CME Perioperative Dental Considerations for the Anesthesiologist

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Although anesthesiologists consistently work in the mouth of patients, they may not have been exposed to a comprehensive education of teeth, surrounding tissues, and intraoral prostheses. Since perioperative dental damage is one of the most common anesthesia-related adverse events and is responsible for the greatest number of malpractice claims against anesthesiologists, several dental considerations are warranted. The likelihood of perioperative dental trauma increases with the vulnerability of a patient's dentition and the presence of associated anesthesia risk factors. Minimizing dental injuries begins with the anesthesiologist's preoperative assessment of the patient's dentition and intraoral tissues. Clear documentation of the patient's preoperative dental condition and notifying the patient of the potential dental damage will diminish costs for any related postoperative dental treatment. Upon discovery of a potentially hazardous dental condition, a consultation with a dentist should be considered before proceeding with the surgical procedure. Exercising cautionary measures during provocative events, such as laryngoscopy and tracheal extubation, can aid in the prevention of dental trauma. In the event of such an injury, several management tactics can promote a swift and reasonable resolution. Establishing an increased awareness of intraoral conditions and the related perioperative risk factors may diminish the incidence of dental damage and financial costs.

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Although anesthesiologists consistently work in the mouth of patients, they may not have been exposed to a comprehensive education of teeth, surrounding tissues, and intraoral prostheses. To more fully appreciate a patient's dentition, this article presents pertinent nomenclature and anatomy and discusses the presentations of various vulnerable dentitions and the likelihood of dental trauma. A thorough preoperative assessment of the patient's dental status, including the recognition of vulnerable teeth, soft tissues, and associated anesthesia risk factors, are of paramount importance in the prevention of perioperative dental damage. This article reviews the incidence, morbidity, pathophysiology, and predisposing risk factors associated with such an injury. For select scenarios, the value of an anesthesiologist performing a more extensive preoperative evaluation is described. The importance of using clear discussion and detailed documentation for the purpose of reducing postoperative distress of all parties involved in the patient's care is reviewed. Special considerations for the pediatric and adolescent patient populations are also discussed. Several recommendations for the prevention of perioperative dental damage and a plan for its management are presented. Exercising an effective risk reduction strategy for these unfortunate injuries can minimize expenses while maximizing anesthetic outcome and patient satisfaction.

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INCIDENCE AND MORBIDITY

Based on retrospective data, the incidence of perioperative dental damage has been found to range from 0.02% to 0.07%.[1–3] However, a prospective study has reported a much higher incidence. Chen et al.[4] examined the dentitions of patients before and after undergoing endotracheal anesthesia and found that the incidence of dental damage was 12.1%. Lockhart et al.[1] surveyed 133 directors of anesthesiology training programs and reported an average incidence of 1:1000 dental injuries during or after 1,135,212 tracheal intubations in 1 yr. These data were reinforced by a review of general anesthetics performed by anesthesia residents in which the incidence of dental injury was found to be 0.1%. It was also found that the level of anesthesia resident training does not affect the risk of dental injury.[5]

Perioperative dental damage is the most common of all medicolegal complaints related to anesthesia, comprising one third of all medicolegal anesthetic claims.[6–12] It is also the adverse event responsible for

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the greatest number of malpractice claims against anesthesiologists.[2,7] This is likely due to the clear causative link between an anesthetic and the damaged dentition. The anesthesiologist is often immediately aware once a dental injury occurs, and, because of its highly sensitive and visible location, patients or their relatives notice the injury soon after the anesthetic. Newland et al.[3] found that 86% of all dental injuries were discovered by the anesthesia provider, whereas 14% were reported by the patient. Although the financial implications of dental damage during anesthesia are not especially significant per incident, payments for the repair of a dental injury can be reported and become part of the National Practitioner Data Bank.[13]

In the perioperative period, the majority of dental injuries (50%–75%) occur during tracheal intubation.[1,2,7,8,14,15] When a satisfactory view of the glottis is difficult to obtain during laryngoscopy, the patient's maxillary anterior teeth are sometimes used as a fulcrum by the laryngoscope blade.[16] Consequently, the maxillary incisors, particularly the maxillary left central incisor, are damaged most frequently.[1,3,6,17] Anterior teeth, such as the incisors, are single rooted with a forward dental axis and a small cross-sectional area, rendering them susceptible to fracture when a strong vertical and/or an oblique force is applied to them.[8] Posterior teeth, such as molars, have multiple roots and a wider cross-sectional area and are much better equipped to withstand such forces. The anatomic advantage of posterior teeth and their remoteness from the laryngoscope during intubation contributes to their lower incidence of perioperative trauma in comparison with the anterior teeth.

