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Review article

# Needle breakage during dental anesthesia: Management strategies and its associated preventive measures

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**KEYWORDS**
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**Abstract** Dental anesthesia is useful and important for the procedures of tooth extraction, oral tissue biopsy, periapical and periodontal surgery and more others. However, needle breakage during dental anesthesia, presents a considerable challenge in its clinical

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Foreign body removal;
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Broken instrument

management. Retained fragments can lead to pain, trismus, dysphagia, and infections, and may migrate into deeper spaces, increasing the complexity and risk upon its retrieval. To avoid such consequences, prompt removal of the broken fragment is often advocated. However, no standard guidelines were developed. This review provides a comprehensive analysis of the current imaging modalities and surgical techniques used in fragment localization and retrieval. The surgical approaches may vary depending on the location of broken fragment. In addition, the use of C-arm fluoroscopy, endoscopes, dynamic navigation systems and static surgical guides can facilitate the surgery. Conversely, magnets and metal detectors have shown to be ineffective. Factors such as needle location, patient cooperation, systemic health, maximum mouth opening, and surgical risks must be carefully considered. Additionally, this article emphasizes the importance of prevention. Proper injection techniques, use of long and thicker needles, adequate patient preparation, and avoiding prebending are critical to reduce the risk of breakage.


## Introduction

Needle breakage (NB) during administration of dental anesthesia is a rare but potentially serious complication. While around half of the cases are asymptomatic, 39 % of patients experienced pain and tenderness, which may occur in the pterygomandibular area, behind the ear, near the temporomandibular joint, or during neck movements.[1] Trismus can occur when needle fragments impinge upon the pterygoid muscles, and was observed in 20 % of cases.[1–3] Foreign body sensation and paresthesia are occasionally noted.[4] In more severe scenario, complications such as facial cellulitis and meningitis have been reported.[5,6] Rare manifestations include difficulty in neck movement, and hearing impairment.[7,8]

Fractured needle, if left for observation, may migrate and potentially violate anatomical structures such as vessels and nerves, and increases the risk of hemorrhage, neurological damage, and surgical complexity.[9] Therefore, timely removal of a fractured needle is strongly recommended. Various methods for removing the fragments are advocated but the procedures are often invasive and are not always successful.[5,7,8] Beyond clinical concerns, NB may cause profound psychological distress, leading to needle phobia and aversion to dental treatments in the future. These consequences emphasize the importance of understanding its prevention and management strategies.

According to rough estimations, the incidence of needle breakage during dental anesthesia is around 1 per 14 million injections.[10] However, only 100 cases have been reported in the literature over the past five decades.[6] Considering the global number of dentists and the high frequency of anesthesia administration, the true incidence of NB is much likely underestimated. Although the administration of dental anesthesia is simple and is taught at school, cases of NB continue to appear, and these incidents often involve some avoidable risk factors (Fig. 1). In addition, there is no consensus regarding its management and retrieval. This article aims to perform a critical review over the current clinical techniques for fractured needle removal, to re-emphasize the associated preventive measures, and to point out future research directions.

## Pre-operative assessment of broken needles

The treatment diagram for needle breakage was shown in Fig. 2. If the fragment is superficial and visible, inform the patient to stay still, and immediately remove the fragment with a hemostat.[11,12] Because the visible end may vanish in the soft tissue during intraoral movements, having a mosquito nearby during anesthesia is advisable in case of any emergency situations.

In contrast, retrieving a completely embedded needle is more complicated. Clinicians without surgical expertise should refer the patient to maxillofacial surgeons as soon as possible.[6,13] The needle's location, the clinician's surgical skill, the extent of mouth opening, patient cooperation, as well as the equipment and technology availability should be fully evaluated before attempting the surgery. The needle's location and depth within the tissue influence the selection of surgical approaches. Interdisciplinary collaboration may be required to ensure safe and effective removal of deeply embedded bodies.

