Effective Anesthesia during Various Manipulations in Maxillofacial Surgery and in Dental Practice: Overview of Medicines

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Authors’ contributions
This work was carried out in collaboration among all authors. Author MVK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors DRA and MA managed the analyses of the study. Author GV managed the literature searches. All authors read and approved the final manuscript.

ABSTRACT
In the practice of modern specialists of maxillofacial surgery and dentists, the use of local anesthetics is a necessary condition for comfortable medical manipulations. Accordingly, in order to achieve the medical goals, it is necessary to make a competent choice of anesthetic medicines. Most often, drugs that are used contain amides, the method of administration of which is blocking or infiltration anesthesia. The specialist should take into account that not all patients will always have the same effective response to a particular local anesthetic, for this reason, it is necessary to constantly update information about modern local anesthetics in order to apply them in medical practice.
The aim of the work is to review the medicines used for local anesthesia both in the practice of dentists and maxillofacial surgeons when providing care for the patients over the age of 18.

**Keywords:** Local anesthesia; dental manipulations; maxillofacial operations; surgical practice.

**1. INTRODUCTION**

Specialists who perform surgical manipulations both in the field of maxillofacial surgery and in the field of oral surgery need to provide pain relief to patients, since performing various surgical interventions without proper use of anesthetics can lead to patient discomfort, as well as the shock of pain. At the same time, the planned result of the operation will not be achieved, and the patient's well-being will deteriorate [1].

Effective anesthesia not only eliminates the anxiety of patients after their visit to the clinic, but also optimizes the operation process itself; all this has a positive effect on the results of treatment.

It is known that the fear of patients before dental intervention in 99.9% is caused by the possible onset of pain. Accordingly, providing a painless intervention, especially during surgical intervention, will help to reduce the anxiety to dental procedures.

At the present stage, local anesthesia is used as the main method of anesthesia in maxillofacial surgery. This is a type of pain relief, in which medicines are administrated at certain places. Local anaesthesia is administrated only at the site of procedure which provides anaesthesia and analgesia at that site without affecting consciousness. The advantages of local anesthesia are that patients do not take systemic medications, and they do not need to wait long for recovery after anesthesia.

Local anesthetics have the ability to reduce the permeability of sodium channels in peripheral nerves and bind themselves to Ca 2+, which blocks the transmission of nerve impulses to the brain and makes patients painless [2].

The aim of the work is to review the medicines used for local anesthesia both in the practice of dentists and maxillofacial surgeons when providing care for the patients over the age of 18.

**2. RESEARCH METHODS**

A general survey of sources in the field of the organization of local anesthesia during maxillofacial surgery, as well as in oral surgery, was carried out. We also compared the effectiveness of various local anesthetics used in modern medical surgical practice.

**3. RESULTS**

Modern anesthetics used both in the practice of dental surgeons and in the activities of maxillofacial surgeons can be divided into ethers and amides. However, ethers are quite allergenic, so specialists gradually abandon them. The basic principle of the development of local anesthetics is that the drugs should be non-toxic and effective.

The amide group includes lidocaine, articaine, novocaine, mepivacaine, and bupivacaine. Usually, local anesthetics in the treatment of teeth are compounds with high solubility in fats, so they are often made in the form of hydrochloride to increase their solubility in water. Let's consider the features of the action of these types of anesthetics in more detail.

Lidocaine. Lidocaine has the ability to dilate blood vessels, and most drugs are absorbed by the body in a short time. This process not only reduces the duration of anesthesia, but also significantly increases the risk of poisoning. Consequently, when lidocaine is used as a local anesthetic, epinephrine is often added to the solution to achieve the goal of narrowing the blood vessels and delaying the absorption of the medicine [3].

Lidocaine is the gold standard for evaluating the safety and effectiveness of other local anesthesia agents and is widely used in the practice of surgeons. However, the authors believe that although lidocaine has a good anesthetic effect on the teeth, it exists only in cases of effective anesthesia. Some other scientists have noted that the injection of lidocaine effectively anesthetizes only the pulp of the front teeth of the lower jaw, but has a limited analgesic effect on the back teeth. The most likely causes of this
phenomenon are anatomical variations of the opening of the lower jaw and insufficient diffusion capacity of lidocaine in soft tissues. This explains the fact that some patients still feel uncomfortable with complex removal.

