissue and pulp of teeth anterior to the mental foramen; does not cover the tongue!)

The above methods are also recommended where contraindications exist for inferior alveolar block injections, such as infections or acute inflammations at the injection site, as well as in children or adults with mental disabilities, where there is a high risk of self-injury to the tongue and lips (biting) (8,9).

When blocking the inferior alveolar nerve, three chief parameters should be kept in mind: injection site, anterior-posterior needle position, and insertion depth.

1. Injection site – the deepest segment of the pterygomandibular suture, where it bends up toward the palate (fig. 7)

Fig. 7 Injection site in mandibular nerve block anaesthesia

Fig.9 Target site in mandibular nerve block anaesthesia (the tip positioned on the opposite side)

Fig. 8 Anterior-posterior needle position in mandibular nerve block anaesthesia

Fig. 10 Target area in mandibular nerve block anaesthesia

1. Anterior-posterior needle position – at the intersection of two points:

- point 1 – on the horizontal line that runs from the coronoid process to the deepest part of the pterygomandibular suture (where it bends up toward the palate);

- point 2 – on the vertical line drawn through point 1 at 3/4 of the distance from the anterior mandibular branch (fig. 8)

1. Insertion depth – the needle should be inserted slowly until it touches the bone. Recommended needles: long 25 or 27G needles. The mean insertion depth is equivalent to 20-25mm (2/3-3/4 of the length of a long needle). This means that the tip of the needle should stop slightly above the mandibular foramen, at the entrance of the inferior alveolar nerve. The anaesthetic should be deposited in the closest possible vicinity so as to avoid nerve damage (if the needle is positioned too close, the pressure of the solution may be too high) (9) (fig. 9).

***Block injections with CCLAD***

Blocking the inferior alveolar nerve is particularly useful whenever anaesthesia is needed in several teeth, soft tissues and mandibular bones within a single quadrant, but at the same time, the technique is plagued by a considerable failure rate (5) (fig 10).

CCLAD systems ensure an adequate concentration of the anaesthetic near the target nerve by controlling its flow rate, minimising the risk of needle deflection (thanks to the bi-rotational technique), and monitoring tissue resistance, which allows control and correction of the the needle position within the tissue (3).

A very slow delivery speed ensures greater patient comfort during injections performed with the bi-rotational technique; the dentist also has a greater control over needle deflection, which allows the optimal concentration of the anaesthetic at the target site to be achieved. The slow diffusion rate means that the drug is able to spread over a greater volume of the bone and reach the nerve, even in patients with atypical anatomy.

To ensure safety and needle control, CCLAD systems employ pen-grip handles and hand support points. The handle should be grasped as close to the needle as possible; if grasped at a greater distance, it should be held more vertically to compensate for its weight.

When inferior alveolar block anaesthesia is performed in highly vascularised areas, needle position control and automatic aspiration guaranteed by CCLAD systems are of crucial importance. Aspiration is recommended whenever the needle position is slightly changed or corrected, in order to to avoid any complications associated with intravascular delivery. In the Danish Calaject system (fig. 11), automatic aspiration is triggered whenever the foot controller is released; the procedure is very convenient and does not require any extra action on the part of the dentist, which improves patient safety and allows the doctor to focus on other important aspects of the injection (7).

Palatal injections

The characteristic structure of the palate means that injections in this area are experienced as particularly unpleasant and associated with considerable discomfort. The high density of the palatal mucous membrane, along with a thin or lacking submucosa, mean that special caution must be exercised to make sure that anaesthesia is painless and effective.

CCLAD systems make it possible to fine-tune the pressure of the anaesthetic and make it permeate through the openings in the alveolar bone. The bone surrounding tooth roots (with its small openings) normally impedes diffusion. However, if the anaesthetic is delivered at an adequate pressure and a constant, low speed, it travels through the openings and diffuses throughout the bone.

If the pressure is too high or the delivery time is too short, the liquid forms a barrier that slows down or blocks the diffusion altogether, which reduces the overall efficacy of the anaesthesia. In other words, if the delivery rate is too fast, the liquid cannot permeate all the way to the cancellous bone, but gets deflected from the surface of the cortical bone and leaks out.

Failing to consider the varying sensitivity/elasticity of tissues and their adaptive capabilities may cause anaesthesia to fail and increase the risk of pressure-related tissue damage (localised ischemic necrosis) (10, 11).

Fig. 11 Positive aspiration result (blood drop).

Fig. 12 Injection site in AMSA

**Thanks to CCLAD systems, palatal anaesthesia is better tolerated than traditional methods.**

The bone above the roots of the first molars and medial incisors is often considerably thicker, which impedes the diffusion of the anaesthetic and creates the need for palatal anaesthesia (anterior and middle superior alveolar nerve block – AMSA; palatal anterior superior alveolar nerve block – P ASA).

***Anterior and middle superior alveolar nerve block (AMSA)***

AMSA is recommended whenever anaesthesia must be induced in several teeth in a single quadrant, e.g. during periodontal procedures and conservative aesthetic treatments, where the smile line is essential, as well as whenever a supraperiosteal injection (infiltration) fails, e.g. because of high bone density. The injection site is located on the hard palate in the middle of the line that connects the median palatine suture with the free gingival margin (fig. 12).