Two-dimensional images like orthopantomography, lateral cephalometric radiograph, posterior-anterior skull view, oblique skull view, provide first-line imaging for documentation and localization of broken needles. However, these conventional methods are gradually replaced by computed tomography (CT), which provides detailed information of the surrounding anatomy.[6,14] However, despite the enhanced accuracy of CT, the needle's position seems to differ between mouth opening and closing. Therefore, some authors advocate taking CT with mouth open to stimulate the position during surgery.[15,16]

Magnetic resonance imaging (MRI) and ultrasonography are less frequently utilized. Metal objects are generally contraindicated for MRI due to the risk of needle migration and thermal injuries under electromagnetic forces.[17] However, there has been cases where MRI was successfully employed.[18] A possible explanation is that anesthetic

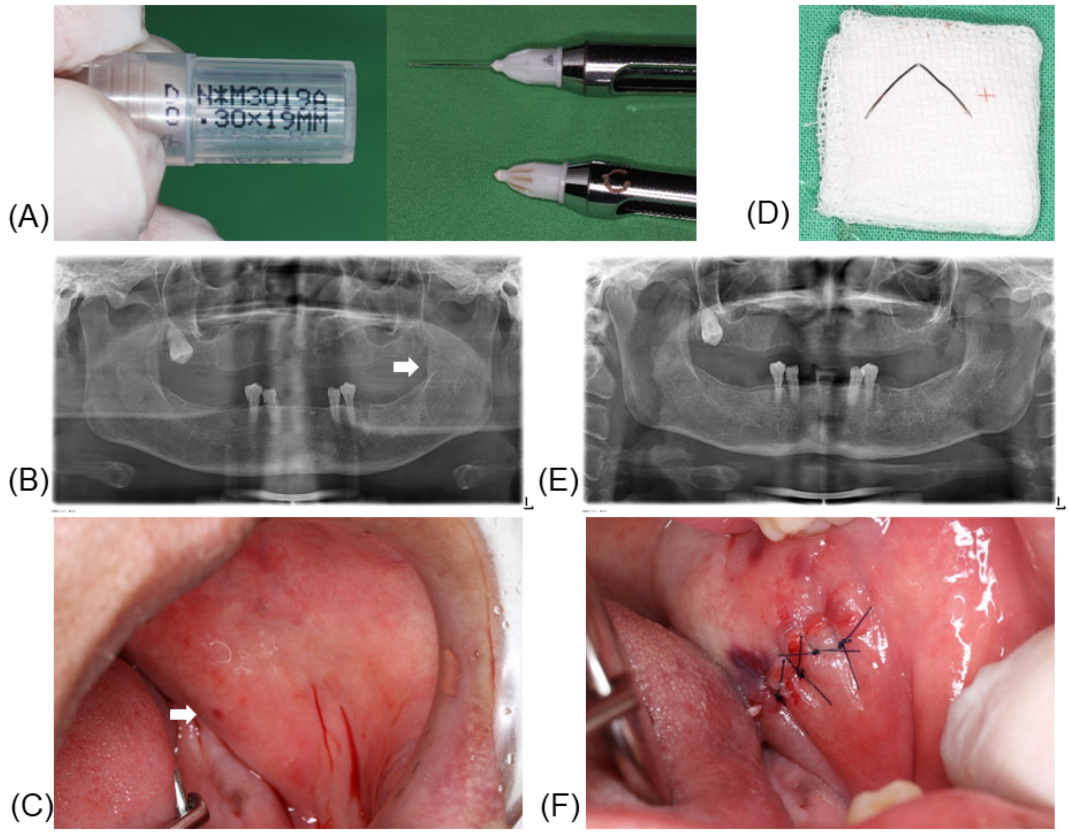


**Figure 1** Conventional surgical exploration for needle retrieval. A local dentist referred a patient to the Emergency Dental Department, Kaohsiung Veterans General Hospital, following an accidental needle breakage during inferior alveolar nerve block (IANB). **(A)** The faulty needle and a counterpart of identical dimensions (30-gauge, 19 mm) were presented at the hospital. The broken needle was completely detached from the hub. **(B)** An orthopantomogram was performed for initial evaluation, and revealed a deformed needle (white arrow) at the anterior border of left mandibular ramus. The patient was asymptomatic and denied any problems with mouth opening. **(C)** A red spot was observed in the left pterygomandibular raphe area. Using this red spot (white arrow) as an initial reference, a mucosal incision was performed, and followed by blunt dissection under tissue tension formed by assistant's finger. **(D)** The needle was successfully retrieved after exploration and careful dissection. **(E)** Another orthopantomogram confirmed the complete removal of the needle. **(F)** The soft tissue was sutured with 4-0 nylon. In the present case, neither the patient nor the referring dentist reported any sudden or forceful movements during anesthesia procedures. The use of short needle for IANB was a major risk factor for its breakage. The deformation of the needle implied that needle was bent prior to the injection, or that it had an aggressive contact with the bone during administration. In addition, IANB usually was not needed for a mandibular first premolar extraction; instead, local infiltration might be sufficient.

