VILNIUS UNIVERSITY
FACULTY OF MEDICINE
INSTITUTE OF DENTISTRY

Kristin Marie Kennel
Dentistry 5th year, Group 2

Master's Thesis

Wisdom Tooth Extractions: Classification, Indications and Complications

Scientific Supervisor: Assist. Dr. Alina Čebatariūnienė

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Abstract

The prophylactical and therapeutical reasons for wisdom teeth extractions and their possible complications are still widely debated. Therefore, practitioners must deal extensively with wisdom tooth extraction to have in-depth knowledge of all indications and contraindications, especially the difficulties of extracting wisdom teeth. The following results were gained using several databases and literature search strategies. The wisdom tooth classifications according to Winter, Archer and Pell, and Gregory are included in the work, and they classified the wisdom teeth according to the angulation, impaction degree, and the location of the mandibular ramus. Despite ranking the wisdom teeth, complications can still occur during the extraction procedure. Wisdom teeth are often extracted in their early developing stage because the literature showed significantly lower risks for intraoperative complications. The procedure for that is called germectomy. The Pell and Gregory classification may indicate an increased risk for damaging the inferior alveolar canal and lingual nerve, whereas the Archer classification may illustrate the risk for oroantral communication. Their incidence and their following clinical symptoms are also discussed. The most common extraction indications presented during the search that the literature included pericoronitis, caries in the adjacent molar and external root resorption. Various complications of wisdom tooth extraction are occurring in the literature, like mandibular fractures, temporomandibular joint dislocation, arterial bleeding or nerve injuries for possible complications.

Keywords: third molar; intraoperative complications; postoperative complications; prophylactic and therapeutic extractions

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5.2.6. Subcutaneous emphysema

6. Conclusion and results

Abbreviations

IAN	Inferior Alveolar Nerve
Impacted tooth	A tooth that didn't erupt or cannot erupt due to lack of space or due to the angulation
LN	Lingual Nerve
NSAID's	nonsteroidal anti-inflammatory drugs
OAC	Oroantral Communication
3-D	Three dimensional

1. Introduction

Problem statement. In dental practice, the surgical removal of wisdom teeth is standard practice. Thanks to modernized surgical technologies, this procedure has become more accessible and can be performed in a shorter time in dental offices, often without requiring hospitalization. Though these surgeries do not encounter difficulties, they can result in complications. A complication rate of 8.4% in the mandible and 5.9% in the maxilla following the extraction of third molars is reported in the literature (1,2). Complications may occur intraoperatively or develop postoperatively. Intraoperative complications are injuries to the adjacent second molar, arterial bleeding, oroantral communication, nerve complications, mandibular fractures, dislocation of the temporomandibular joint or luxation of a tooth into the maxillary sinus. Postoperative complications may include alveolitis, osteomyelitis, pain, secondary bleeding or infection. Dentists should be able to foresee the difficulties of the removal of wisdom teeth and handle oral complications. The classification of mandibular third molar impaction and extraction difficulty degree helps the clinician choose an optimal treatment plan (3). Moreover, a careful review of the updated indications and the necessity of extraction should be considered preoperatively. The indication for removing wisdom teeth can be due to prophylactic considerations or therapeutic necessity. Indications for wisdom teeth extraction are infections, unrestorability, pathologies, periapical lesions if the tooth is interfering with orthodontics or fracture gaps. However, prophylactic removal of wisdom teeth in the absence of symptoms is still controversial. Before the treatment, the patient needs to know the possible risks and outcomes. If a complication occurs, the management of the situation often determines the outcome. Soft skills directly impact the value of care provided, the patient's confidence in the dentist and the patient's perceptions of the treatment outcomes. The patient may need to be referred to a specialist or the hospital, and it is a very stressful situation for the operator as well as the patient. The patient should be involved in the decision-making as well. Due to these findings, the aim of the thesis was to assess the prophylactic and therapeutic reasons for wisdom tooth extractions and their resulting possible complications.

The main tasks of the study were:

1. to find out certain methods of wisdom tooth classification;
2. to establish the updated indications for third molar removal;
3. to assess the possible local complications associated with wisdom tooth surgery.

Literature search was performed in the following databases: the PubMed and GoogleScholar. The last search was done on April 2023, including articles published from the previous 10 years.

The search aimed to identify all relevant studies written in English and German. In total, 133 papers were reviewed.

The content of the thesis: The thesis consists of a summary, introduction, problem statement, literature review, literature search strategy, keywords, discussion, conclusion, explanation of abbreviations and references.

1.1. Nerve anatomy

The teeth and gingiva of the mandible are sensitively innervated by the mandibular nerve. The teeth receive their nerve supply from the inferior alveolar nerve (4). The lingual gingiva is supplied primarily by the lingual nerve, the labial gingiva by branches of the mental nerve, a branch of the inferior alveolar nerve, and the buccal gingiva by the buccal nerve. The lingual nerve innervates the front two-thirds of the tongue up to the terminal sulcus (5). The inferior alveolar nerve is a terminal branch of the dorsal mandibular trunk (Fig. 1). The nerve runs between the lateral and medial pterygoid muscle. It runs laterally and dorsally on the lingual nerve, between the mandibular ramus and the sphenomandibular ligament, to the mandibular foramen (6). The nerve then moves with the vessel of the same name into the mandibular canal. The terminal branch of the inferior alveolar nerve is the mental nerve. The nerve passes through the mental foramen, giving off the mental branches for the innervation of the skin of the chin, the inferior labial branches for the skin and mucosa of the lower lip, and the dental and gingival branches for the innervation of the anterior teeth and their gingiva. There is usually a very close relationship between the inferior alveolar nerve and the apices of the wisdom teeth. The mandibular canal often lies buccally in the spongiosa, but sometimes a lingual course can also be found (4,7,8). The lingual nerve arises from the dorsal trunk of the mandibular nerve and curves in front of the inferior alveolar nerve between the lateral and medial pterygoid muscles forward (Fig. 1). The nerve runs just below the mucosa of the floor of the mouth above the submandibular gland, encompasses the submandibular duct from the lateral and inferior sides and continues towards the lateral edge of the tongue (4). The lingual nerve receives sensory and secretory fibers from the intermedius part of the facial nerve via the chorda tympani. In its course, the nerve often comes into close contact with the medial periosteum in the root area of the wisdom tooth region of the lower jaw (9).

