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# Edema Management in Oral and Maxillofacial Surgery

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## Abstract

This chapter will discuss the expected edema and interurrences in maxillofacial surgery, which involves important anatomical structures, such as the upper airways. It will also discuss important issues such as intrinsic and extrinsic enhancers of edema and the main consequences of a severe edema setting according to physiological, functional, and psychosocial points of view. Edema assessment and measurement is still performed subjectively in the clinical routine. However, for the accomplishment of studies, more objective forms are being tested, but still not very successful for clinical applicability. It is known that the best way to deal with edema is prevention; so in elective surgeries, much is discussed about the best management forms. This way, besides edema prevention, it is important not to cause unwanted reactions for the patient or in the performed procedure. Therefore, it will also be debated about preoperative medications and their consequences. Another point discussed involves main treatments for the underdeveloping edema and the one already installed, such as manual lymphatic drainage therapy, a treatment that is well known and used in other specialties, but is still very little widespread among maxillofacial surgeons.

**Keywords:** edema, oral surgery, maxillofacial surgery, postoperative period, postoperative care

## 1. Introduction

Every surgical procedure presents pain and edema in a variable degree, and many pharmacological and alternative methods have been used in an attempt to control and reduce them.

Maxillofacial surgery acts on the patient's face. The maxillofacial surgical procedures include outpatient surgeries using local anesthesia and also more extensive and invasive procedures under general anesthesia. The most used procedures are exodontia, biopsies, surgical cysts and tumors treatment, bone grafts, rehabilitations with osseous integrable implants, orthognathic surgery, face trauma treatment, and infections treatments.

An inflammatory response is expected after any injury or surgical procedure, in an attempt to defend and repair damage tissues. Inflammatory mediators (prostaglandins, leukotrienes, bradykinin, and others) are released, and consequently,

there is an increase in vascular dilatation and permeability, resulting in an edema. However, when it comes to facial edema, the major concerns are related to airway permeability, making the care with this edema a fundamental step for the treatment. It is known that in outpatient surgeries, the extent and the consequence related to edema are smaller and more predictable than in hospital surgeries, but not less important, as we will discuss further on the topic of complications.

Many studies discuss the importance of edema for such surgeries, especially outpatient procedures, which not always presents significant amounts of edema. Besides that, the discussions about the treatment are not conclusive.

Edema is characterized by the excess of plasma proteins in the interstitial space. Its formation occurs when the lymphatic flow exceeds the transport capacity of the lymphatic system or when this system becomes inefficient in absorbing and transporting these proteins [1]. Although the primary edema is a condition usually developed by vascular and/or congenital diseases, the secondary edema occurs due to a lymphatic system injury, whether by infection, cancer, or surgery [2, 3].

## **2. Edema: risk factors**

Despite the fact that the edema is part of the inflammatory process, and therefore, a consequence of the surgical process, the severity and localization of it can be related to some factors, intrinsic to the patient or related to the surgery.

The increase in the surgical procedure difficulty due to one or more of these factors directly influences on the severity and extension of the postoperative morbidities [4].

### **2.1 Preexisting conditions**

Any condition that affects postsurgical inflammatory response directly interferes with the postoperative quality, recovery, and also with the edema formation. Therefore, all efforts are made to maintain airway permeability and prevent its obstruction.

An worrying condition is the angioedema, which results from changes in the immunoglobulins involved in the inflammatory response. Due to the fact that is a severe, acute, and rapidly evolving edema that mainly affects the larynx, pharynx, and face, there is a great risk of airways obstruction, and therefore, it is associated with reintubation and risk of death [5–8].

Unfortunately, the occurrence of angioedema is a difficult prediction factor, mainly if the patient never presented its manifestation. For this reason, a rapid and accurate diagnosis is essential, as well as the establishment of artificial airways and adequate drug treatment [6–8].

### **2.2 Body mass index (BMI)**

The BMI consists in the division of ratio of body weight per height of the individual. Despite there is no consensus in the literature, some studies have related BMI with the severity of postoperative edema [4, 9–11].

Although is expected that individuals with higher BMI (overweight) develop greater edema, this correlation is not always found. Therefore, on those studies, other variables such as age and gender were considered more influential than BMI in the postoperative edema formation [4, 9].

The relation between BMI and the facial edema occurs because adipose tissue is responsible for most of the pro-inflammatory cytokines. So people with a higher BMI have more adipose tissue, more inflammatory biomarkers and, consequently, greater inflammation and greater edema [11, 12].

In the literature, a positive correlation between BMI values and developed edema is observed. Thus, individuals with higher BMI develop greater edema, but their rate of reduction is faster in the first postoperative days [10, 11]. However, individuals with lower BMI develop smaller edema, and although the rate of reduction in the first postoperative days is slower, the total resolution of edema occurs before than in people with a high BMI [10].

### **2.3 Operative time**

The duration of surgery is appointed as one of the predictive factors for a greater or smaller postoperative edema. This is because a longer surgery requires a greater manipulation of the tissues, and consequently, a greater inflammatory process [4, 13–16].