needles used nowadays barely have any magnetism owing to their composition and manufacturing process. Ultrasound can help locate needles within superficial soft tissue, but performs poorly when fragments are deeply embedded or obscured by bone.[17,19] However, ultrasound can serve as an alternative option for CT, by providing real-time images while minimizing radiation exposure in young children.[20]

The reliability of the preoperative radiographic measurement may be affected by the intraoperative migration of the needle. Consequently, clinicians tried to develop intraoperative stereotactic techniques, such as c-arm fluoroscopy and endoscopy, which will be discussed later.

## To retrieve broken fragments, or not?

Some clinicians have advocated that embedded broken needles do not need to be removed unless symptoms present.[21] However, in several reported cases where the broken fragments were left for observation, the subsequent migration into deeper anatomical space greatly increased the difficulty and risk of retrieval.[5,8,16,22,23] Therefore, regardless of the symptom presentation, prompt removal of fractured needles is strongly recommended to prevent needle migration, and to reduce the risk of infection, foreign body reaction and psychological distress.[19,24] In addition, it might be easier to find the fragment when the operator still remembers where the needle was injected.

Broken needles during mandibular block anesthesia are mostly located in the pterygomandibular space at first.[1] However, after migration, these fragments can be found in the periauricular region,[8,25] post-auricular area,[26] parapharyngeal space,[5] perivertebral space,[7,22,27] and around the skull base.[9,23] In addition, the rate of migration varies considerably among reported cases. A broken needle appeared near the fourth cervical vertebra a few days after

