Review

NEEDLE BREAKAGE DURING INFERIOR ALVEOLAR NERVE BLOCK ANESTHESIA: A REVIEW

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ABSTRACT

Needle breakage is a frustrating accident during inferior alveolar nerve block administration. Proper treatment of such a complication is fundamental considering that, without an appropriate localization, the fragment manipulation may worsen the condition and lead to a deeper migration into vital structures. This review examines in depth the potential risk factors of needle breakage, analyzing the proper management and treatment of such conditions. Preventive measures are also proposed to decrease the risk of breakage. Changing the needle direction is only allowed if most of the needle is withdrawn with the tip just beneath the mucosa. The use of a bidirectional rotation insertion technique during the administration could be another measure to minimize needle deflection. Repeated injections with the same needle, should be avoided since they increase fragility and susceptibility to fracture. Needles and syringes should be checked for irregularities before the injection. Furthermore, adequate preoperative sedation should be considered, especially in pediatric patients, to achieve proper compliance. After carefully evaluating the entry point, if the fragment is still visible, an immediate attempt to retrieve it with fine artery forceps is required. When the needle is completely covered by the mucosa, the retrieval becomes complex and unproper maneuvers may lead to a further displacement into deeper tissues.

KEYWORDS: *needle breakage, IAN, inferior alveolar nerve, anesthesia*

INTRODUCTION

Modern disposable hypodermic needles were introduced only in the second half of the 20th century. Previously, available reusable needles were made of carbon steel. These needles required sharpening and sterilization after each use, and the risk of breakage due to metal fatigue represented a frequent complication (1). Nowadays, scientific advances

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in metallurgy, enhanced training in anesthesia, and the introduction of modern disposable hypodermic needles have largely decreased the risk of breakage.

A 50-year retrospective analysis conducted by Augello et al. (2) revealed that, in most of cases, needle breakage occurred during inferior alveolar nerve block administration (70 %, 45 patients out of 64). Pogrel (1), based on data from North California dentists, reported an estimated risk of 1 case out of 14 million for each inferior alveolar nerve block administered.

The success rate of the inferior alveolar nerve block anesthesia is relatively low when compared to other techniques, with a failure rate up to 30 % (3). Kroman et al. (4) demonstrated that a deep penetration of the needle, up to 21 mm, is necessary for optimal anesthesia. Proper diffusion of the anesthetic solution into the pterygomandibular space (Fig.1) should be considered when analyzing failures, and perineural tissue differences have shown a profound impact on the onset time of analgesia (5).

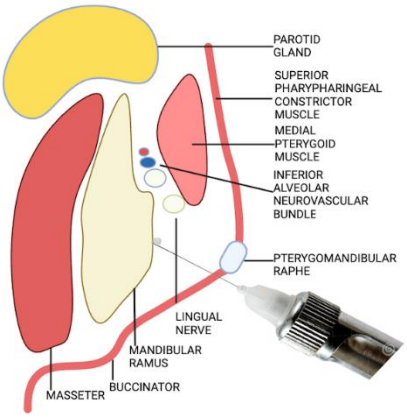

Fig. 1. *The pterygomandibular space is defined by the medial surface of the ramus laterally, medial pterygoid muscle and associated fascia medially, lateral pterygoid muscle superiorly, parotid gland posteriorly and pterygomandibular raphe, buccinator and superior constrictor muscles anteriorly.*

Various approaches have been proposed in order to increase the effectiveness and reliability of such techniques. Malamed has provided a thorough description of the conventional injection technique (6). In this technique, the pterygomandibular raphe and other landmarks, such as the coronoid notch, are used to locate the exact position of the nerve as it enters the mandibular foramen. The medial surface of the ramus and the pterygomandibular raphe outline the proper injection site. With the syringe barrel located at the opposite side (premolars teeth) and kept parallel to the mandibular plane, the coronoid notch is palpated. Drawing an imaginary line from the fingertip to the deepest portion of the pterygomandibular raphe, the location for the needle insertion is defined at one-quarter of this distance, towards the pterygomandibular raphe. At this point, the needle is inserted 20/25 mm until bone is gently contacted and the solution is deposited. Despite the clearness of the procedure, the general difficulty encountered in retrieving the anatomical landmarks, has brough clinicians to develop other strategies. An alternative technique has been proposed by Thangavelu et al. (7). With the needle penetration site located 6/8 mm above and 8/10 mm posterior to the coronoid notch, the barrel of the syringe is oriented towards the contralateral premolars. From this point, the needle is advanced until bone is reached. Touching the medial side of the ramus (used as a guide), the barrel is further adjusted towards the midline and, after 21/24 mm of penetration, readjusted to the opposite side to reach the area above the inferior alveolar nerve entry in the mandibular canal. Frequent contact of the periosteum with the tip of the needle is a constant of this technique, which has been reported to achieve a success rate of up to 95 %. Palti et al. (8) proposed specific landmarks on the mandibular molars for identifying the optimal injection site, while Suazo et al. (9) proposed an alternative injection site represented by the retromolar triangle. Other different techniques include the Gow-Gates technique (10), the Vazirani-Akinosi nerve block (11), and the Fischer 1-2-3 technique (or indirect technique) (12).