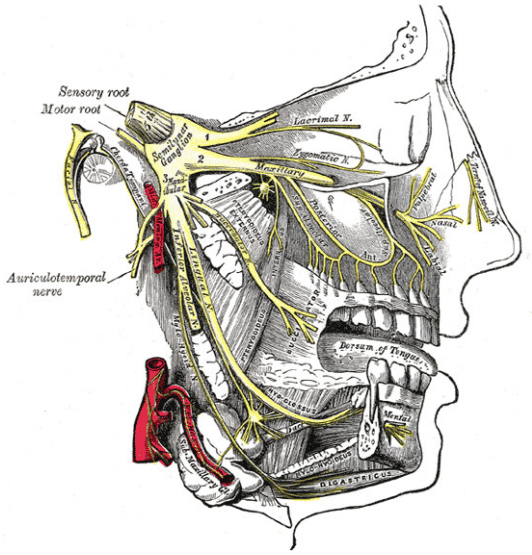

Figure 1: Depiction of the mandibular nerve. Contributed by Gray's Anatomy Plates (10)

2. Molar development stages. Germectomia

A pathological condition known as dental impaction occurs when a tooth is unable to erupt into its natural functional position (11). Germectomia (Lat.: *germ-* = developing crown; *-ectomia* = excision, resection) is a method that removes a tooth that has formed less than one-third of the root (12). It is a surgery frequently necessary for children who are still developing (13). The third molar is surgically removed at a specific developmental time. In consonance with the research of Mazur et al., orthodontic, infectious, and cariogenic causes, as well as prevention, were the main clinical indications for germectomy (14). According to Demirjian's classification system, the development of the third molar is characterized based on its shape, and the process is separated into eight stages: stages A through D represent the formation of the crown from the emergence of the cusps to the completion of the crown. It includes enamel mineralization (AB) and crown dentin mineralization (CD). The stages E through H represent the root formation from radicular bifurcation to apical closing, whereby the stages EFG represent the root formation cover and H the entire development (15). It is feasible to define germectomy of the third mandibular molar in this situation as the surgical removal of the third molar in the stages of B, C, and D (14,13). The study of Ling et al. compares the complications between surgical third molar removal and germectomy on an objective and subjective level. It is outlined that compared to the surgical removal group, the mean surgery time for germectomy was much lower (14.14 ± 4.94 min). The main statement of this research concluded that delaying the extraction of impacted mandibular third molars until a problem arises puts the patient through needless discomfort, a more complicated surgery, and a higher chance of postoperative problems (12). Germectomy is a straightforward treatment that takes less time to complete, which lowers the likelihood of problems (12). The proper surgical technique, the operator's

abilities, and the patient's cooperation in strictly adhering to postoperative instructions are all unquestionably related to the nearly nonexistent percentage of problems (11). Numerous studies have demonstrated that teenagers heal more quickly and experience fewer postoperative and surgical problems (16). The notion of postoperative risks, which might rise when surgery is delayed and results in the development of a germ with a higher bone density and complete root development, is confirmed and supported by the literature. As a result, third molar extraction becomes more challenging and takes longer as individuals age (16). The likelihood of postoperative complications following germectomy is increased in female patients, and distally angled third molars or molars exhibiting Class III impaction are more likely to do so. No other kind of issue has been discovered to be significantly more common when impacted third molars are out early instead of later. One significant benefit of germectomy that clinicians should consider is that because the molar roots have not yet fully grown, such an operation is less likely to harm the inferior alveolar or lingual nerve. As a result, the relationship between a tooth germ and the nerves is nonexistent (11).

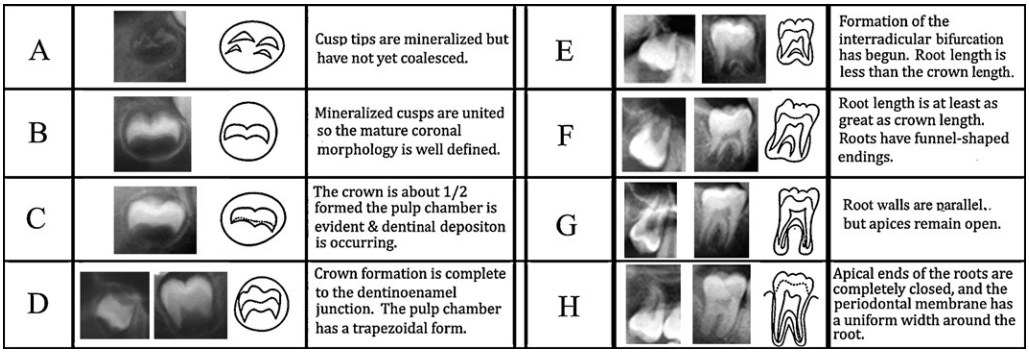

Figure 2. Demirjian molar development staging as modified by Kasper. (13)

3. Classification of Wisdom teeth

The most commonly affected teeth in the mandible and maxilla are the third molars, whose impaction rate has been reported to vary between 16.7% and 68.6% (17). An impacted tooth is a partially erupted or impacted tooth that fails to form proper relationships with other teeth and tissues within the dental arch despite its eruption time. According to a Swedish study, around 72% of young adults between the ages of 20 and 30 have at least one wisdom tooth retained in their jaw (18,19). Based on the study of Seyd et al., the prevalence of impacted third molars was much higher in the mandibular arch than in the maxillary arch (49.4% to 18.4%). Some classifications of wisdom teeth have been established based on the position or angulation (= angle of the tooth axis of the third molar to the tooth axis of the second molar) to the neighboring tooth, to the mandibular canal in the lower jaw, or the assessment of the wisdom tooth roots. Research shows that with 40.5% mesioangular impaction is the most predominant type in the mandible and vertical angulation with 56.5% in the maxilla (20,21). The high rate of surgical

removal of impacted third molars in the mandible makes this subject essential (22). The preoperative classification should allow an assessment of the degree of difficulty and, thus, subsequently provide a statement about the duration of the operation, the extent of the surgical intervention, and the probability of complications (23). Classifying the impacted teeth enables the type and degree of retention to be determined, as well as the degree of treatment difficulties to be evaluated. This influences the possibility of procedure-related problems, which targeted elective operations like surgical removal of the impacted wisdom tooth can reduce (22).

3.1. Pell- Gregory Classification

Pell Gregory Classification (1933)		
Depth of the retention	A	The occlusal plane of the impacted tooth is level with the occlusal plane of the second molar
	B	The occlusal plane of the impacted tooth is between the occlusal plane and the cervical line* of the second molar.
	C	The impacted tooth is below the cervical line* of the second molar.

Table 1: * corresponds to an imaginary line at the amelocemental transition of the second molar

Location to the mandibular ramus	A	There is sufficient space between the ramus and the distal portion of the second molar to allow the third molar to erupt correctly.
	B	The space between the second molar and the ramus of the mandible is smaller than the mesiodistal diameter of the third molar.
	C	All or most of the third molar is in the ramus mandibulae

Table 2: Classification according to Pell-Gregory, adapted from Garcia et al. (24-26)

3.2. Winter Classification

G. B. Winter described different types of impaction based on angulation, or the inclination of the crown of an impacted third molar, which refers to the angle made by the second and third lower molars' long axis (22,27). Based on the study of Jarón et al., the most common occurrences are the mesioangular impaction (52.56%) and the distoangular position with 39.04%.