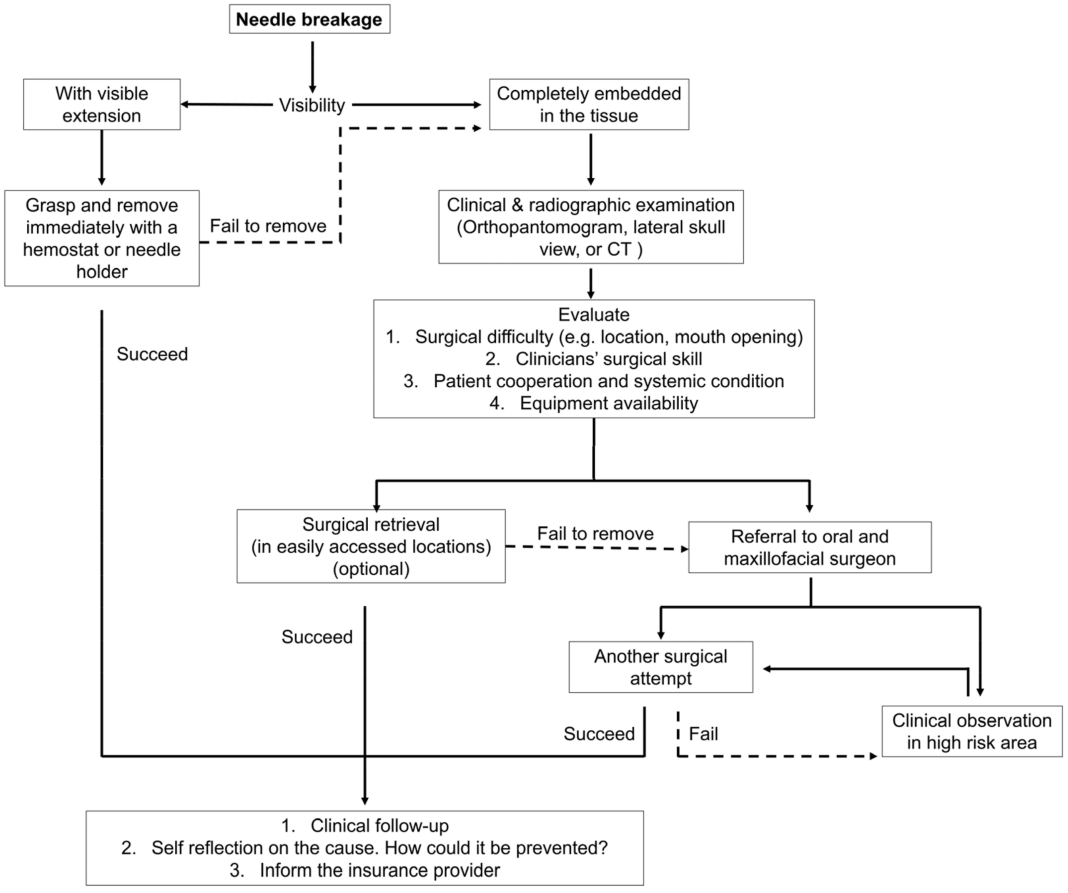


**Figure 2** Diagram for treatment of needle breakage. If the needle breakage is visible, grasp and removal of the broken needle immediately with a hemostat or needle holder. If broken needle cannot be removed or completely embedded in the tissue, clinical and radiograph examination to evaluate surgical difficulty, patient cooperation and systemic condition as well as equipment availability. Referring the oral and maxillofacial surgeon should be considered.

its breakage.[22] A 35-mm needle migrated to the post-auricular area and the lateral aspect of the neck two weeks post-fracture.[26] In another instance, a 25-mm needle fragment which was originally at the anterior border of the ascending ramus exhibited a 14.8 mm migration toward the skull base within two months.[18] Conversely, some retained fragments did not show significant change in their position even after 6—12 months of observation.[11,24] Omori hypothesized that bent fragments could stuck to bony structures easier than straight fragments, and would stay in place.[19]

Migration of broken fragments during local infiltration anesthesia were also reported. In one case report, an asymptomatic patient chose to observe the embedded needle in the mandibular gingiva.[28] The CT scans did not identify obvious change in its location at the three-month follow-up; however, it was later found in the neck another nine months later. In another report, the fragment was found around the maxillary tuberosity a few days after the treatment of a maxillary first molar.[3]

Up to now, it is challenging to predict the path and velocity of needle migration, and it is unclear what types of fragments could be left safely for observation. Apart from muscle forces, it is hypothesized that external stimuli such as shaving, face rubbing or washing distribute to the migration.[28] Future investigations should aim to elucidate how fragment dimension and anatomical position influence the likelihood and extent of migration, to allow better clinical-decision making. Based on current evidence, early removal is advisable especially when fragments are located superficially.

## Strategies for fragment retrieval

Various methods have been proposed for locating and removing broken needles, ranging from the conventional surgical exploration, to advanced techniques with the assistance of C-arm fluoroscopy, surgical static guides and dynamic navigation system (Table 1). However, due to the rarity and high heterogeneity of such events, no meta-analysis or clinical trials have been conducted to compare the success rate of these approaches. As a result, discussions on this topic rely heavily on case reports and series. In addition, although the use of magnets and metal detectors has been discussed in the literature, these techniques are generally deemed ineffective.[29,30] Moreover, surgery can be performed under either local or general anesthesia, but patients should be informed that its duration of the operation is unpredictable, and might be tiresome with local anesthesia.

**Table 1** Strategies for needle retrieval.

| Method | Advantages | Disadvantages |
|---|---|---|
| Conventional surgical exploration[3,4,11,13,14,19] | Allow timely intervention (no specialized devices needed). | Probably the most invasive option, particularly when performing without imaging guidance.<br>Its success heavily relies on the clinician's surgical skill and observation. |
| Assistance with C-arm fluoroscopy[5,10,18,22,28,31] | Provide real-time intraoperative images, which help locate the needle. | Two-dimensional image.<br>Decreased image quality was occasionally reported. |
| Surgical guide and blue dye[15] | The targeted area could be marked with colored dye. | Require time for surgical guide fabrication. |
| Dynamic navigation surgery[16,20,24,30,32] | Allow minimally invasive approach and rapid identification of broken needle. | Marker-based registration method is more time-consuming and additional radiation exposure may be needed.<br>Learning and training are essential for conducting the surgery effectively.<br>High cost. |