When a needle breakage occurs, and the fragment is buried in the soft tissues, retrieval surgery should be performed to avoid life-threatening complications resulting from the potential migration of the needle. The limited access and proximity to vital structures represent a challenge for surgeons (13). The surgical procedure is typically unpredictable, and a complete analysis based on 3D imaging is needed to assess the best surgical approach (14).

Electromagnets, as long as iron has been eliminated from stainless steel alloys, are no longer effective for detecting fragments (15). 3D imaging (CT and CBCT) represents the gold standard for properly evaluating the needle position and planning the best retrieval procedure. However, 2D techniques may be useful tools, such as plain films (16) or C-arm fluoroscopy (17, 18). Due to the difficulties encountered in properly locating fragments during the intraoperative retrieval procedure, these latter are often considered valid and complementary to 3D imaging (19, 20). The main advantages of these techniques are the rapid intraoperative collection and review of images without disturbing reference needles, along with a general reduction of radiation dose and excellent image quality (17, 19). Recent innovations in computer-assisted surgery through navigation systems have hugely improved the clinical results (21). Navigation system technologies are primarily used in neurosurgery or cranial base surgery. The dynamic nature of the mandible and surrounding soft tissues represents an important limitation. However, using customized 3D-printed mouth openings or interocclusal splints during image acquisition and surgical procedures effectively matches the imaging data with the

patient's actual position (13, 20-23). Intraoperative ultrasounds have also been proposed for detecting foreign bodies in soft tissues (24). However, accuracy and size are the main limitations to their use.

The aim of this review is to investigate the most influential risk factors related to needle breakage, assess the dynamics related to this occurrence, describe the most used retrieval strategies, and provide preventive measures and guidelines for properly managing such a complication.

MATERIALS AND METHODS

This review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement. The main research questions were captured in the PICO (Population, Intervention, Comparison, Outcomes) format: “What are the main risk factors related to needle breakage during an inferior alveolar nerve block, and how can this event be avoided?” Is it possible to define a proper management of such complications?" An electronic search was conducted on the PUBMED /MEDLINE bibliographic database (PubMed). 36 articles with a period from 1960 to 2021 were selected using the following algorithm:

- "needle" AND ("fractured" OR "broken" OR "breakage") AND ("inferior alveolar nerve block" OR" inferior alveolar nerve anesthesia “OR "pterygomandibular space").

Due to comprehensive details about the analyzed complication, case series, and case reports were chosen as the primary source for this review. Titles and abstracts of articles were subjected to an initial selection process, considering relevance, type of study, and population. A hand search was conducted for the resulting studies by analyzing complete articles and their relevance and adherence to inclusion criteria.

Data extraction/analysis

From the selected studies were extracted the following data: patient age, needle size, timing (from the accident to the treatment), migration sites, reported cause of fracture, symptoms, and surgical technique performed for the retrieval.

Data were collected and analyzed using Microsoft Office Excel 2007© (Microsoft Cooperation, München, Germany). The descriptive analysis included 27 articles.

RESULTS

Needle type/ symptoms reported

Data analysis showed that needle size varied from 27 to 30 G, with the latter being the most commonly used. Needle length varied from 21 mm (21, 25) to 40 mm (17). Patient ages ranged from 3 (26) to 65 (27).

The most reported cause of needle breakage was abrupt movement of both operator or patient, and in the majority of cases, needle breakage occurred in the hub portion. Improper techniques (15) and management (double bending, reutilization) of the needle (27), or a combination of these (28, 21) represented other important factors related to an increased risk.

At the initial consultation, trismus and generalized pain during mandibular movements were the most reported symptoms. Other symptoms, such as otalgia (27, 29) or reduced head movement (30), result from the migration of the fragments.