Aside from laryngoscopy, dental damage can be caused by other events: aggressive suctioning in the posterior of the mouth[6]; oropharyngeal airway placement subjecting anterior teeth to extreme lateral forces[1,6–8]; and biting down vigorously upon the endotracheal tube or laryngeal mask airway (LMA) shaft *in situ* during emergence from anesthesia.[18] Other provocative events include the forceful removal of an oral airway, endotracheal tube, or LMA upon emergence, and shivering during the recovery phase which may cause spasm of the masseter muscle leading to excessive pressures while clenching and/or grinding of teeth.[7,8,19] Approximately 9%–20% of anesthesia-related dental injuries occur during tracheal extubation or in the recovery room.[1,2,4,6,8,14,17,20,21] In addition to the variance in the causative events, the type of tooth injury varies as well. Enamel fracture and loosening/subluxation of a tooth were found to represent 55.2% of all injuries, followed by tooth avulsion (9.0%) and crown fracture (7.7%).[3]

DENTAL NOMENCLATURE, DENTAL ANATOMY, AND PATHOPHYSIOLOGY OF DENTAL INJURY

The complete adult (permanent) dentition includes 32 teeth, supported by two opposing arches of bone: the upper jaw (maxilla) and the lower jaw (mandible). The dentition is further divided into four quadrants of up to eight teeth each. The posterior of each quadrant has the potential for three molars and two premolars (bicuspids), whereas in the anterior there is one canine, one lateral incisor, and one central incisor. In the United States, the Universal Numbering System is used (Fig. 1). Teeth are numbered from 1 through 32, counted sequentially whether they are present or missing.

Numbering of the teeth is based as if one were directly facing the patient, beginning at the maxillary

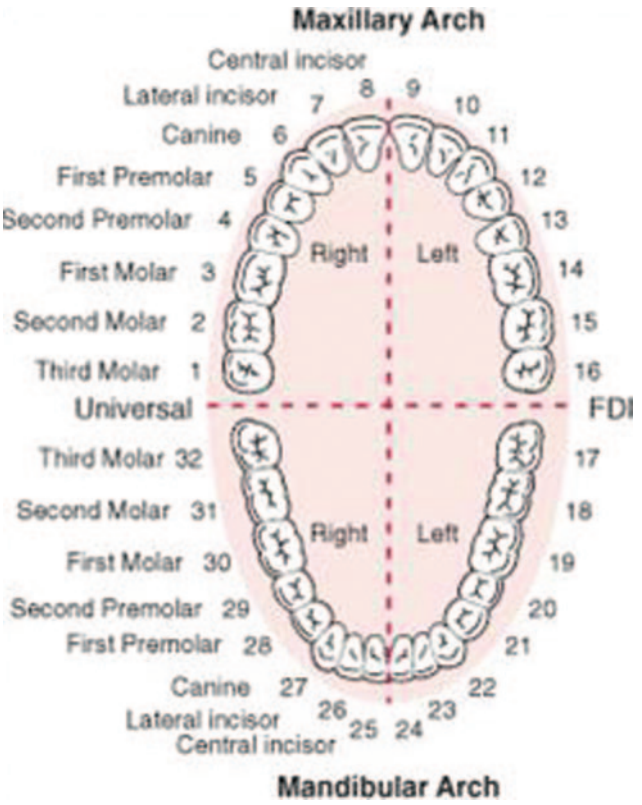

Figure 1. Universal numbering system—adult dentition divided into four quadrants, up to eight teeth per quadrant, numbered in a clockwise fashion.

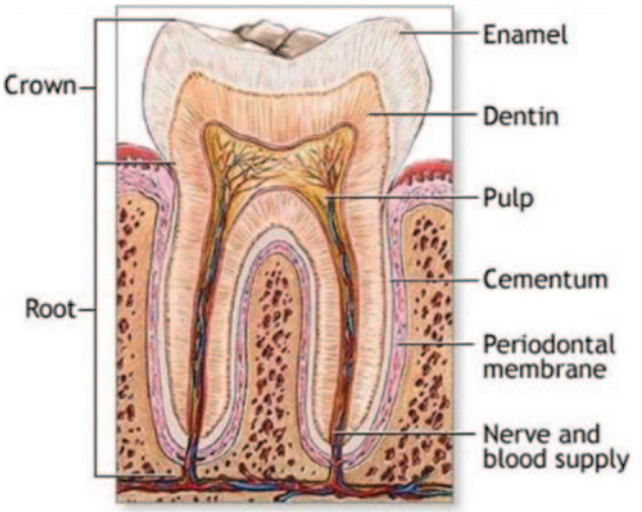

Figure 2. Tooth anatomy.