(1) **Conventional surgical exploration**

Base on radiographic measurements, this approach involves tissue dissection to explore the needle fragment visually, or with the aid of dental loupes. Optical devices such as endoscopes and microscope may also enhance the visibility during the surgery by providing bright and magnified images.[2,31]

Two main techniques are employed for the surgical exploration in the mandibular ramus area. In the first method, the surgery begins with a superficial mucosal incision.[3,4,13,19] Then a blunt instrument such as a hemostat or a surgical curette is used for supraperiosteal dissection, to minimize the risk of vessel and nerve injury. Ideally the dissection should be perpendicular to the body of the needle to facilitate its findings. If the needle cannot be found in the superficial layer, a deeper incision is made. This conservative method is suitable for fragments located at the anterior region of the pterygomandibular space (Fig. 1).

In the second method, a deep incision and a full thickness flap are performed since the beginning, so the inferior alveolar nerves and lingual nerves could be identified and protected.[11,14] The lingula can also serve as a reference point for further exploration. This method may be more appropriate for the exploration of deeply embedded needles.

(2) **Surgical exploration with the assistance of C-arm fluoroscopy**

C-arm fluoroscope is a portable radiographic device which provides real-time images from multiple angles during surgery. These radiographs can be captured alone, or with the presence of reference objects (e.g. needles, hemostat) to help locating the fragment.[18,22,28,31] Although successful outcomes have been documented with this method, the images are two-dimensional and some authors complained about their poor resolution and problems with halation.[5,10] To decrease radiation exposure during the surgery, the image acquisition time is often reduced; therefore, the resolution was compensated. The use of an intensifier and compensating filters may help improve image quality.[5,22]

(3) **Static navigation surgery (surgical exploration with surgical guides)**

Recently, Lukas et al. made a surgical guide by incorporating CT images, computer-aided design, and three-dimensional (3D) printing technologies to help locating the needle.[15] The patient took a CT with a bite block to stimulate the intraoperative position, and an intraoral scan was performed. By incorporating the two images, a surgical guide with a direction pointer was digitally designed and then printed with a 3D printer. With the guide in the mouth, methylene blue was injected with a needle to mark out the targeted surgical area.

(4) **Computer-assisted dynamic navigation surgery**

Computer-assisted dynamic navigation surgery integrates preoperative CBCT data with intraoral scans, to provide real-time surgical guidance using an optical tracking system and specialized 3D planning software. It facilitates rapid identification and removal of broken needles through a minimally invasive approach.[20,24,30,32]

Dynamic navigation systems are categorized into marker-based and marker-free registration methods. Earlier reports selected marker-based registration, which relies on splints or screws for spatial orientation.[20,24,30,32] The preoperative preparation is time-consuming, and this delay may result in needle migration, potentially increasing risks to the patient's comfort and safety. Apart from the initial CT scan, a second scan with the splint or screws in place is often necessary, resulting in additionally radiation exposure. In contrasts, marker-free registration relies on the patient's

native anatomical landmarks for intraoperative guidance, eliminating the need for splint fabrication and additional CT scan.[16] These advantages have made marker-free registration more popular. However, its reliability in more complex anatomical regions has not been validated.

Some authors found the use of dynamic navigation system troublesome probably due to inadequate experience and skill.[14] The actual fragment position might not be coincident with that during CT taking, leading to navigational deviation. High costs of such devices further limit the feasibility in clinical settings.