Timing/ migration sites

Due to the potential risks derived from fragment migration, the time between the incident and the retrieval intervention should be as short as possible. Studies have considered treatment intervals ranging from several days to months (30) or even years (22).

The retrieval surgery may represent a severe risk for neurological or tissue damage (31). Some authors suggested leaving the fragment in situ as long as the patient is asymptomatic (22), since the formation of scar tissue and fibrosis could play a fundamental role in preventing further displacements. However, effective stabilization is hardly achievable (27), and the fragment migration itself represents a potential trigger for trismus, infections, paresthesia, or hemorrhage, in addition to psychological trauma (29).

Significant migration sites reported included the perivertebral space (30), vascular structures (28), parotid space (17), posterior cervical space (19), parapharyngeal space (29), pterygoid muscles (13, 22), and the external auditory canal (29).

Retrieval surgery

Although general anesthesia was typically administered to most patients, in some cases, only local anesthesia was used (32, 14).

It is important to note that during the surgery procedures, the needle may be further dislocated (33) into the soft tissues. This further complication may worsen the condition and jeopardize the retrieval (19). Some studies reported that previous failed attempts to retrieve the fragments (17, 19) have contributed to further migration.

When the fragment is located in the pterygomandibular area, two are the main surgical approaches: a vertical incision on the medial aspect of the mandible followed by blunt sopra-periosteal dissection, or a parallel incision to the external oblique ridge followed by a subperiosteal dissection. This latter approach provides a better identification and protection of the inferior alveolar and lingual nerve and is generally preferable (20). Incisions close to the fragment in the lingual aspect are generally contraindicated (33).

Intraoperative navigation systems with 3D-printed templates or interocclusal splints showed to be effective and reliable tools for the retrieval. A proper machine calibration enables a more precise detection of the fragments, leading to a significant decrease in both operative time and invasiveness of the procedures (20-23).

Extraoral approaches such as endaural approach (29), neck explorations via open transcervical approach (30) and incision along the lower border of the mandible (28) were also reported. A spontaneous extrusion (27) was also observed.

DISCUSSION

Needle breakage during inferior alveolar nerve block anesthesia is a rare but unpleasant complication. Despite the improvement of the alloys and the transition to disposable stainless steel hypodermic needles, needle fracture is still present. Catelani et al. (34) reported cases in which manufacturing defects were the leading cause of breakage. However, improper injection techniques, patient movements or wrong choice of the needle, rather than material defects, should be considered.

Augello et al. (2) highlighted that the use of 30 G needles, based on the incorrect belief that a thinner needle reduces pain, was related to a higher risk of breakage. As reported by Fuller and Moller, there were no significant differences in pain perception when 25, 27, and 30 G needles were compared (35, 36). Moreover, the injection pressure increases as the needle diameter decreases (33). A higher injection rate is also linked to increased pressure and, thus pain, with subsequent abrupt movement of the patient and increased risk for needle breakage. Other factors, such as periosteal contact or excessive proximity of the tip to the nerve, can lead to similar results (33). From data derived from the descriptive analysis, some preventive measures can be proposed (Table I).

Table I. *Preventive measures.*

PREVENTIVE TIPS
Use a 27 G long needles; avoid 30 G needles
Avoid bending the needle
Avoid inserting the needle up to its hub. Leave at least 5 mm outside the tissue
Avoid position changes during administration
Avoid repeated injections; needles should be replaced after every use
Use of bidirectional rotation insertion technique

The use of 30 G needles when administering inferior alveolar nerve blocks (19) is not recommended. Since the hub-needle junction represents the most delicate and rigid part, a full insertion is also contraindicated (37), and it is advisable to use long needles instead of short ones (21, 38). Bending the needle is also not recommended, as it weakens the structure. Changing the direction of the syringe when the needle is inserted into deeper tissues produces similar results (33). This procedure is only allowed if most of the needle is withdrawn, with the tip just beneath the mucosa (39). Using the bidirectional rotation insertion technique during administration could be another measure to minimize needle deflection (31, 40). Moreover, repeated injections with the same needle should be avoided since they increase fragility and susceptibility to fracture (41). Needles and syringes should be checked for irregularities before the injection (26), and adequate preoperative sedation with anxiolysis procedures (e.g., nitrous oxide-oxygen sedation) may be considered, especially in pediatric patients (25), to achieve proper compliance.