The advantage of AMSA is that it does not produce numbness in the lips and facial muscles, which improves patient comfort and allows the dentist to better assess the aesthetic aspect (smile line) (12).

The target area covers: the pulp of maxillary incisors, premolars and cuspids (with just one injection per quadrant), the buccal surfaces of the surrounding gingiva (without the lips), and the adjacent gingival tissue on the palatal side, from the median palatine suture to the free gingival margin (fig. 13).

Contraindications for AMSA include specific anatomical features, such as thin palatal soft tissue. It is not recommended for patients who are unable to keep the mouth open throughout the 3-4 minute delivery time.

The advantages of AMSA include: effects on several teeth with a single injection, relative ease of performance, a lower anaesthetic volume and fewer injections needed in extensive procedures within the maxilla (the anaesthesia is less toxic and traumatic). AMSA does not produce numbness in the lips and facial muscles, which seems particularly important in aesthetic treatments within the smile line (11).

Fig. 13 Target area in AMSA.

Fig. 14 Target area in P-ASA.

However, the technique has certain drawbacks as well. Due to the longer delivery time (0.5 ml/min.), it is not recommended for patients with temporal and mandibular joint disorders. If the palatal bone is very dense, the anaesthetic may leak out, which is why tissue resistance and the flow rate should be monitored with the CCLAD system throughout the procedure. The flow rate is very important; if the drug is deposited too rapidly, it may lead to tissue ischemia (causing necrosis or palatal ulcers). For this reason, anaesthetic agents should never be used with vasoconstrictors at concentrations of 1: 100 000 and more.

The patient needs to be informed about the symptoms that may appear during an AMSA injection, including a sense of tension and numbness in the palatal tissues and teeth in the area extending from the medial incisor to the second premolar. As mentioned before, the technique does not cause numbness in the lips and facial tissues. Ischemia is observed at the injection site.

***Palatal approach-anterior superior alveolar nerve block (P ASA)***

The technique is used in procedures performed on anterior maxillary teeth and soft tissues, as well as aesthetic treatments within the smile line, where bilateral anaesthesia is needed in anterior maxillary teeth (plaque removal, periodontal procedures). A single injection (lateral to the incisive papilla in the papillary sulcus) is enough to produce anaesthesia in the pulp of medial and lateral incisors and partially also in cuspids and their periodontium (fig. 14).

Contraindications for P-ASA include certain anatomical features, such as e.g. very long cuspid roots. The procedure is not recommended for patients who cannot tolerate long delivery times (3-4 minutes), either. In P-ASA injections, the anaesthetic solution should be delivered slowly (0.5 ml/min.), since rapid delivery may lead to excessive ischemia (necrosis). For this reason, like in AMSA, vasoconstrictors should not be used at concentrations at or above 1:100 000 (12).

A clear advantage of the P-PASA nerve block is that it allows bilateral anaesthesia of the anterior maxillary teeth with a single injection (reduced traumaticity) and a lower anaesthetic volume (reduced toxicity), as well as eliminating the unpleasant sensation of numbness in the upper lip and facial muscles (13, 14).

The patient should be informed about the symptoms that may appear during and after the P-ASA injection, including a sensation of strong pressure and numbness in the anterior palate, dental numbness from the left to the right maxillary incisor, palatal tissue ischemia between the two cuspids and no numbness in the face and upper lip.

**The safety of nerve block and palatal injections performed with CCLAD systems is ensured by the stable pen grip handle that allows the needle position within the tissue to be controlled, as well as automatic aspiration, slow needle insertion, the use of the pre-injection, bi-rotational insertion and anaesthetic pathway techniques, and slow anaesthetic delivery at a controlled speed and at a lower dose than in traditional anaesthesia.**

Conclusion

The challenge of finding effective and well-tolerated local anaesthesia methods has fuelled the development of new, and the enhancement of existing, techniques. To ensure patient safety and comfort, caution should be exercised in the use of anaesthetics, which must be delivered at well-adjusted doses that limit their toxicity (especially in children). Special delivery techniques must also be employed to produce the desired effect and minimise the risk of failure.

The advent of computer-controlled anaesthesia has made it possible to control the delivery speed and tissue resistance with high precision, allowing the adjustment of these parameters to the specific anatomical features of a given mouth region and thus reduce patient discomfort (3, 14).

In CCLAD, the physiological flow rate and diffusion of the anaesthetic, without any loss or leakage, allows the volume needed to produce effective anaesthesia to be minimised. A large area can now be anaesthetised with a single injection, e.g. with techniques such as AMSA or P-ASA, which makes the injection less traumatic (13).

In anaesthetic techniques performed in highly vascularised areas, such as mandibular nerve blocks, CCLAD systems enable automatic aspiration to ensure a better control of needle position and reduce the risk of complications associated with intravascular delivery (3).

The challenge of delivering effective local anaesthesia in dental care requires a constant Improvement in anaesthetic techniques, as well as the introduction and use of new devices designed to increase the comfort of patients and doctors.



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