(5)**Magnets and electromagnets**

To the best of our knowledge, there are no documented cases of successful retrieval of broken anesthetic needles using magnets or electromagnets. Nonetheless, they have successfully removed fractured curette tips and suture needles, likely due to the differences in the metal composition.[33–35] Although Dental anesthetic needles contain a high percentage of iron, the austenite crystal structure of these alloys lacks inherent magnetic properties. Processes such as thermal treatment, precipitation hardening and plastic deformation can induce partial transformation into ferrite or martensite phases, and slightly increase the magnetic susceptibility.[29,36] An *in vitro* study revealed that even after thermal treatment, these needles demonstrated only minimal magnetic response, implying that magnets are ineffective for retrieving such fragments.[29]

(6)**Metal detectors**

Metal detectors are capable of identify various ingested metallic foreign bodies, such as coins, batteries and hairpins.[37] However, their sensitivity decreases toward smaller items, such as screws or needles, which typically produce very weak signal amplitudes. Instances of failed detection of needle fragments using metal detectors or implant finders have been reported.[5]

Although research suggests that current anesthetic needles remain undetectable by both magnets and metal detectors, these shortcomings highlight the need for advancement in needle material and design. Future research could focus on developing needles that adhere to International Organization for Standardization requirements, while integrating magnetic properties to facilitate fragment retrieval. Attaching a mini-metal detector to the tip of an endoscope might also be a promising solution in such cases.

(7)**Special considerations for migrated broken fragments**

When a fractured needle migrates far away from the oral cavity, its retrieval through an intraoral approach may be much more complex. In a case report, an intraoral surgery failed to retrieve the needle from the skull base despite the use of c-arm fluoroscopy,[9] suggesting that these cases should be treated by more relevant specialists including otorhinolaryngologist, neurosurgeons and vascular surgeons.

The approaches for needle removal vary significantly according to the fragment location. Needles which have migrated to the superficial skin can be retrieved via a skin incision or manual pressure.[26,31] For needles close to the external auditory meatus and cochlea, consultation of otorhinolaryngologist is recommended.[8,25] In cases involving the parapharyngeal space, a tonsillectomy may facilitate the search of needle under surgical microscope.[5] Needles at the base of the skull have higher surgical risk due to the surrounding anatomy. Successful needle removal from the cranial base with the assistance of endoscope has been reported in a patient who developed symptoms like bacterial meningitis.[6] Needles migrated to the neck and perivertebral space can be successfully retrieved via a transcervical approach.[7,22,27,28] Endovascular surgeries are helpful in removing needles near large vessels and nerves.[9,23]

## Prognosis and post-operative complications

The success rate for removing needle fragments is uncertain. In a case series, the surgeons had successfully located and retrieved all broken fragments from 16 patients under general anesthesia, although some procedures took up to several hours.[10] However, in many case reports, the first surgical attempt failed to find the needle, and a second or third attempt was required.[4,5,7,9,23,28] In general, 96.5 % of needles had been eventually removed among 86 reports in the literature.[6]

Post-operative complications following successful needle removal may include including edema, fever and hematoma. 88 %–91 % of cases resolve without long-lasting sequelae.[1,6] Prolonged trismus (6 %) and paresthesia to the mandibular nerve (3 %) was occasionally reported. Scar formation resulting from extraoral surgical approaches may result in esthetic problem.

## Prevention of needle breakage (NB)

Prevention of needle breakage is much simpler than the subsequent retrieval procedure. It is essential to acquire risk factors along with appropriate preventive measures to avoid NB. The following key points are recommended.

(1)**Calm the patient and avoid sudden movements**

Unexpected movement of the patient during injection were the main cause of NB (54.3 %).[1,6,10] Proper patient preparation, such as calming anxious patients and notifying the patient prior to the injection, is usually useful for adults, while age-appropriate terminology and distraction technique are useful in pediatric patients.[38] The needle should stay outside the vision of the patient. Slow fluid injection, vibration and application of topical anesthesia are effective in reducing anesthetic pain.[38] Conscious sedation or general anesthesia may be considered for patients with uncooperative behavior or severe dental fear.