The increasing of the surgical time can occur due to factors related to the surgery and intrinsic to the patient, such as age and anatomical variations. In addition of it, the surgeon's experience is related to the increasing or decreasing of the operative time [13, 15, 17].

The operative time is predictive not only for the amount of edema, but also to the intensity of pain and trismus. This is due to a bigger trauma or intraoperative complications, which is directly related to the increase in surgical time [4, 14, 16]. Thus, although studies indicate that there is a correlation between high surgical time and greater postoperative edema, factors that caused an increasing of the surgical time must be considered.

### **2.4 Type of surgery and surgical trauma**

The type of surgery performed interferes directly in postoperative edema. Thus, large surgery (such as orthognathic surgery) is expected to cause a greater inflammatory process and, therefore, larger and more diffuse edema than minor surgery (third molar extraction, for example) [14, 18].

However, when it comes to the same type of surgery, variations can occur depending on the surgical difficulty level. It is expected that a major difficulty surgery occurs in a longer surgical time and causes a more intense and extensive surgical trauma. Therefore, the inflammatory process will be bigger, as well as the postoperative edema [4, 11, 14, 16, 19].

Some factors can contribute to the increasing of the surgery difficulty level, such as denser bones, teeth with roots formed and consolidated in the bone by masticatory stimuli, quantity of procedures, and unfavorable dental position [9, 11, 14].

The position of the third lower molar closer to the lingual wall appears to result in more severe postoperative edema, due to a more extensive surgical trauma in consequence of the bone amount removed [11]. In addition, the distal and horizontal position of the teeth is related to the greater postoperative edema, as the need to perform osteotomy and odontosection, which results in a greater surgical trauma [14].

In large surgeries such as orthognathic surgery, factors like the duration of the surgery, combined procedures (maxillary and mandibular osteotomy and mentoplasty) and bone density are related to the amount of postoperative edema. Thus, surgeries in only one of the jaws present less surgical trauma than the bimaxillaries, and therefore, develop smaller edema. When it comes to bone density, thicker and denser bones cause more difficulty in the osteotomies, increasing surgical trauma and inflammatory process [18, 20].

Surgeries involving maxilla, such as Le Fort I osteotomy, result in greater internal edema to the cavities, increasing the risk of airways obstruction [18].

## **2.5 Surgeon's experience**

It is very difficult to evaluate the experience of one surgeon, since there are no preestablished protocols to separate experienced surgeons from inexperienced. Some papers use the classification based on the training phase in which the surgeon is, others how long the surgeon is graduated, or even the amount of surgeries already performed by the professional [14, 17, 21, 22].

Surgeon's experience indirectly interferes with postoperative edema. This is because it does not directly affect the factors that converge to the edema formation, but rather those that are related to the severity of the postoperative edema [14, 17, 21, 22].

The greater the experience of the surgeon, the lower is the occurrence of postoperative complications. In addition, the more experienced surgeon is capable to solve more quickly and efficiently intraoperative complications, as well as perform the surgical procedure accurately. And more, the surgeon's experience is closely related to possible planning errors (such as implant and orthognathic surgeries) and execution. Less experienced surgeons are more likely to make these mistakes, culminating in the prolongation in the surgery duration and even possible the need for surgical reintervention [17, 21, 22].

Therefore, the surgeon's experience interferes in the surgical time, trauma extension, and blood loss, which are decisive factors for the inflammatory process and, consequently, for postoperative edema [14, 21].

## **2.6 Blood loss**

Although there are no studies relating the amount of transoperative bleeding to edema, it is known that there is a relation between blood loss and postoperative quality.

Lymphedema is characterized by the increasing volume of a body segment. However, this swelling is not always present only by edema, especially in the postoperative cases. Hematomas and clots also cause enlargement of the region volume. That way, trans- and postoperative bleeding contributes to swelling, as there is an increase in the body segment volume but, unfortunately, it is not possible to clearly distinguish whether it is edema, hematomas, or the combination of them [23].

Besides that, the amount of blood lost during surgery influences the inflammatory process. The greater the bleeding, the more intense and lasting is the inflammatory process, and the greater is the postoperative edema [18, 20].

Due the fact that these surgeries are performed in oral cavity, there is a possibility of swallowing blood during the surgical procedure. Besides the malaise caused by blood loss, postoperative vomiting increases the pressure in the newly operated region and causes an increasing of the edema. In addition, due to the bleeding caused by the pressure increasing, there may be formation and/or increasing of hematomas [24–26].

Therefore, strategies are necessary in order to reduce the amount of bleeding and, consequently, not only to improve postoperative quality, but also to help control facial edema and reduce the period of hospitalization after oral and maxillofacial surgeries.

## **2.7 Induced hypotension**

The mean arterial pressure interferes directly in the bleeding and, thus in surgical time. Lower mean blood pressure reduces transoperative bleeding, reducing as well the amount of blood lost, improving the visualization of the surgical field, reducing surgical time, and the formation of hematomas and swelling [27–30].