Vertical impaction	The second molar's and the third molar's impacted long axes are parallel (10°-10°)

Mesioangular impaction	The wisdom tooth is angled in the mesial direction of the adjacent second molar (11°to 79°)
Distoangular impaction	The long axis of the wisdom tooth is tilted posteriorly away from the adjacent second molar (-11° to -79°)
Horizontal impaction:	The long axis of the impacted wisdom tooth and the second molar is at the right angle (80° to 100°)
Buccolingual impaction	Each tooth is oriented towards a buccolingual direction

Table 3: Classification of Winter (22,27)

3.3. Archer Classification (1975)

Archer established a classification for the upper jaw based on the angulation or, rather depth of the retention, which he subdivided based on the bony coverage.

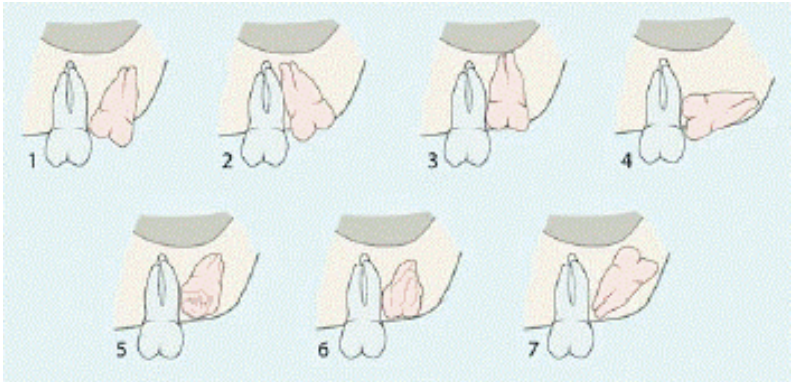

Figure 3: Classification according to Archer (1975): one mesioangular, two distoangular, three vertical, four horizontal, five bucco-angular, six lingo-angular and seven inverted (28,29)

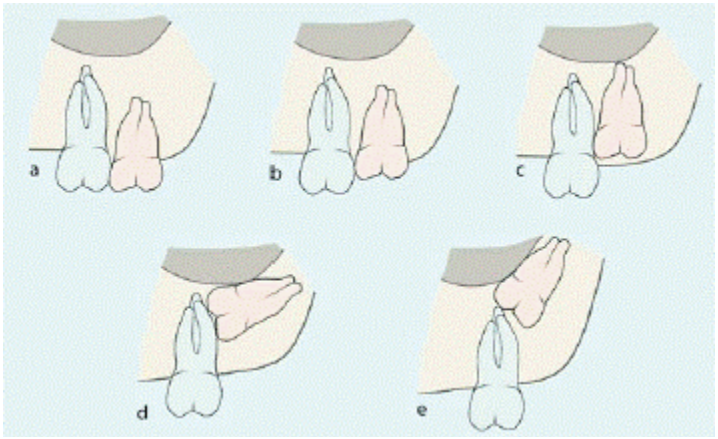

Figure 4: Classification according to Archer (1975) according to the depth of retention compared to the adjacent second molars (28,29)

Classification according to Archer (1975)		
	1	Mesioangular
	2	Distoangular

Angulation	3	Vertical
	4	Horizontal
	5	Buccoangular
	6	Linguoangular
	7	Inverted

Depth of the retention	A	The occlusal plane of the impacted tooth is approximately at the same level as that of the second molar.
	B	The occlusal plane of the impacted tooth is at the center of the crown of the adjacent molar.
	C	The occlusal plane of the crown of the impacted tooth is below the cementum-enamel junction of the adjacent molar or lower, adjacent to or even over their roots.

Table 3: Classification of Archer, adapted according to Frangiskos et al. (3)

3.4. Clinical importance of the classifications

Male patients between the ages of 40 and 60 are more likely to experience postoperative mandibular fractures following third mandibular molar extraction brought on by early chewing force. Deeply impacted lower third molars, Class II and III, B and C, according to the Pell & Gregory classification system, mesioangular according to Winter's classification, and on the left mandibular side are the characteristics that most frequently characterize mandibular fractures at the mandibular angle (30). Using cone-beam computed tomography (CBCT), the study of Khojastepour et al. examined the interactions between impacted mandibular third molars and the cortical plates and inferior alveolar canal (IAC) with the Pell and Gregory Classification. Most teeth were level C in-depth and Class I in terms of the ascending ramus. The impacted mandibular third molars typically had a lingual position and were in touch with or crossed the IAC. The kind of tooth impaction, as determined by the Winter and Pell, and Gregory categories, and the placement of the third molar teeth concerning the cortical plates and IAC were significantly correlated. Teeth that were mesioangular, Class III regarding the ascending ramus, and level C in depth had a higher likelihood of being in the buccal position and having their apex meet the IAC (31). In the study of Iwata et al., various risk factors for an oroantral perforation were examined in maxillary wisdom tooth extraction. Teeth with the Archer classification type B/C/D were connected with an oroantral communication. According to Archer's classification for the upper jaw, the presence of class C represents an increased difficulty of the surgical intervention since it involves an extensive osteotomy with limited

access and the risk of displacement of the tooth or its parts in the maxillary sinus. Thanks to the classifications, the surgeon can assess the risks more precisely and with specific background knowledge. The doctor can prepare better based on the established categories by analyzing the exact position of the wisdom tooth. Accordingly, it is important to act before, during, and after the operation. The patient can be informed and sensitized before the procedure and thus be familiar with the preventive behavior after the operation (as with the increased risk of mandibular fractures).

4. Indications for the surgical wisdom tooth extraction

Extraction and indications for extraction should be based on scientific evidence that allows informed decisions to be made in the patient's best interest (32). The indication for removing wisdom teeth can be made in two ways. On the one hand, the removal can be carried out due to prophylactic considerations and, on the other hand, due to therapeutic necessity. A therapeutic indication is given if pathological changes have occurred in the wisdom tooth or its surroundings (32). Prophylactic means removing the wisdom tooth before damage has occurred (20). A concept of increasing importance in prevention is the ability to distinguish between patients without molar symptoms but with associated disease and those with molar symptoms but without the associated disease. These signs and symptoms include, among others, pain, infection, and local and regional swelling caused by wisdom teeth (32). According to the study of Alfadil et al., with 66.8%, the most common reason for extraction was the prophylactic indication (20). The primary indication for wisdom tooth extraction is the presence of a related disease. Scientific evidence suggests that if a patient presents painful symptoms related to adjacent tooth infection, caries, or changes in periodontal health, remove the affected wisdom tooth. Removal is also considered necessary when molars may cause problems during planned prosthetic, orthodontic, reconstructive, or surgical treatment. One of the conditions that could indicate an extraction is pericoronitis (33). The crowns of the molars' surrounding mucous membranes become inflamed, which is unpleasant and occasionally accompanied by erythema, edema, and localized suppuration (34). Additional symptoms of pericoronitis could include localized adenopathy, fever, trismus, and dysphagia (32,35). Pericoronitis in wisdom teeth is still a contentious issue because the best course of action depends not only on the available research and the surgeon's expertise but also on the patient's preferences (32). Untreated pericoronitis can cause the localized infection to spread to the adjacent head and neck regions, including the sublingual, submandibular, parapharyngeal, pterygomandibular, infratemporal, submasseteric, and buccal spaces (36). It is also possible that the wisdom tooth is affected by periodontal disease, where the treatment includes either extraction of the molar or routine