An immediate removal is generally recommended when breakage occurs, to avoid further complications. Acham et al., analyzing the literature from 1980 to 2018, reported an immediate removal within one day in 53.8% of cases, 30.8 % within 3 months, and 12.8% delayed 3-12 months or later (42). In this context, the case reported by Brooks and Murphy (43) was noteworthy. In a relatively short time, the fragment migrated from the pterygomandibular space to the jugular foramen, transecting the internal carotid artery and requiring prompt cerebrovascular intervention. The authors postulated that the

cutting bevel of the needle and the contraction of the nasopharynx and oropharynx musculature facilitated such a rapid and extensive migration (43).

Proper management and treatment of such conditions are fundamental for the clinician. After carefully evaluating the entry point, an immediate attempt to retrieve the fragment with fine artery forceps is required if the fragment is still visible.

If the needle is not clinically detectable, it is mandatory to reassure and adequately inform the patient to avoid excessive jaw movements, which may trigger fragment movement and migration into adjacent structures (44). Chewing and swallowing may also contribute to further migration, potentially damaging the maxillary artery, internal carotid artery, internal jugular vein, or cranial nerves (glossopharyngeal, vagus, and hypoglossal nerve) (29). Attempts to palpate the mucosa are also not recommended since they may complicate the retrieval (33), leading to further dislocation into deeper tissues. The patient should be immediately referred to the local maxillofacial unit, and the remainder of the needle should be preserved for further analysis and assessment.

The rapidity of injection is also linked to pressure increase and thus pain, leading to possible abrupt movements of the patient and increased risk for needle breakage. Periosteal touching and excessive proximity of the needle at the nerve can represent a potential trigger for pain and so involuntary movement (19).

Due to the risk of dislocation into deeper tissues, generating a life-threatening condition, proper management and treatment are fundamental for the operator. They must be conducted using explorative surgery and previous clinical and radiographic evaluation. Timing of surgical removal is also a fundamental issue and must be minimized to prevent complications. Acham et al., analyzing the literature from 1980 to 2018, reported an immediate removal within one day in 53.8% of cases, 30.8 % within 3 months, and 12.8% delayed 3-12 months or later (38). After analyzing all the clinical reports, some preventive measures can be proposed.

It is not recommended to use a 30G needle when administering inferior alveolar nerve blocks (24). Provided that the hub-needle junction represents the most delicate and rigid part, a full insertion is neither recommended nor recommended (39), and it is advisable to use long instead of short needles (29, 33).

Bending the needle is also not recommended, as it weakens the needle as long as the grip and the direction of the syringe are changed when the needle is inserted into deeper tissues (19). Changing the needle direction is only allowed if most of the needle is withdrawn with the tip just beneath the mucosa (40). Using a bidirectional rotation insertion technique during administration could be another tip to minimize needle deflection (26, 41).

Repeated injections with the same needle should be avoided since they increase needle fragility and susceptibility to fracture (42). Needles and syringes should be checked for irregularities before the injection (16). Furthermore, adequate preoperative sedation or the use of oxide/oxygen analgesia/anxiolysis should be considered, especially in pediatric patients (43), to achieve proper compliance. If the fragment is still visible, an immediate attempt at retrieval is required with fine artery forceps after carefully evaluating the entry point. If the needle is not clinically detectable, it is mandatory to reassure and adequately inform the patient to avoid excessive jaw movements to limit the needle's migration (1). Chewing and swallowing may also contribute to the migration and cause potential damage to the maxillary artery, internal carotid artery, internal jugular vein, or cranial nerves (glossopharyngeal, vagus, and hypoglossal nerve) (27).

Palpating the mucosa is not recommended since it could complicate retrieval (19), leading to a further dislocation into deeper tissues. It is mandatory to immediately refer to the local maxillofacial unit and accurately describe the incident. Furthermore, sending the remainder and a new, fresh needle to the same unit and informing the dental defense company is advisable.

CONCLUSIONS

Even if a rare complication, needle breakage can be a traumatic event for both patient and clinician. Practitioners must know that immediate and adequate management is necessary if such a complication occurs. Before every injection, some preventive measures should be considered to minimize the risk of breakage. If the fragment is still visible, an immediate attempt to retrieve it is required. However, when the needle is completely covered by the mucosa, the retrieval becomes complex, and improper maneuvers may lead to a further displacement into deeper tissues. In such cases, the patient should be referred to the maxillofacial unit as soon as possible. Special care should be taken during administration in pediatric patients.

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