The hypotension induced during surgery is a strategy to improve the surgical field through the reduction of bleeding and consequently reducing surgical time and postoperative inflammatory process [24, 27, 28, 31]. Induced hypotension, or controlled hypotension, is defined by the reduction of systolic blood pressure to 80–90 mmHg with a reduction in mean arterial pressure (MAP) to 50–65 mmHg or a 30% reduction in MAP [30, 32]. It is obtained through medicament during anesthesia. Despite being considered safe and presenting proven benefits, induced hypotension requires preparation and good skill of the anesthesiologist and should not be maintained for long time due to hypoperfusion risks of the organs such as the central nervous system (CNS), heart, liver, and kidneys [29, 32].

Although in the current literature have not yet been found studies that have investigated the correlation between hypotension induced in face surgeries and postoperative edema, hypotension is capable to improve several factors involved with the development and amount of edema.

## 2.8 Age

The age at which the patient is operated has been pointed out as one of the predictive factors for the development of bigger or smaller edema. Despite studies attempt to find this relation, there is still no consensus on the relation between age and severity of developed edema [4, 14, 15, 33, 34].

On the one hand, some authors argue that face surgery in younger individuals results in less difficulty in the procedure and consequently less surgical trauma and less edema [11]. On the other hand, there are authors who affirm that the reduction of the inflammatory response and diminution of the lymphatic system elasticity occur with the increase in the age. Thus, older individuals develop less edema and have less efficacy of the lymphatic system [4, 14–16, 33–35]. Besides that, older patients have a prolonged inflammatory process and, therefore, slower reduction of edema [15].

## 2.9 Gender

Another factor pointed as an influencer in the formation of edema and its quantity is gender. Although is expected that women develop greater swelling due to hormonal variations, use of oral contraceptives, and bigger risk for dry socket, the male gender is pointed out in studies as being more predisposed to a greater amount of postoperative edema [11, 13, 34].

Factors such as increased bone density and thickness and stronger muscles can do postoperative edema to be more severe in men than in women. This is because they are factors that directly interfere in the level of difficulty and quantity of surgical trauma, injuring more lymphatic structures and increasing the inflammatory response, generating more edema [11, 34].

However, the smaller thickness of the female mandible increases the chances of fracture of the mandibular ramus during third molar extraction, increasing surgical trauma [4, 13].

Anyway, this significant difference in the amount of developed edema is observed on the first postoperative day, but it is irrelevant on the seventh day [11, 34].

Thus, even in studies in which the amount of postoperative edema does not present a significant difference between the genders, the extent of surgical trauma and the occurrence of intraoperative complications are indicated as the main influential factors for the severity of postoperative edema [10, 19]. However, the occurrence and intensity of these factors are difficult to predict, so that is the reason to consider the gender and its risk factors and predict the level of the surgery difficulty.

## **2.10 Vomiting**

The presence of nausea followed or not by vomiting is a factor that can be observed in clinical practice. Increased patient effort during vomiting increases facial edema and also stimulates postoperative bleeding. However, although the relation between nausea and vomiting with edema is not mentioned in the literature, it is a fact that can be verified in clinical practice, especially in the postoperative period of orthognathic surgery.

## **2.11 Postoperative rest**

Another important factor related to the control or prevention of edema formation consists on the postoperative rest and positioning of the patient. It is known that the dorsal decubitus tilted by approximately 30° decreases the pressure in the face blood vessels and helps to control the bleeding and edema.

After surgery, the periosteum is detached in the operated region. Thus, the mobilization of this periosteum, by movement or compression of this region, stimulates the inflammatory response potentiating the edema.

Although these factors are not in specific scientific studies, clinical observation makes it possible to affirm the importance of both bedside and resting care in the postoperative period of face surgeries.

## **3. Forms of evaluation and edema measurement**

In maxillofacial surgery, the observation, control, and reduction of edema are important postoperative factors, due to the possibility of airway compromise. In this way, surgeries with potential formation of exacerbated edema should present evaluation and control of this condition, in order to assist the decision related to the maintenance or replacement of the edema treatment protocol.

Between the techniques described for evaluating edema, the most used ones clinically are subjective, and are totally dependent on the professional's experience and on the patient's report. Although there are more objective methods of clinical evaluation with good reproducibility, these are limited to the upper and lower limbs, making it impossible to apply to regions such as head and neck [35, 36].

In the head and neck regions, most of the methods reported in the literature measure the edema by the distance between two points, based on anatomical points, such as mandibular angle, lateral, and medial epicanto of the eyes and middle of the chin.

Other measurement devices that provide more accurate data about the changes related to edema values include imaging exams. However, due to the fact that it involves high cost and exposes the patient to ionizing radiation, these techniques need specific indication [37]. Ultrasonography (US), magnetic resonance imaging, and computed tomography are examples of usable exams [38]. The US presents changes in the echogenicity of its images, which are not specific for volume changes caused by increasing of subcutaneous fluids [39]. In addition, to the face part, the echographic measurement does not always point the more swollen site due to the reproduction of the distances from the skin to the bone, which leads to imprecise and disproportionate results [40].