periodontal maintenance. However, when periodontal pockets are found, extraction is advised, especially if the patient has poor oral hygiene or if periodontal care is impractical. Furthermore, absolute wisdom tooth extraction is recommended in the case of manifest pathological structures in connection with tooth follicles, untreatable periapical changes or teeth with a fracture gap (37). Wisdom teeth are linked to other teeth having periodontal disease in young people. Because fewer oral pathogens were present after the wisdom teeth were removed, the second molars and teeth in a more anterior position had better periodontal health. The distal surface of the second adjacent molar had better periodontal health following the removal of the third molar with periodontal signs and symptoms (32,38). Based on the study of Dicus-Brookes et al., third molar removal may be advantageous, whether or not they are symptomatic if a periodontal probing depth of 4 or higher is found on the distal surfaces next to the second molars (39). Another indication for extraction is in the case of teeth that cannot be restored, have been destroyed by caries or pulpitis that cannot be treated (37). The impaction of wisdom teeth has a negative impact on the prevalence of distal caries in adjacent second molars. According to the research of Bokhari Syed et al., 39% of patients with impacted third molars in the mandible also had distal cervical caries in their second molars. Distal caries in second molar teeth caused by impacted third molars were most commonly related to mesioangular type, male gender, and age group 21-28 years (40). Relative indications for removing wisdom teeth include root resorption, bone loss and periodontal damage to neighboring teeth. Wang et al. used cone beam computed tomography to investigate the incidence and risk factors of external root resorption in second molars with mesially and horizontally impacted mandibular third molars. External root resorption was present in 20.17% of second molars overall and identified the age over 35 and impaction depth as significant risk factors (32,41-43).

5. Complications of surgical wisdom tooth extraction

The surgical removal of wisdom teeth is a routine procedure in the context of dental surgery. Despite improved conditions, complications can still occur during the surgical procedure or afterward (44). The mandible is more prone to complications after this treatment, including inflammatory ones (such as dry socket, postoperative discomfort, delayed healing, postoperative infection, hematoma, edema, trismus, etc.) and iatrogenic ones (such as nerve injury, bone fractures, etc.). According to Rahkshan, one of the two most frequent side effects of the wisdom tooth extraction procedure, along with dry socket, is postoperative pain, which starts to manifest when the effects of anesthesia wear off and peak on the first postoperative day (45). Other common complications include, in particular, crown and root fractures, openings of the maxillary sinus, and nerve complications at the time of the surgical intervention.

Therefore, detailed planning is required to assess the degree of difficulty, the duration of the operation, and possible complications. Knowing the risk factors for postoperative complications might affect therapy planning, patient management, and clinical prognosis (45). An X-ray examination is essential for ultimately depicting the tooth and the relevant surrounding anatomical structures. The primary X-ray diagnosis for the surgical removal of the wisdom teeth includes a current panoramic tomographic image, if possible, not more than six months old (46).

5.1. Intraoperative Complications during wisdom tooth extraction

The complications that can occur during the surgical removal of the wisdom tooth in the mouth, jaw, and face area and thus affect bones, soft tissue, nerves or teeth are the subject of the following performances (47). Complications related to the local anesthetic and its effect on the patient, e.g., intolerance, nerve damage, or circulatory problems after its application, are not considered below.

5.1.1. Injury to the adjacent second molar

Damage to neighboring teeth is possible, especially when using forceps and elevators. If the elevator for luxating a lower third molar is supported on the adjacent tooth, a special force also acts on it, which can lead to its luxation or crown fracture. When using forceps, it is essential to ensure that the jaws do not touch the neighboring teeth while performing dislocation movements (48). In addition, during the use of forceps, it must be taken into account that after the extraction, when the tooth is already yielding, the teeth of the opposing jaw can be hit or injured by the forceps due to the "extraction swing." If the neighboring tooth is dislocated, a decision must be made immediately about whether the tooth can be saved. This depends on the degree of previous damage and the current damage, and it needs to be checked whether the tooth can be repositioned and fixed. In this case, pulp vitality and tooth mobility must be controlled in follow-up appointments (49). In the case of surgical tooth removal, damage to the root surface of the neighboring tooth can also occur. Additionally, tooth sectioning might aid in reducing opposition from nearby teeth (49). Extrusion, lateral luxation, and intrusion are also possible, e.g., during the inappropriate use and force of the elevator. The process of moving the remaining tooth structure to a more coronal or supragingival position within the same socket where the tooth was initially located is known as surgical extrusion (50). The apical displacement of a tooth into alveolar bone is the meaning of intrusion. The injury may seriously compromise the long-term prognosis of the affected permanent dentition due to damage to the periodontal ligament, root cementum, neurovascular bundle, and surrounding alveolar bone that results from this (51). A traumatic shift of a tooth in a direction other than axially is known as

lateral luxation (52). The mechanisms of root canal obliteration, pulp necrosis and root resorption can occur. Root canal obliteration is the reaction of the pulp to injury, which is shown by the quick accumulation of mineralized tissue in the root canal area (53). One of the possible effects of trauma to the molars is external inflammatory resorption. It happens when the root canal system has become infected with bacteria, and there has been cementum loss due to trauma to the dental root's external surface (54). Similar to occlusal trauma, the impact of pressure on the neighboring teeth during and after extraction can be explained. An injury to the teeth or their attachments caused by excessive occlusal pressure is known as occlusal trauma. The periodontal ligament, which connects and supports the teeth to the alveolar bone, comprises thick, fibrous connective fibers (55). Therefore, the periodontal ligament may be related to discomfort brought on by applying pressure to the teeth. The degree of tooth movement and bone density may both be affected by excessive occlusal pressure. Additionally, they might impact the alveolar bone and the periodontal tissue (56). Clinical signs of occlusal traumas include tooth movements, fractures, migrations, susceptibility to temperature extremes, wear on the facets of the teeth, premature occlusal contacts, and discomfort when pressing on the muscles (55).