Since regional anesthesia for blocks cannot guarantee the success of each operation, scientists are trying different methods of lidocaine injection during surgical procedures. It has been suggested infiltrating injection of lidocaine may be an alternative method of anaesthesia for the lower jaw. Another opinion suggests that only 45-67% of patients were successfully anesthetized by buccal infiltration using lidocaine as a local anesthetic. A possible reason for this may be insufficient tissue permeability for lidocaine to fully penetrate the thickened bone plate on the buccal side of the lower jaw.

Lidocaine can be injected into the body by periodontal intraligamental injection, but modern specialists have developed various types of lidocaine, such as gels and slow-release tablets, to simplify the procedures for the introduction of local anesthetics and increase the effectiveness of their use [4].

Articaine. In 1969, a new type of potent local anaesthetic agent, namely articaine, was used by dental specialists. The molecular structure of articaine contains a thiophene ring, which results in a higher lipid solubility of articaine compared to the benzene ring in lidocaine. Moreover, articaine is able to form additional hydrogen bonds after injection into the oral mucosa, which is another key factor in increasing the solubility of articaine in lipids.

A higher solubility in lipids means a stronger diffusion capacity of articaine in hard and soft tissues, and nerve endings in target organs can be quickly anesthetized due to the strong solubility of articaine in lipids.

Unlike lidocaine, articaine is metabolized not only in the liver, but also in the blood. In the presence of groups of carboxylic acid ethers in the molecular structure, articaine can decompose in the liver, but only 10-15% of drugs go through this process. In the blood, the remaining 85-90% of articaine is inactivated to articaic acid, which is non-toxic and inactive as an anesthetic, with the formation of additional ester bonds in the chemical structure of articaine [5]. Because of its strong tissue permeability, articaine is commonly used in infiltration injections to anesthetize the bones of the jaw, especially in the area of the posterior teeth of the upper jaw. Some scientists even believe that articaine has excellent permeability in the upper jaw, and in 70.4% of patients who received an injection of articaine as a local anesthetic, there is a feeling of anesthesia in the soft tissues of the palate, while the same data is only 29.6% in the mepivacaine groups.

Currently, the attention of scientists has been attracted by the controversy about the use of articaine for infiltration injection in the lower jaw. It is believed that the injection of articaine on the molars of the lower jaw demonstrates obvious advantages in terms of anesthetic effect and speed. However, some scientists hold the opposite view. For example, in the department publications it was noted that articaine could not effectively anesthetize the canines of the lower jaw and the second molars. The reason may be a thickening of the buccal bone plate and a deviation of the mandibular canal in these areas to the lingual side. Several factors, such as the thickness of the buccal cortex, the position of the chin opening, and the direction of the mandibular canal, affect the success rate of articaine's analgesic properties.

Prilocaine is another type of amide local anesthetic. There are many similarities between prilocaine and articaine in clinical characteristics and chemical structure, but it should be noted that prilocaine has a benzene ring, not a thiophene ring like articaine. Prilocaine is the weakest vasodilator among amide local anesthetics, so it can be used in patients who have contraindications to epinephrine. The researchers found that patients who were injected with prilocaine felt more comfortable than patients who received lidocaine, indicating that the toxicity of prilocaine was lower than that of lidocaine.

As shown in previous studies, the onset of action of prilocaine was faster than that of lidocaine. On the one hand, the weak vasodilating effect of prilocaine causes more local anesthetics to remain in certain areas and promote their rapid entry into the target organs. On the other hand, the pKa (7.7) of prilocaine is slightly less than that of lidocaine (pKa = 7.85), indicating that prilocaine may produce more uncharged base molecules in the body to speed up the anesthesia processes [6].
Prilocaine is metabolized not only in the liver, but also in the kidneys and lungs, while lidocaine is metabolized only in the liver, which accelerates the metabolism of prilocaine. In particular, the metabolic process of prilocaine can be divided into two stages. The first stage occurs in the tissues of the kidneys and lungs, and the metabolites are decomposed in the liver in the next stage. This multi-level procedure accelerates and simplifies the metabolism of drugs and reduces the likelihood of poisoning patients.