Bioelectrical impedance is another method described in the literature for the measurement of edema. This technique measures the amount of peripheral and total fluid in the body. However, low-cost and easily applicable devices for measuring body edemas as well as limbs are still scarce [36].

The evaluation methods developed for use in researches have evolved greatly. The first studies used subjective methods and difficult reproducibility, which made them less reliable in relation to the real magnitudes and behavior of edema. Van Gool et al. and Album et al. demonstrated the lack of correlation between subjective evaluations and objective measures of edema [41–43]

The measurement methods should be capable of being used in clinical and patient tolerable trials. Thus, portable devices were studied with the objective that they could be easily used with precision and transported to the place where the patient is, making possible to obtain early measures and follow-up of the edema [42, 44].

Therefore, objective measurement methods represent a more appropriate approach to the problem. However, these measurements should be evaluated and validated by doing repeated measurements on untreated individuals to verify its accuracy.

The methods already tested and used in studies were [45, 46]:

- facial bow method;
- ultrasound method;
- stereophotographic method;
- method of cuboid element;
- measurements with tape measure;
- sonographic evaluation;
- photo evaluation;
- face scanning; and
- evaluation with 3D mold.

#### **4. Complications related to the postoperative edema**

The early stage of inflammation presents accumulation of fibrin and polymorphonuclear neutrophils in the extracellular space of injured tissues. The processes that occur in this phase are vessel diameter change, increased vascular permeability, exudate formation and migration of neutrophil cellular exudates into the extravascular space. The chemical mediators of acute inflammation include histamine, prostaglandins, leukotrienes, serotonin, and various cytokines. It is known that prostaglandin associated to bradykinin has the most potent pain-activating effect [14, 47, 48].

The control of inflammation and, therefore, swelling aims to reduce pain and improve life quality in the postoperative period. The processes of the inflammatory mediator may last up to 96 hours.

Trismus occurs as a result of muscle spasm caused by the inflammatory process. In this process, there is compression of the nervous structures by the edema, leading to the limitation of movement accompanied by a painful sensation, which can be from discomfort to severe pain [14, 47, 49].

Although it is subjective and dependent on several factors, the evaluation of postoperative pain in maxillofacial surgeries is essential, since this is one of the main complaints of operated patients and is directly related to edema. Therefore,

pain, edema and trismus are consequences of the formation and release of prostaglandins, bradykinins, and other mediators of inflammatory response [14, 47].

Patients with moderate and severe edema may be unable to discern pain from discomfort caused by stretching of the skin by increased facial volume. In addition, the pain is related to the patient's emotional state, being influenced directly by their mood, level of satisfaction, and well-being [18, 20, 50].

Therefore, edema can also cause psychological and emotional problems due to the esthetic alteration of the affected body segment [50]. The maxillofacial surgeries carry great esthetic and functional expectations. However, patients, although relieved to have undergone surgery, may present mood swings due to the difficulty of self-care, pain, and edema. Changes in body image are one of the major complaints related to edema [20].

Edema can also influence self-care. This is because it makes feeding and oral hygiene difficult because it prevents proper visualization of the oral cavity and limits the range of mandibular movement. In addition, patients submitted to orthognathic surgery have shown greater difficulty in removing and placing intermaxillary locking elastics according to the degree of edema they develop [20].

Internal edema to the cavities is a major concern in the postoperative period. This is because breathing may be affected by pressure and possible obstruction of upper airway structures, causing respiratory distress and discomfort, and even leading to the need for re-intubation or performing a tracheostomy in the most serious, life-threatening cases [6, 8].

Severe postoperative edema is an important complication that can affect upper airway permeability and may lead to obstruction in more severe cases. The procedure that presents the greatest risk of airway obstruction due to edema is the Le Fort I type osteotomy, performed in the maxilla and covering the floor of the nasal fossa [18]. Thus, severe edema can cause respiratory and functional problems, which increases hospitalization time and the need for ICU admission.

Peripheral nerve damage is the result of direct or indirect trauma to a nerve. The direct relationship between edema and paresthesia is known and can be explained by the spatial relationship of the nerve vessels with adjacent structures, such as muscles and bones.

Following the same mechanism of acute compressive neuropathies, facial edema caused by surgical trauma, infections, fractures, or injuries can compress the sensory and motor nerves of the face (trigeminal nerve and facial nerve). This compression, or even stretching of these nerve bundles, impairs the conduction of the nerve impulse, resulting in paresthesia and even temporary paralysis.

Studies on nerve conduction measured the magnitude of the conduction blockade of nerve action potentials and the focal slowing of conduction. Direct correlation between degree of changes and duration of compression was demonstrated. Another observation is related to local ischemia, which, in combination with direct pressure effects, contributes to the development of compressive neuropathies. In severe cases of acute compression, with direct relation to extensive and prolonged edema, remyelination of nerve fibers can take weeks or months after resolution of compression.