5.1.2. Arterial bleeding

The physiological process known as hemostasis prevents bleeding at the site of an injury while maintaining regular blood flow throughout the body (57). A succession of enzymatic activations that form a clot with platelets and fibrin polymer is made easier by hemostasis (58). While tissue regeneration occurs, this clot seals the injured region, regulates the hemorrhage, and stops further bleeding. Once the wound recovers, the plug gently remodels and dissolves as the damaged area's normal tissue grows back (59). Primary hemostasis begins immediately following vascular damage and a platelet blockage develops (60). The secondary hemostasis stabilizes the fibrin network and turns the fragile platelet particle into a clot (61). Because excessive bleeding complicates surgery and raises the risk of morbidity, bleeding control is a crucial step during dental surgery operations (62). A wide range of hemostatic agents are available as adjunctive measures to improve hemostasis during dental surgeries to prevent such complications when long-lasting bleeding occurs despite the proper use of conventional methods for hemorrhage control (63). Both healthy people and patients with compromised systems are susceptible to bleeding problems. Due to various causes, including anticoagulant therapy, inherited bleeding disorders, uncontrolled hypertension, severe soft tissue trauma, and noncompliance with postoperative instructions, some patients tend to hemorrhage excessively during or after oral surgery (62). In the event of bleeding, the application of pressure is the first

remedial measure. If the bleeding does not stop, the wound must be closed tightly with sutures. Sutures compress the gingival margin and thus seal the socket. A mattress suture with proper knotting technique is recommended to avoid ineffective air knots (64). Using an efficient hemostatic agent improves hemostasis and offers a variety of advantages, including better-anticoagulated patient care, quicker operations, less wound exposure, and quicker recovery (62,65,66).

5.1.3. Dislocation of the temporomandibular joint

Temporomandibular joint dislocation can occur on one or both sides. It mainly arises in older patients and women when molars in the lower jaw are extracted, the teeth are firmly attached to the bone or the jaw is not sufficiently supported during the extraction (67). Identification of patients who already experience discomfort or display any symptoms of dysfunction in their temporomandibular joints and masticatory structures is recommended (67). If the temporomandibular dislocation is only on one side, the lower jaw deviates toward the healthy side. The inability to close the oral cavity, as well as speech difficulties, saliva drooling, and lip incompetency, are the most prevalent clinical symptoms. Preauricular discomfort is common in acute dislocation, but chronic, recurrent dislocation is rarely accompanied by it. Dislocations, typically bilateral or unilateral, may cause the jawline to turn to the opposite side. A hollow feeling in the joint cavity may be felt when palpating the preauricular area (68). Although acute dislocation is extremely painful clinically, it is manageable. The conservative management methods include using analgesics for symptomatic pain alleviation and manual reduction. According to Hippocrates, the manual reduction technique involves pressing the mandible downward, rearward, and upward (68,69).

5.1.4. Mandibular fracture

The mandibular fracture during wisdom tooth extraction is a dramatic event for the practitioner and the patient. With a reported incidence of 0.0033% to 0.0049%, the mandibular fracture is an uncommon but severe complication following third molar removal (70). The mandible is the biggest, heaviest, and hardest facial bone. These injuries could develop during surgery or right after. Typically, it occurs within the first four weeks following the mandibular third molar extraction and may develop immediately or later (30). A peak incidence in the 36–60 year age range reported in the literature corroborates that growing older is a predictor of mandibular fractures (71,70). The lower jaw is severely weakened when impacted wisdom teeth are displaced. Therefore, the mandibular angle is the site of surgical and postoperative fractures that occur most frequently, followed by the mandibular body and the canine region (30). Spontaneous fractures are often observed in this region when atrophy or massive osteolytic

processes have been previously diagnosed. Osteotomies additionally weaken the jaw. Therefore, the force required to dislocate and remove the wisdom tooth should be less if the bone loss from the previous osteotomy was large. Cysts, tumors, osteomyelitis, or diseases of the bone system also increase the risk of fracture (72,73). Diagnosing a fracture with certainty is difficult. Suspicious murmurs after overcoming resistance, abnormal mobility, and dislocations should prompt the clinician to take an X-ray. The most crucial sign of a fracture is the breaking sound that the patient reports. When evaluating mandibular fractures, computed tomography is the preferred method (74). Fractures can significantly impact a patient's occlusion, bring on an infection, and cause a lot of pain when they happen. Both closed and open types of reduction and fixation are necessary for interventions to stop these sequelae. The type of injury, the patient's medical history, and comorbidities should all be considered when deciding how to treat these injuries. Most injuries are managed according to general principles, but certain situations, such as edentulous patients, complicated and comminuted fractures, and pediatric patients, require extra care. Mandibular fracture treatment entails creating the ideal conditions for bone healing, including sufficient blood flow, immobilization, and accurate fracture section alignment. Because of this, most fractures need to be reduced and fixed to promote primary or secondary bone healing (75).

5.1.5. Oroantral communication

Oro-antral communication, which takes place between the maxillary sinus and the oral cavity, is abnormal. The thin floor of the main sinus, located close to the nose, sits immediately above the back of the mouth's tooth roots. Sometimes, this structure is harmed due to an illness or dental work, and channels or openings between the mouth and the sinus develop (76). As an unnatural communication between the oral cavity and the maxillary sinus, oroantral communication (OAC) is a pathological route for germs. It can lead to infection of the antrum, which further impedes the healing process. The surgical closure of the OAC can be done in various ways. Numerous factors affect the choice to close oroantral communication and fistula (77). Most (48%) of these issues arise during the excision of upper molar and premolar teeth. The root projection or anatomic closeness within the maxillary sinus is the leading cause. OAC can also result from trauma (7.5%), dentoalveolar/periapical infections of molars, implant dislodgement into the maxillary sinus, osteoradionecrosis, flap necrosis and dehiscence after implant failure (78). According to the research, postoperative OAC occurs between 3.8% and 18.7% of the time (2). Based on a study by Pourmand et al., the age of the patient was associated with an increased chance of OAC. The chance of OAC was also increased by root fractures (2). The nose blow test is used to identify the oroantral connection. An X-ray does not show a

contour disruption of the otherwise continuous maxillary sinus floor structure in all cases of the oroantral connection. It can only indicate the suspicion of an opening of the maxillary sinus, but it is not clear proof. Treating OAC aims to close the defect and stop food particles and oral germs from entering the sinus. Oroantral communication has been linked to persistent sinusitis, infection, and delays in healing (79). Without epithelialization and in the absence of a sinus infection, a small OAC with a diameter of fewer than two millimeters may heal on its own after a blood clot forms. However, defects more significant than five millimeters in diameter or those present for longer than three weeks are less likely to heal on their own and usually need surgical intervention (77).