Prilocaine is considered to be as effective as lidocaine and articaine in oral and maxillofacial surgery. With good safety, this drug can be used in the treatment of children, the elderly and patients with contraindications to epinephrine.

Although the anesthetic efficacy of prilocaine is similar to that of lidocaine and articaine, the authors have shown that prilocaine has a short duration of anesthesia and belongs to a short-acting anesthetic drug. Some scientists are of the opinion that patients should receive injections of prilocaine with felipressin to prolong the duration of anesthesia. However, this combination of drugs can have side effects on the cardiovascular system, and doctors should conduct a comprehensive assessment if necessary. In addition, there is a potential risk of patients developing methemoglobin after prilocaine injection [7].

Mepivacaine. Mepivacaine has been used in oral and maxillofacial surgery for almost 50 years, and its safety and effectiveness are fully recognized. Like prilocaine, mepivacaine, which is well used in dental treatment in children, has weak vasorelaxation and can contribute to long-term anesthesia of the pulp. In other words, mepivacaine and prilocaine are the only two medicines that can be administered without epinephrine in maxillofacial surgery. Some authors have noted that cases of bradycardia have been reported in animal studies, but there has been no evidence that the same phenomenon can occur in humans.

Mepivacaine was almost completely metabolized in the liver, and 1-6% of the medicines were excreted in the urine in their original form. Due to its excellent pharmacological properties, mepivacaine is considered the preferred analgesic medicine for people with cardiovascular diseases [8]. The clinical advantage of mepivacaine is its analgesic effect on inflamed pulp. According to the literature, the effectiveness of anesthesia of inflamed pulp is much lower than that of normal pulp, and the use of mepivacaine seems to provide a new strategy for solving this problem. However, it should be noted that mepivacaine may increase the risk of a cheek bite when used in a medium-duration operation.

Bupivacaine. Bupivacaine is one of the types of aniline anesthetics, which is considered the most successful drug in the event that a long-term anesthetic effect is needed. However, in the practice of dental surgeons, it is not used often enough. The reason is that small operations in dental clinics usually last for 30 minutes, and bupivacaine anesthesia time is longer than the operation time, which can cause discomfort to patients with soft tissue numbness.

In special cases, bupivacaine can show its unique benefits in maxillofacial surgery. For example, compared to lidocaine, bupivacaine plays a large role in the channels of resistance to tetrodotoxin, which are extremely important for local anesthesia of inflamed tooth pulp. Bupivacaine was often used as an ointment for local anesthesia. However, poor adhesion of the ointment reduces the time spent on the mucous membrane, which can cause incomplete anesthesia. However, modern specialists have created a new gel material containing bupivacaine or lidocaine, which has a higher effect of application in local anesthesia in maxillofacial surgery. The study showed that the gel containing lidocaine reached the peak of the anesthetic effect after 8-11 minutes, while for the gel with bupivacaine, this figure was 15-18 minutes. In addition, the duration of anesthesia with bupivacaine gel was 25-30 minutes, compared to 15-18 minutes with lidocaine gel. Accordingly, it can be concluded that bupivacaine has the ability to provide twice the time of anesthesia than lidocaine with local anesthesia, which is enough for clinicians to remove one tooth.

The authors also used a 0.5% bupivacaine solution to flush the alveolar pits after removing the third molars of the mandible, and they concluded that there was no obvious pain within 24 hours after the operation. This method of anesthesia is convenient and simple and provides a promising strategy for the clinical use of bupivacaine [9].
4. DISCUSSION

In addition to the choice of drugs for local anesthesia, there are many subjective and objective factors that can affect the effectiveness of anesthesia. For example, bone structures, the condition of the pulp – all this has a huge impact on the results of anesthesia. Some patients experiencing dental anxiety may be afraid of needles, and this also affects the effectiveness of pain relief. However, these factors can be improved by training doctors and educating patients. Clinicians should focus on the following three objective factors that affect the success of the use of anesthetic drugs: the choice of injection methods, the condition of the pulp and bone structures [10].