Another aspect in relation to the neurosensorial disorders is related to the inflammatory mediators that are released when a trauma to the tissue occurs. These are located in the edema region and act temporarily as chemical irritants to the nerves.

Thus, studies attempt to relate the use of corticosteroids with the improvement of neurosensory symptoms after tissue trauma with considerable edema. However, due to the lack of standardization of the applied tests and classification, only the presence or absence of the disorder was considered [51]. More controlled clinical trials need to be performed to obtain data on neurosensory disorders.

Some local factors (directly related to the wound) and systemic (linked to the individual) can interfere in the cicatricial process, facilitating complications and sequels and causing esthetic and functional damages to the tissue.

Local factors: dimension and depth of the lesion; level of contamination; presence of net collections (bruises, ecchymosis, edema); tissue necrosis and local infection; poor vascular supply; surgical technique used, material and technique of suture, types of bandages; and traction or mechanical pressure on the scar [52–54].

Systemic factors: age group, ethnic origin, nutritional status, presence of chronic diseases, and use of medicines.

Angiogenesis is essential to healing wounds as it provides restoration of blood flow and transport of nutrients to cells as well as transporting the components of the immune system. Edema makes this stage difficult, because the excessive distension of the tissues leads to compression of the newly formed vessels, altering the blood flow. In this way, the body's capability to carry defense cells and administered antibiotics is impaired, making healing more difficult.

Hypoxia in the area of the lesion stimulates angiogenesis responsively, aiming formation and remodeling of the extracellular matrix for tissue repair. However, this process is limited to the first 48 hours of the beginning of the repair process, being detrimental to vascular neof ormation and regulation of healing factors.

Fibroblasts are involved in deposition of the extracellular matrix and also in approaching the edges of the wound. Thus, the tissue distension caused by edema compromises this narrowing and tissue reepithelialization, making it difficult to form the fibrin network and providing a disordered growth of collagen, which leads to the formation of hypertrophic scars [53].

With excessive edema, a lesion that could have first-intention healing with contact between the edges becomes second intention, due to tissue tension, causing dehiscences of suture and separation of the wound edges. In addition, local edema obstructs the lymphatic vessels, facilitating the accumulation of catabolites and producing a greater level of inflammation.

## **5. Medications used for edema control**

### **5.1 Corticoids**

Inflammation is the local physiological response to tissue injury. Although some amount of inflammation is needed for proper wound healing, the excess of inflammation leads to severe edema and pain that causes discomfort to the patient.

The use of corticosteroids during orthognathic surgery is a fairly common practice for faster resolution of facial edema [55]. However, there is no consensus on its uses, its benefits, and adverse effects. The comparison of drugs in published studies is difficult due to the variety of parameters and methods used. Corticosteroids help reduce facial edema by acting as immunosuppressants that block the early and late stages of inflammation, decreasing the dilation and permeability of blood vessels. From this, there is a reduction of the amounts of liquid, proteins, macrophages, and other inflammatory cells present in the areas of tissue injury. In this terms, corticoids have a beneficial effect on the inflammation control, and consequently, on edema [51].

The use of steroids in patients can be by mouth, intramuscular injection, or intravenous methods. A recent study compared the effects of different routes of methylprednisolone uses on edema and trismus after extraction of third molars [56]. It was concluded that the systemic application of a steroid is more effective for improving the range of motion. However, direct injection of the steroid into the musculature had the best effect in reducing postoperative swelling.

Another study by Ehsan et al. [57] analyzed the effect of preoperative submucosal uses of dexamethasone on swelling and trismus on third molar extraction. They found out that this injection was very effective in reducing these postoperative conditions. In another study, it was found that the uses of corticosteroids in the preoperative period through the parenteral route have a greater impact in the reduction of postoperative swelling and trismus [58]. In addition, patients with zygomatic bone fractures usually present swelling, pain, and trismus before surgery, requiring prolonged treatment than removal of the third molars. Therefore, in order to benefit from steroid medication, patients with facial fractures should receive higher doses than patients undergoing minor surgeries [45].

The use of intravenous systemic corticosteroids before orthognathic surgery helps to reduce facial edema, but adverse effects are not well described in literature [59]. The use of corticosteroids before, during, and after orthognathic surgery, independently of the dosages, promotes reduction in facial edema, mainly until the third postoperative day. The most commonly used corticosteroids are dexamethasone, methylprednisolone, and betamethasone [51, 60]. Betamethasone is considered a potent steroid because it has high anti-inflammatory activity and does not cause fluid retention [60]. Dexamethasone is a highly selective and long-acting synthetic corticosteroid that has potent anti-inflammatory action [61].