5.1.6. Luxation of a tooth root into the maxillary sinus

In the case of extractions in the upper jaw, a root tip can be pushed through the thin bony lamella of the maxillary sinus floor with the elevator to create an oroantral communication (80). Thus, it is uncommon for molars to be traumatized and moved into the maxillary sinus (81). However, because of the close anatomical relationship between the root apices and the sinus floor, the upper third molar may dislocate inside the maxillary sinus cavity during dental surgery. This uncommon occurrence accounts for 0.6-3.8% of iatrogenic instances of foreign body entrapment in paranasal sinuses (82). The antral floor can be between 1 and 7 millimeters thin. Most frequently, displacement of the tooth or the root in the maxillary sinus happens when the root apices of premolars and molars are close to the sinus floor, when a periapical lesion has eroded the floor during extraction of an isolated molar, or it may also happen during their elective removal when force is used instead of skill, and when patience has been lost (83). When a dental dislocation of this kind does occur, it is typically the result of improper extraction techniques combined with an unusual anatomical connection between the tooth and the maxillary sinus (82). The excision of a forced-in root is advised if possible because postponing treatment increases the risk of inflammatory changes in the lining membrane. If a root was pushed into the antrum, its removal is advised because the more prolonged treatment is put off, the higher the risk of inflammation developing in the lining membrane (83).

5.1.7. Nerve complications

Due to their anatomical proximity to the surgical site, the lingual nerve (LN) and inferior alveolar nerve (IAN), both sensory branches of the trigeminal nerve, are always considered at risk of damage when M3 is surgically removed (84). One of the significant risk factors for developing permanent sensory dysfunction in the distribution of these nerves is related to the surgical skill/experience of the surgeon. The type of impaction and the tooth's radiographic proximity to the inferior alveolar nerve are two additional variables. Such long-term

complications may impact the quality of life for the sufferer (85,86). Instead of just asking a patient to describe neuropathic changes, it is crucial to perform objective testing to assess nerve dysfunction. Clinical neurosensory tests or more complex electrophysiologic studies can be used to collect objective data (87). Injury to the IAN and LN causes a complete loss of mechanoreception and nociception (anesthesia) or, at the very least, reduces them (hypoaesthesia) in the supplying region. Nerve transection or severe constriction can cause demyelination and neural degeneration. A neuroma will develop when the nerve is partly or completely severed to heal (84).

5.1.7.1. Nerve injury to the inferior alveolar nerve (IAN)

The clinician must be aware of the various correlations between the anatomical location of the root tip and the inferior alveolar canal (IAC). Several radiographic techniques are available to estimate the location of the IAC and its relationship to surrounding structures. These include digital apical radiographs, panoramic radiographs, spiral computed tomography, and cone beam computed tomography scans (88). The age and ethnicity of the patient, the length of the procedure, the inexperience of the operator, and, most significantly, lingual access surgery are risk factors for nerve injury in connection with third molar surgery (89). Risk factors for inferior alveolar nerve dysesthesia were patient age (26–30 years), horizontally impacted tooth, radiographic proximity to the inferior alveolar canal (IAC), and future surgical treatment (86,90-94).

The IAN structures are typically stretched or crushed during surgery, or the nerve bundle is put under too much pressure by hematoma or swelling after surgery. As a consequence, the ipsilateral chin, lip, vermilion border, skin, and mucosa, as well as the labial or buccal alveolar mucosa of the mandibular anterior tooth, experience sensory changes. Neurosensory symptoms, also known as hypoesthesia, hyperesthesia, or dysesthesia, include swelling, tingling, tightness, pricking, shooting, burning, dullness, paralysis, and itching (95). Coronectomy is an effective and secure long-term alternative in cases with significant IAN risk. Due to the inferior alveolar nerve's location within the bony canal, healing and recovery in instances of inferior alveolar nerve injury happen fairly quickly (96). Numerous radiological indicators can foretell damage to the inferior alveolar nerve (86). The patient's age, horizontally impacted teeth, near radiographic proximity to the inferior alveolar canal (IAC), and surgical treatment by trainees were all risk factors for inferior alveolar nerve paresthesia (85). The research of Kim et al. analyzed a group of 135 controls and 104 cases out of 12,842 patients. Results indicated that deeper impaction status and older age were critical risk factors. The risk of an IAN neurosensory deficit may be minimal in the absence of specific radiographic signs. In 92.3% of the patients,

the sensory symptoms subsided after six months, and 98.1% demonstrated improvement after one year (91).

5.1.7.2. Nerve injury to the lingual nerve (LN)

The LN runs near the lingual surface of the mandible and can therefore be easily injured when wisdom teeth are removed. Most LN injuries associated with third molar surgery result from cuts made by sharp instruments (such as elevators or blades) or rotary drills, which produce a comparatively small defect (97). The precise mechanism of lingual nerve injury during third molar surgery is debatable, but among the most researched causes is supra-crestal incision because the nerve can occasionally be found here and may be cut, lingual plate perforation and lingual flap trauma during osteotomy or tooth sectioning, and the usage of a lingual flap retractor (98). In addition to taste changes in the anterior two-thirds of the tongue, this lesion may cause temporary or chronic lingual sensory disturbances (anesthesia, paresthesia, and/or dysesthesia), leading to improper chewing or tongue biting (99). The lingual nerve is typically not supported by a bony canal, so when it is injured, this causes the nerve fibers that are regenerating to expand randomly within the soft tissue or scar tissue. As a result, lingual nerve recovery is generally delayed compared to the inferior alveolar nerve (96). Most cases were resolved within the first three postoperative months, and 88.6% were resolved within six months, showing progressive improvement over the follow-up time with spontaneous resolution of LN injury symptoms (100). Tojyo et al. tried to establish the risk of severe iatrogenic lingual nerve injuries associated with the extraction of the mandibular third molar through the analysis of clinical data. Gathered and evaluated were the patient's sex, age, nerve injury side, and impaction kind (Winter's classification, Pell and Gregory's classification). The injury side did not significantly differ from the other. The distoangular and horizontal correlations were the highest in patients with lingual nerve injuries. Distoangular impaction incidence was considerably more remarkable in the lingual nerve injury group than in the control group (96). Despite all the precautions to protect it, lingual nerve paraesthesia can still happen with or without lingual flap reflection. It could be attributed to the lingual nerve's anatomical differences (98). Due to the diversity of anatomical structures, 3D imaging is advised before surgically extracting mandibular third molars if conventional imaging cannot rule out complicated conditions (101). Neurapraxia, axonotmesis, and neurotmesis are the three levels of peripheral nerve injury severity (102). The mildest type of peripheral nerve damage, known as neuropraxia, is frequently brought on by localized demyelination or ischemia. In neurapraxia, the injured area is unable to transmit nerve impulses. Conduction of the motor and sensory systems is lost completely or partially (103). Axonotmesis is a word used to describe a

variety of peripheral nerve injuries that are less severe than the transection of the nerve, as seen in neurotmesis, but more severe than those causing neurapraxia (104). A peripheral nerve that has been completely severed is known as neurotmesis. It causes total paralysis, atrophy of the muscles the nerve innervates, and total anesthesia of the nerve's cutaneous distribution (105).