(2)**Appropriate injection technique**

The majority of NB occurred during the administration of inferior alveolar nerve block (IANB).[1,6] Therefore, it is essential for clinicians to have a thorough understanding of these procedures, to avoid technical mistakes that may result in NB. The location of mandibular foramen varies among individuals and age groups, and is difficult to locate

precisely.[39] Successful IANB relies on depositing the anesthetic solution near the inferior alveolar nerve before it enters the mandibular foramen.[40] In a conventional IANB, the syringe should be positioned at the contralateral premolar region, and the needle penetrates the deepest part of the pterygomandibular raphe until bone resistance is felt. At this point, heavy contact with bone may fracture or deform the needle.[13,15] Instead, the needle is gently withdrawn for approximately 2 mm, redirected and inserted further along the medial mandibular ramus before the anesthetic solution is deposited.[41] The thick and dense soft tissue in the pterygomandibular area are also responsible for NB.[42]

Future studies are required to clarify whether different IANB techniques (including direct, indirect, Gow-Gates, and Akinosi technique) and mode of injection (manual or electric) influence the risk of NB. Although most reported cases involved conventional syringe system, one case regarding computer-controlled anesthesia was documented.[43]

(3)**Select needle with suitable length and gauze**

Most of NB occurred at the hub portion, which implies that the hub is the weakest spot of the needle.[1] Therefore, the needles should be long enough to keep the hub away from the soft tissue. In IANB, the depth of penetration is usually between 19 and 25 mm.[40] Hence, a 32-mm needle or longer would be appropriate for adults, while a 25-mm short needle can be used for pediatric patients.[13] Short needles are not routinely used for IANB; however, cases involving the fracture of 19 mm (Figs. 1) and 23 mm needles have been reported.[44]

Previous studies revealed that approximately 80 % of fractured needle possessed a gauze size of 30 or 31.[1,10] The needles with higher gauge size have lower load resistance, and are more prone to deflection and torsion.[45,46] Therefore, although pain on penetration may be less when anesthesia is performed with thinner needles, thicker needles (25 or 27 gauge) are preferable in terms of preventing NB.[1,42]

(4)**Avoid bending the needle prior to injection**

Prebending the needle, especially at the hub area, is strongly discouraged.[1,42] 41.7 %–56.3 % of dentists admitted that they had bent the needle in two studies.[6,10] Sandre et al. further concluded that NB in young patients is frequently associated with to sudden movements, while NB in older patients is more likely due to a needle bending.[10]

Some studies have advocated an arched-needle technique for IANB, in which the needle is prebent into an arch shape to improve success rate.[47] However, its safety and risk of NB require further investigation.

(5)**Enhanced quality control within the manufacturing process**

Manufacturing defects such as Insufficient adhesive, mismatched threading and uneven distribution of glue increase the risk of breakage. Microscopic examination identified defects in 12 %–38 % of needles.[48] Makwana and Walsh encountered three cases of NB in a single month, and interestingly, all broken needles came from one package.[12] Subsequent investigation revealed that insufficient and uneven glue distribution were the main causes. These incidences emphasize the responsibility of the manufacturer for quality control of products and highlights the importance to improve the connection between the hub and the needle. Visual inspection before injection is also recommended.

(6)**Avoid re-using the needle**

High-gauge needles are susceptible to deflection and irreversible deformation upon tissue penetration.[45,48] It is recommended to replace the needle if another injection is needed.

(7)**Use needles with stoppers**

A few manufacturers attached a ball or a disk as a stopper to the two-thirds of the needle length, to prevent complete submergence of the needle into soft tissue.[10,49] In such instances, a part of the needle would always stay outside of the soft tissue, and facilitate its removal once fractured.

## Conclusion

Dental anesthesia is useful and important for the procedures of tooth extraction, oral tissue biopsy, periapical and periodontal surgery and more others.[50–52] However, needle breakage remains a troublesome clinical situation for both clinicians and patients. If the needles were left in places, pain, trismus and dysphagia may developed, and needle migration into deeper anatomical spaces further increases the risk and difficulty of retrieval. Therefore, prompt removal of broken needles is strongly recommended. Panoramic radiographs and CT are frequently employed for preoperative evaluation (Fig. 2), while intraoperative tools, such as C-arm fluoroscopy, endoscopes, 3D navigation surgery and surgical guides, can further help locating the fragments. The surgical methods vary according to the fragment location, and interdisciplinary collaboration may be helpful in removing deeply migrated needles. Preventive measures of NB, including patient preparation, appropriate anesthetic technique and needle selection, are extremely important. All needles should be carefully inspected before injection. Future research is needed to refine stereotactic techniques and needle design, and to clarify the factors affecting needle migration and the impact of injection methods on needle breakage.

## Declaration of competing interest

The authors declare that they have no competing interests.

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