In oral surgery, of all pharmacological agents tested, steroids seem to be the most successful for inflammation control. Corticosteroids, such as dexamethasone, may inhibit the early stage of the inflammatory process and have been widely used in different regimens and pathways to decrease inflammatory process after third molar surgery [62].

Although steroids seem to be the most successful in relieving edema after extraction of the third molar, the immunosuppressive effects of cortisol and its synthetic analogues are well known [63]. Previous studies about dexamethasone in third molar surgeries have concluded the need of accurate clinical research for better evaluation protocols for corticosteroid use [64].

## **5.2 Analgesics**

The use of analgesics and nonsteroidal anti-inflammatory drugs alone or in combination with corticosteroids or opioids is common after third molar surgeries to reduce facial edema and pain [65]. When nonsteroidal anti-inflammatory drugs are given prior to surgery, they significantly reduce postoperative edema [66]. One study compared the use of diclofenac potassium, etodolac, and naproxen sodium given in preoperative of third molar surgery and concluded that diclofenac potassium showed better edema reduction [67]. Another study compared the use of diclofenac potassium alone or in combination with dexamethasone and concluded that combined therapy was more effective in reducing pain, trismus, and edema after third molar surgery [68]. There is no consensus in literature about which analgesics to use, for how long, and what is the best dosage with the least adverse effects.

## **5.3 Hyaluronic acid (HA)**

A new drug trend that has been used to control edema development is hyaluronic acid (HA). Nowadays, few studies are found in literature and their actual efficacy as well as their use is not well established yet. HA is a high molecular weight glycosaminoglycan, a major component of the extracellular matrix [69]. It can be found in several tissues, and one of its properties is formation induction of early

granulation tissue, which helps the healing and improves inflammatory process [70]. HA turned out to be effective in reducing edema when used as spray after third molar extraction [70, 71]. The use of HA associated with platelet-rich fibrin was capable to decrease edema after third molar extraction surgery, compared to the isolated use of platelet fibrin [72]. Further studies using HA in larger groups and in other types of surgeries are necessary to establish a protocol use, consensus on its effects, and investigation of possible adverse effects.

#### **5.4 Adverse effects of medications at the doses used**

The adverse effects of corticosteroids are rare but important to evaluate. Complications are well known and include immune system suppression, hypertension, hyperglycemia, suppression of adrenal corticosteroid activity, allergic reactions, skin steroid acne, glaucoma, and psychiatric disorders. In addition, the use over 7 days may lead to development of Cushing's syndrome [54, 73].

Thus, it is noted that complications are related to prolonged use. In maxillofacial surgeries, it is generally used for a short time, at most 24–48 hours, so side effects are rare.

Also, it is known that anti-inflammatory drugs for edema control may increase bleeding by directly interfering in coagulation cascade. Thus, its benefit regarding edema control is compromised.

## **6. Most commonly used forms of edema control**

### **6.1 Cryotherapy**

Cryotherapy is the therapeutic use of cold applied for reducing skin and subcutaneous tissues temperature. It is indicated for inflammation control, pain, and edema after surgery or injury [65, 74]. Thus, physiological cooling exerts autonomic-mediated effect that induces vasoconstriction, favoring minimization and control of edema [75].

It is a treatment modality widely used because it is simple, inexpensive, and can be applied many times. Its therapeutic effects are due to alterations in blood flow, consequent vasoconstriction, and reduction of metabolism, also providing restriction of bacterial growth.

However, information concerning cryotherapy effects on edema is controversial [74]. Few studies report the effects of cryotherapy in maxillofacial surgeries, although its use is consecrated by the great majority of surgeons and in several types of surgeries.

Considering that during the first 10 minutes of ice application, most of the local temperature reduction occurs, most studies recommend the application for 10–20 minutes, having a rest period of the same time or twice as long [74]. The use of cryotherapy for 30 minutes every 1½ hours, for 48 hours after third molar extraction was quite effective in facial edema control [76].

Cryotherapy is contraindicated for patients with peripheral vascular disease, hypersensitivity or cold intolerance, as in Raynaud's phenomenon and in areas with impaired circulation. A disadvantage of cryotherapy is that its use normally starts at 0° and rapidly reaches room temperature [75].

The cryotherapy protocols use differ greatly from each other, especially regarding duration and application form [74]. Its efficacy has been questioned because despite its common and daily use in clinical practice after maxillofacial surgeries, there is no consensus or protocols on its use, so new studies are needed.

## **6.2 Hilotherapy**

Hilotherapy began to be used recently in postoperative of maxillofacial surgeries for control and reduction of facial edema. It is a preformed polyurethane face mask, in which cold and sterile water stream passes through, promoting cryotherapy at regulated and maintained temperatures [77].

A recent systematic review showed that hilotherapy is used immediately after surgery, with temperatures of 14–15°C. However, in third molar extraction, single application was used for 45 minutes, and after orthognathic surgeries, the application was for continuous period from 48 to 72 hours. Both protocols had positive effect in reducing facial edema [78]. Therefore, it can be concluded that extensive surgeries require longer application.