5.1.8. Iatrogenic displacement of the bur

It is uncommon to remove an impacted third molar with a high-speed handpiece. This iatrogenic complication can mostly be avoided by using the right tools and techniques. The operator needs to check the equipment's function, especially the burs, to make sure that they are sharp and not worn down and should use light pressure with minimal lateral pressure (106,107).

5.1.9. Ear bleed through styloid fracture.

Excessive force applied to the mandible during extraction procedures, mainly when directed posteriorly, increases the risk of damaging the external auditory canal and the styloid process. Because it is usually associated with fractures of the skull base, ear bleeding is an unpleasant clinical indication that necessitates careful examination and urgent treatment (108).

5.1.10. Tooth displacement into pterygomandibular space

The displacement of mandibular third molars can be caused by various anatomical predispositions, including distoangular inclination and a thin or dehiscent lingual cortex. Most of these issues are brought on by inadequate preoperative clinical and radiological evaluation, inexperience, and excessive and uncontrolled force. The infection brought on by dislodged teeth or root pieces may result in life-threatening problems, tissue injury, discomfort, swelling, trismus, foreign body reactions, and severe physical and psychological difficulties (109).

5.2. Postoperative complications after wisdom tooth extraction

The presentation of postoperative complications only includes those that arise from surgical methods or their consequences and are mostly described as wound-healing disorders.

5.2.1. Alveolitis

Alveolitis sicca (AS), also known as dry socket or *dolor post extractionem*, has been documented to occur up to 4% of the time in the literature (110). Lower molars may experience *alveolitis sicca* a little more frequently (110). A dry socket is an extraction alveolus without a blood clot accompanied by postoperative discomfort and sudden, intense, and lancing pain in and around the extraction site, starting at any moment between the first and third post-extraction days (45). The ears, neck, and temporal area are occasionally affected by pain. There may be halitosis, a bad flavor in the mouth, necrosis tissue, marginal gingivitis, and local lymphadenitis (111). Fever is uncommon, except in patients with compromised immune systems or those receiving radiation treatment. Smoking, poor oral hygiene, and prior infections (pericoronitis)

are risk factors. Moreover, pain can become extremely severe and interfere with sleeping (110). Even though the cause is unclear, the primary reason has been hypothesized to be a cascade of fibrinolysis brought on by bacterial enzyme activity, which prevents the development of clots. Despite its unknown cause, understanding its risk factors may help with prevention (by identifying high-risk patients), therapy planning, and psychologically preparing the patients (45). The first step in treating dry sockets is to rinse the area with saline or chlorhexidine gluconate to remove any remaining food fragments or bacteria. For several days, dry socket medication should cover the exposed bone with a resorbable but sturdy covering that will shield the bone from the painful mechanical stimulus, food impaction, and bacterial infiltration. The goal of treating a dry socket lesion is to make the socket as competent as possible by producing a durable layer of the epithelium to cover the exposed bone inside the socket and around the occlusal perimeter (112,113). Smoking should be discouraged in patients as it can prevent clot development, hinder the healing process, impact blood vessels and impair the body's ability to recover (45,114). Nearly all common dental treatments are negatively impacted by tobacco use. Smoking's fibrinolytic activity reduces the alveolar blood supply after tooth extractions, resulting in the painful condition known as dry socket, which is frequently observed in smokers (114)(115). Based on the study of Sanari et al., in the first seven days, smokers reliably scored higher on the patient-reported pain scale than non-smokers (114). According to the research of Kusnierek et al., the combined prevalence of dry sockets in smokers was around 13.2%, and that of non-smokers was around 3.8% (116). This retrospective study by Pourmand et al. evaluated the incidence of alveolitis is typically stated as being between 5% and 0.5% (86,117,118). A preoperative panoramic radiograph was obtained in each case. The assessment included both anatomical and clinical parameters. Ninety-two individuals (5.9%) out of the 1,562 operations had 106 complications. 5.1% of these problems occurred during surgery, and 0.8% did so following (119).

5.2.2. Osteomyelitis

The term osteomyelitis is used for the sole inflammation of the bony structures. Inflammation can occur as a local event or spread to larger jaw sections. A transfer to neighboring parts of the skeleton, e.g., the base of the skull or soft tissue, is also possible (120). In the field of dentistry, osteomyelitis is an uncommon illness. When microorganisms infiltrate bones, it causes an infection and inflammation of the bone structures, which include bone marrow, cortical bone, periosteum, blood vessels and nerves (121). Over 60% of instances involve staphylococcus aureus. Still, other microorganisms may also be present, such as streptococci, enterococci, pseudomonas, enterobacter, and some anaerobic bacteria (113,121). Three

etiologies can cause osteomyelitis to manifest: bacterial spread from nearby regions, direct inoculation of the microorganism (due to injuries or surgery), and hematogenous spread. Pathological fractures of the bone brought on by a compromised bone structure are a severe complication of osteomyelitis (121). A typical symptom is severe, unpredictable jaw discomfort. Clinically, it is distinguished by mandibular enlargement that results from an infection of the bone marrow that also frequently affects the periosteal tissues and the cortical plates. Sclerosis, partial osteolysis, periosteal bone formation, lamina dura widening, and the diffuse boundary of the mandibular canal are all radiological features of diffuse sclerosing osteomyelitis. Current treatment regimens include antimicrobial medicine, hyperbaric oxygen, steroid or analgesic drugs, and surgical debridement. However, the results of these treatment choices could be better (122).

5.2.3. Pain after wisdom tooth extraction

It is usual for pain to occur after an operation. Due to the traumatic damage to the tissue, pain receptors can be stimulated again after the local anesthetic has worn off. Arousal can be increased due to chemical inflammatory agents and pain mediators. The pain usually occurs in the immediate postoperative phase, at its strongest, and subsides continuously if no infection develops. Not every pain needs treatment. However, since the pain reduces the quality of life and performance of the patient and the patient often feels at the mercy of the pain, pain therapy is very important. After surgical interventions, pain can be a sign of wound healing disorders, which can vary depending on the traumatization of the tissue. In particular, postoperative pain increases patient distress and anxiety and can disrupt circulatory and endocrine homeostasis. It has also been reported that postoperative pain can adversely affect wound healing, so reliable and rapid analgesia is required. Nonsteroidal anti-inflammatory drugs (NSAIDs) and paracetamol are usually prescribed to treat postoperative pain after tooth extraction (123,124).