Traditional methods of injection with local anesthetics in maxillofacial surgery include blocking anesthesia, infiltration anesthesia, local anesthesia, and freezing anesthesia. Currently, block anesthesia is mainly used for local anesthesia of the lower jaw, whereas infiltration anesthesia is often used for the upper jaw. However, successful single injection methods often fail to achieve the desired goals.

In recent decades, doctors have been exploring the possibility of combining two or more injectable methods. The authors noted that the anesthetic effect of injecting 4% articaine as an additional anesthesia is much better than a single injection of lidocaine, especially with continuous anesthesia.

Moreover, when choosing anesthetic blocks or infiltration anesthesia, it is impossible to avoid inserting needles into soft tissues, and sometimes it even gives patients additional pain. Some doctors used 5% lidocaine as a surface anesthetic in the surgical area to eliminate pain after injection. However, the question of whether local anesthesia can completely eliminate pain during injection, the results of worldwide studies were very different due to the different size of the needles and the expertise of the doctor. So, some scientists just thought that 5% lidocaine could only reduce the pain when the needle is inserted, but the pain of injecting the drug still exists, unless there was a long waiting time. In addition, some scientists believe that injecting local anesthetics is quite painful. For this reason, it is necessary to use an additional, so-called freezing anesthesia, which will improve the anesthetic effectiveness of local anesthetics administered by injection. The emergence of some new methods of administration of painkillers not only replaced the traditional ones, but also significantly increased the effectiveness of anesthesia [11].

When using painkillers, specialists should also take into account the condition of the dental pulp. Its abnormal condition usually makes it difficult to treat one's teeth. Any changes in the tooth pulp make these tissues more sensitive to pain. When the tooth pulp is inflamed, the membrane potential of the nerve at rest changes, and the threshold of excitability of the teeth also decreases. In addition, pulpitis is often accompanied by acidosis, and, as mentioned above, an acidic environment does not contribute to the decomposition of amides.

Thus, mepivacaine and bupivacaine do not guarantee good anesthesia for all patients with pulpitis. In recent years, research on opioids in dental treatment seems to offer doctors new insights, but it should be used with extreme caution.

It is very important to properly judge the condition of the tooth pulp in order to select suitable local anesthetics and injection methods. Erroneous decisions can lead to a significant reduction in the effectiveness of anesthesia and cause unnecessary pain to patients.

Bone structures largely determine the success of the use of local anesthetics in maxillofacial surgery. The opening of the lower jaw is the key position of the inferior alveolar nerve, buccal nerve, and lingual nerve in the lower jaw and beyond. In general, the opening of the lower jaw is located posteriorly above the midline of the branch. Accordingly, clinicians should fully consider the anatomical variations of each patient.

Infiltration anesthesia is often used as the main method of injection into the upper jaw due to the porous structure of the upper jaw, whereas in the lower jaw it does not work. In the literature, there is an opinion covering some successful cases of infiltration anesthesia of the lower jaw, but the general opinion is that the probability of success is low or it should be combined with other injection methods [12].

Thus, when using drugs for local anesthesia in dentistry or in maxillofacial surgery, doctors should have a deep understanding of the anatomical variations of each patient.
5. CONCLUSION
Oral and maxillofacial surgery is an important part of dental treatment, and effective drugs for local anesthesia can improve the effect of treatment and relieve patients from anxiety and fear of pain. New anesthetics have replaced the usual medications. For example, procaine, which was widely used in the last century, is almost invisible in the dental clinic due to its own allergenicity. With the first appearance of lidocaine, amides gradually became the main drugs in dental practice, after which some other amides were obtained, such as articaine, mepivacaine and bupivacaine. The technique of injecting a local anesthetic has also been optimized with the development of science, in particular, a computer injection system has found application.

Due to the rapid development of the range of different topical painkillers in oral surgery and maxillofacial surgery, it is necessary to realize that there is still a long way to go to get the best method of local pain relief, since there are many meta-scientific studies in dentistry and maxillofacial surgery that need to be analyzed.

CONSENT
It is not applicable.

ETHICAL APPROVAL
It is not applicable.

COMPETING INTERESTS
Authors have declared that no competing interests exist.

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