Hilotherapy, when compared to facial cryotherapy performed using ice blocks, was more efficient in facial edema control and reduction after maxillofacial surgeries [77–80].

A recent study has shown that the use of facial hilotherapy performed at home after third molar extraction surgery is safe, easy to apply, brings benefits in reducing facial edema and also improves quality of life [75].

One of the difficulties in using hilotherapy is the cost of the device, which can reach high values. However, once this is resolved, its use will probably replace conventional cryotherapy in a few years as studies have shown beneficial effects in reducing edema and postoperative pain with greater patient comfort.

## **6.3 Laser**

Low-power laser is a relatively recent method and has been used as an alternative to edema control because it is capable of promoting modulation of the inflammatory response, reducing pain, edema and trismus, in addition to accelerate tissue repair [71, 81]. It is considered easy to apply and does not cause adverse effects [65].

Laser acts in reduction of edema by controlling and decreasing inflammatory response. So, it promotes faster recovery of injured lymphatic vessels and potentiates the action of lymph nodes [82].

Despite this, there is still no consensus about which is the best protocol for use in maxillofacial surgeries, so that its effects can be better utilized. However, different protocols can be found in literature, especially regarding to which postoperative moment laser should be applied and how many sessions are necessary. In laboratory tests, low-power laser was able to improve pain by regulating inflammatory factors at doses around 7.5 J/cm<sup>2</sup>. In addition, application in an area using more than one point promotes better results than the concentrated application in a single point.

The need to control inflammation in preoperative period is known. However, using laser before third molar extraction surgery seems to have only analgesic response [83].

The laser can be applied in minor surgeries, such as dental extractions and also larger, such as orthognathic surgery. Although the application of intraoral and extraoral laser at the end of the surgery does not show benefits in the immediate reduction of edema, when evaluated in the following days, the patients present a reduction in facial edema [82–84]. That occurs due to the latency period in which there is the biomodulation caused by the laser on the inflammatory response, with prolonged and residual effect [83], not requiring more than one application [84].

Therefore, the use of laser is questioned in small and controlled inflammatory processes, since benefits to patient do not justify treatment costs [85, 86]. Still, in some cases, laser seems to have analgesic effect only, not helping to reduce facial edema [87].

Thus, although low-power laser has potential to control inflammatory process and reduce complications, results depend on an indication that justifies its use and, mainly, the protocol used.

## 6.4 Manual lymphatic drainage (MDL)

Manual lymphatic drainage is a resource that, if applied correctly and by a trained professional, helps in the resolution of edema. By means of slow movements and gentle pressure (30–40 mmHg) following the lymph pathway, the MLD proposes to potentiate the function of the lymphatic system [88, 89]. Thus, it is a nondrug option in the treatment of edema.

The benefit of manual lymphatic drainage is undeniable; however, in maxillofacial surgeries, it is still little used and little known, due to the scarcity of studies that demonstrate its effectiveness in this type of surgery and also prove the safety of its application. In surgeries in other regions of the body, the use of MLD to decrease edema is quite consistent, with well-established protocols and benefits. In maxillofacial surgery, there are still no protocols for beginning and no consensus regarding their benefits due to the amount of work done so far.

The MLD had proven efficacy in the postoperative period of third molar extraction, alveolar bone graft, and orthognathic surgery [90–92]. In a clinical trial with a split mouth model, third molar extraction was performed by adding MLD on one side only in the postoperative period. Using reproducible facial measures and Visual Analogue Scale (VAS) for pain, it was concluded that MLD is able to significantly reduce postoperative swelling and pain in this surgery [93].

The same effect was observed in the postoperative period of alveolar bone graft with filling of the bone defect by spongy bone of the iliac crest. However, this study compared the MLD performed by a physiotherapist to an adapted drain that was taught and applied by the patient. Both groups showed improvement over the course of the day, but MLD applied by physiotherapist had better results on edema and pain compared to self-drainage [92]. Despite that, attention should be paid to the absence of a control group so that the study would effectively prove the benefits of MLD. However, it is possible to conclude the importance of the physical therapist in the postoperative period of this surgery, since this professional has skills that can contribute to the improvement of the discomfort caused by the edema and the referred pain.

In the orthognathic surgeries, MLD was very effective in reducing postoperative edema when compared to a placebo, both applied by a physiotherapist. In these cases, not only was drainage capable to accelerate the regression process of edema, but also to anticipate its peak. It was also observed that the maximum edema was lower in the patients who received the MLD. Thus, MLD is able to promote the control of edema when applied during its development period and also to accelerate the process of regression of swelling in the postoperative period [91, 94].

However, even in this study, MLD was not effective in relation to pain perception. The authors attribute this to two factors: the application of a placebo, which may have interfered in patients' perception of pain and the fact that the patients did not develop severe edema, and therefore, the pain or discomfort related to the edema may have been lower, as well as the perception of relief in the group that received the MLD [91].