5.2.3.1. Classification of pain

Postoperative pain can be divided into acute pain and chronic pain. Acute pain occurs immediately after surgery (up to seven days), and pain lasting more than three months after injury is considered chronic pain. Acute and chronic pain can originate from the skin, deep body, or visceral structures (125,126). Afferent neural pathways mediate the feeling of pain (127). Acute postoperative pain can be classified as nociceptive, inflammatory, or neuropathic. Nociceptive pain is physiological pain and a response to noxious stimuli such as tissue irritation, impending injury, or actual injury. Inflammatory pain occurs when nociceptive fibers become hypersensitive in response to the release of inflammatory mediators such as cytokines. The clinical presentation of inflammatory pain consists of the four classic signs of inflammation:

pain, heat, erythema, and swelling. Inflammatory pain can last from hours to days and is usually reversible. Neuropathic pain is caused by nervous system damage or dysfunction in the peripheral or central nervous system. It results in pain due to increased axonal sensitivity to stimuli. Neuropathic pain can occur soon after surgery and persist as chronic postoperative pain (126,128).

5.2.3.2. Pain in the adjacent second molar

Another cause of post-extraction pain is hypersensitivity of the adjacent second molar. Adjacent tooth pain can be caused by injuries from crown fractures, dislocation of large restorations, subluxations, and trauma due to high forces exerted during extraction. Pain in the adjacent tooth is often felt at night or under pressure and is characterized by a dull, persistent, and gradual progression. It increases with the percussion of the adjacent second molars and can be moderate at rest but is exacerbated by biting the opposite tooth during chewing, clenching, or bruxism. Adjacent tooth pain after the extraction of third molars can be caused mainly by a post-osteotomy inflammatory reaction and post-extraction pressure. Often, the buccal bone is removed during the surgical extraction of the mandibular third molar. In the case of a fully impacted tooth extraction, the osteotomy is often extended to the buccal aspect of the second molar, which is close to the periodontal ligament space of the neighboring tooth. Cytokines released by osteoclases are responsible for bone destruction and cause pain by pressure on periodontal tissue and alveolar bone (55).

5.2.4. Secondary bleeding

If bleeding occurs again post-extraction after a bleeding-free period of different lengths, this is generally referred to as post-bleeding and is described as bleeding that persists for more than 8 to 12 hours after a dental extraction. Post-extraction hemorrhaging can occur anywhere between 0% and 26% of the time (129). The difference between secondary and continued bleeding from the extraction or surgical wound is often unclear since the bleeding usually stops after the surgical procedure or, at most, a type of spotting continues to occur. If the bleeding becomes more severe, the patient should return (130). The patient should bite down on a swab that is ideally dipped in tranexamic acid after approximately localizing the bleeding. Inhibiting fibrinolysis with tranexamic acid encourages the formation of clots, which frequently leads to sufficient hemostasis. Using sutures to pierce the wound is one of the most efficient ways to stop bleeding. This can be done with resorbable materials that have round-bodied needles. Removing the suture material in challenging circumstances is unnecessary because doing so would cause the flesh new trauma (131). Additional options include packing the alveolus or using Tabotamp to conceal the bleeding defect. An absorbable hemostatic called Tabotamp

encourages platelet coagulation. As a result, it is ideal for managing bleeding brought on by medications that prevent platelet aggregation, like Aspirin (132).

5.2.5. Temporal abscess

Infections of the temporal spaces are uncommon and infrequently documented in the literature. Abscesses in this area have been linked to temporomandibular arthroscopy, drug injections, maxillary sinusitis, and maxillary sinus fractures (133).

5.2.6. Subcutaneous emphysema

Using air-water cooled high-speed dental handpieces that allow the air to enter the soft tissue through the reflecting flap and infiltrate the surrounding tissues is the leading cause of subcutaneous emphysema linked to dental extraction. It usually invades the spaces around the teeth, although occasionally, it can travel down the fascial planes to distant locations. Most of the time, emphysema cures on its own, but in more severe cases, it can result in consequences such as secondary infections, airway obstructions, pneumomediastinum, and tension pneumothorax (106).

6. Conclusion and results

The prophylactic removal of the third molars at a young age is recommended because the third molar extractions become more complex with higher age and have an increased complication rate due to various factors, e.g., changes in bone physiology. As described in the present work, the changes in bone physiology are particularly noticeable since the wisdom teeth do not erupt normally. They often are impacted or grow against the adjacent second molar, where its roots can be damaged. In addition, surgical removal is then unavoidable. This, again, involves risks and complications since it is an operative intervention. Risks such as damage to the adjacent tooth, arterial bleeding or nerve complications can occur during the extractions. Pain is the most common symptom after the wisdom tooth extraction, which should resolve during the first week. Several classifications that evaluate the difficulty of the procedure and aid in developing an ideal treatment plan have been created in order to reduce the number of complications during third molar extraction. These classifications are of particular importance in the surgical removal of wisdom teeth. The classifications developed by Winter and Pell and Gregory, which categorize third molar inclinations and locations based on the relationship between the dental longitudinal axis, occlusal plane, and ascending mandibular ramus, are often used. In clinical practice, these systems have been widely embraced and used. Furthermore, the Archer classification shows the retention based on the bony coverage of the wisdom tooth. In the upper jaw, the position of the wisdom teeth can be described because of their topographical proximity to the maxillary sinus. It is not uncommon for roots or complete wisdom teeth to develop in the

maxillary sinus and persist there. Also, iatrogenic dislocations of wisdom teeth into the maxillary sinus have been described. The causes that make it necessary to remove wisdom teeth are primarily based on therapeutic and prophylactic reasons. Retained and displaced wisdom teeth, in particular, usually make surgical intervention unavoidable. Intraoperative and postoperative complications have become rarer thanks to modernized surgical techniques, instruments and medicament options. Nevertheless, they are unavoidable even today. Therefore, the surgeon must expect complications with every surgical intervention. Furthermore, the type of position of the tooth in the bone and pathological conditions such as cysts, apical inflammation, etc., can cause complications during the operation. However, postoperative complications, which often occur after previous intraoperative complications, need to be observed. The complication rate after wisdom tooth extraction is reported by the reviewed literature 8.4% in the mandible and 5.9% in the maxilla. Risk factors for IAN injuries appeared more often in cases of deep impaction, older age, and narrowing of the channel and roots. After six months, 92.3% of the patients with IAN injuries subsided the symptoms. Postoperative complications include alveolitis, reported up to 4% in the literature, osteomyelitis, secondary bleeding or pain. According to the literature, the most common indication for extraction is the presence of diseases, including pericoronitis, caries in the adjacent molar, which occurs in 39% of the cases, or external root resorption in the second molar, with 20.17% occurrence. Furthermore, despite a complication-free intervention, complications can also occur after the treatment. Despite the perfect behavior of the attending physician, complications like alveolitis can occur because the patient himself can provoke them. For example, it can be triggered when the prescribed smoking break is not taken by the patient or when the patient does not properly clean the exposed alveolus after the procedure. It can therefore be said that an extensive follow-up discussion and surgical care also play a crucial role in the outcome of the procedure. In conclusion, a successful wisdom tooth extraction can only be carried out through the interaction of a comprehensive anamnesis (radiological and intraoral), good preparation by the treating dentist, the skills of the dentist and good postoperative care.

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