Although the benefits of MLD in the postoperative period of oral and maxillofacial surgeries have been studied, there is still no agreement as to when the application of MLD should begin. However, it is known that the peak of edema in maxillofacial surgeries occurs between 48 and 72 hours after surgery, and therefore, the beginning of MLD before this period seems to anticipate the peak of edema and regression, causing the amount of edema at the peak being lower [91, 94].

It can be concluded that MLD represents a safe nondrug option in the treatment of postoperative edema, when well indicated and applied by a qualified professional. Despite all the proven benefits, it is necessary to observe the need for MLD

in various oral and maxillofacial surgeries. It is known that it is able to accelerate the process of regression of edema and provide relief of pain, but the need should be questioned in cases of small surgeries with the formation of discrete and local edema. In those cases, typical of a small controlled inflammatory process, MLD can be an unnecessary treatment to the patient, increasing the costs of the treatment and not having all its benefits observed.

### **6.5 Kinesio taping (KT)**

Elastic bandage, or Kinesio taping, was first used in athletes, to aid in the recovery of muscle injuries, provide more stability to the joints, and provide relief from pain. However, it was realized that due to its way of functioning, it could be beneficial in the treatment of lymphedema.

KT, through the formation of convolutions in the skin, increases the interstitial space. Thus, through this increased space, fluids tend to move from higher pressure areas (congesta) to areas of lower pressure, improving blood and lymphatic flow. This occurs following the placement of the KT, which is positioned according to the path of the lymphatic system. In that way, KT may be able to relieve swelling caused by bruising and edema [23, 45, 95, 96].

In maxillofacial surgeries, its efficacy has already been tested in several surgeries: surgical reduction of mandible fracture, surgery to reduce fractures of the zygomatic-orbital complex, third molar extraction, and orthognathic surgery [97].

In the surgical reduction of mandibular fracture and zygomatic-orbital complex, KT is effective in reducing edema, anticipating the day of peak edema, the amount of edema formed on this day, and accelerating its reduction. However, despite the more rapid resolution of edema, no effects on trismus or pain relief were found [95].

In third molar extraction surgeries, KT anticipates the day of maximum edema and the amount of edema formed on this day. However, the rate of edema reduction is lower when compared to patients who did not use KT. Despite that, patients who use KT postoperatively seem to have resolution of the edema earlier. Furthermore, KT was effective in relieving pain, but not in trismus [96].

Even so, in the exodontia, when compared to the placement of drains for the treatment of lymphedema, KT is not as effective. Drain placement at the surgical site is shown to be much more effective not only at the faster reduction of edema but also in relation to pain, although it is an invasive approach. Despite this, none of the treatments helped reduce trismus in this study. It should also be considered that drainage placement, despite being effective in reducing edema, may lead to other complications, in relation to the possibility of subcutaneous emphysema, infection, and external facial scar [98].

In orthognathic surgeries, the application of KT is beneficial in the treatment of postoperative edema, being capable to anticipate the day of maximum edema, reduce the maximum amount of edema formed, and accelerate the regression process of edema. However, it does not appear to have significant effects with regard to pain or trismus [97].

Thus, KT is a nonmedicated treatment option for the control and treatment of postoperative lymphedema of maxillofacial surgeries. However, its effects on pain and trismus need to be better elucidated. Although one of the goals of KT is to prevent the formation of bruises and/or to treat them, there is still no proof of it. Therefore, it is a function to be explored with great interest, since the increase in volume of a body segment is not only due to edema but also due to hematomas.

Therefore, KT is a relatively inexpensive treatment option, but it requires specific training and professional habilitation, as well as presurgery testing to check for allergy to the components of the bandage.

## 7. Conclusions

In this chapter, factors related to edema development in maxillofacial surgeries and alternatives for its control and treatment were presented. It is known that this condition is strictly related to the inflammatory process, and therefore, controlling edema also requires controlling postoperative inflammation.

Several factors contribute to edema severity, and knowing which factors cause these and their influence on inflammatory process, it is possible to predict the quality of the postoperative period. The inflammatory process control, and consequently edema restriction, is fundamental for the quality of healing process and postoperative. Thus, it is necessary to have attention and intervention of surgical team on controllable factors that lead to a most severe or mild formation of edema, such as surgical time and precise surgical planning.

In addition, knowing about the risks for each factor related to the edema development makes individual and personalized treatment possible, which brings great benefits to the patient. Aiming at reducing complications related to edema, better postoperative quality, increased satisfaction and reduction of hospitalization time and treatment costs, and several drug and nondrug methods may be employed. Currently, there is a tendency in reducing medicament use in order to reduce the occurrence and severity of adverse effects. In this way, nondrug methods are increasingly study targets and used in clinical practice.

Therefore, more studies are needed to prove the efficacy and safety of these methods. Also, the formation of a well-trained and integrated multiprofessional team is necessary, aiming for safety, comfort, and faster patient recovery in postoperative period of maxillofacial surgeries.

## Conflict of interest

The authors declare that they have no conflict of interest.

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