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Table 1. Common Dental Terminology

Amalgam ("Silver Filling")	A silver-colored restoration (filling) containing a mixture of metals such as silver, tin, copper, and mercury. It is usually placed in posterior teeth because of its superior strength and resilience properties.
Bridge	A fixed nonremovable, multiple-unit prosthesis. To maximize esthetics and strength it commonly consists of an exterior layer of porcelain fused to a metal substructure. Cemented onto prepared teeth, its continuous design spans the (edentulous) space of a missing tooth or teeth, and restores function.
Calculus ("Tartar")	A yellow or brown layer coating the surfaces of teeth formed upon the mineralization of dental plaque. It can develop above or below the gingival margin (gum line) and lead to periodontal disease.
Composite ("Bonding")	A tooth-colored restoration made of a resin-based matrix and filler such as glass ceramics. It chemically adheres to prepared tooth structure by means of polymerization during a light curing process. It is often placed in anterior teeth because of its superior esthetic qualities.
Crown ("Cap")	A single unit prosthesis cemented on top of a tooth which was mechanically reduced. Posterior teeth requiring a restoration with maximal strength properties may be covered with a full metal crown (i.e., alloy of gold, platinum). Anterior teeth demanding greater esthetics are commonly treated with a crown comprised of an outer layer of tooth-colored porcelain.
Denture	An acrylic-based prosthesis for restoring function and esthetics to an edentulous space. A removable partial denture (RPD) incorporates metal clasps into its design that flex around natural teeth (abutments) to provide stability and retention. A complete denture has no metal clasps and replaces an entire edentulous arch.
Implant	A fixed structure made of a biocompatible screw that is surgically inserted into the bone of an edentulous space, simulating a natural tooth's root. Osseointegration occurs between the titanium alloy screw and the bone. After healing of the soft tissue, a prosthetic crown is attached to the screw, restoring function, and esthetics.
Plaque	A sticky, clear film that develops from a combination of saliva, food debris, and bacterial byproducts. Its accumulation on the surfaces of teeth leads to gingival inflammation and the onset of periodontitis.
Veneer ("Laminate")	An ultrathin tooth-colored restoration made of composite or porcelain, bonded or cemented onto a tooth's minimally or nonprepared labial surface. It is primarily used to optimize the esthetics of anterior teeth.

right quadrant's third molar (#1) and sweeping in a clockwise fashion through the maxillary left then mandibular left quadrants and ending at the mandibular right third molar (#32). A child's dentition (also known as "primary" or "deciduous") consists of a maximum of 20 teeth. Each quadrant is comprised of two molars, a canine, a lateral incisor, and a central incisor. In the United States, each "baby" tooth is designated a letter from A through T. In many other countries, the Federation Dentaire Internationale system is commonly used. In this system, each tooth is designated a specific two-digit number based upon two components. The first digit denotes its specific quadrant, determined by a clockwise arrangement, permanent dentition (#1–4) or primary dentition (#5–8). The second digit refers to the tooth's location from the midline of the dentition. For example, the permanent mandibular right first molar is designated as tooth #46 (i.e., it is situated in the fourth quadrant and is the sixth tooth from the midline).

The tooth is divided into two parts, the crown and the root, each consisting of three layers (Fig. 2). Enamel is the outer layer of the crown that becomes fragile if not supported by viable dentin. Dentin is the middle layer, yellowish in color, and provides the framework of the tooth. The pulp is the innermost layer and consists of blood vessels and nervous tissue.[22] Cementum is the outer layer of the root. Dental caries is the most common disease affecting teeth. The process involves bacteria adhering to a tooth and producing acids that decalcify and undermine the enamel.[23] As the decay develops further and encroaches upon the pulp, sensitivity is noted by the patient. A deep carious lesion may require endodontic (root canal) therapy. A tooth becomes proportionately more vulnerable to injury as its natural structure becomes more compromised. Treatment of caries involves removal of the decayed portion of the tooth and the placement of a dental restoration (filling),[24] (Table 1) producing a tooth that is physically weaker and more prone to injury.[4,8,20]

Patients who present with decayed or restored teeth are classified as having a preexisting dental condition. This category also includes individuals having significant periodontal disease, an inflammatory process involving a bacterial infection of the periodontium.[25] The periodontium is the tissue that surrounds the tooth and provides it with support, and is comprised of gingiva (i.e., gums) and the underlying alveolar bone and periodontal ligament.[26,27] Periodontal disease commonly manifests in an adult's mouth as inflamed gingiva, gingival recession, and calculus (i.e., tartar) accumulation (Fig. 3). Dissolution of the periodontium leads to increased tooth mobility and ultimately to a dentition that has increased vulnerability to subluxation or avulsion when subjected even to slight forces.[1,4,7,20]

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Figure 3. Periodontitis—gingival inflammation, recession, and reduced bony support which can result in tooth mobility.

Figure 4. Dental examination—manual retraction of lip or cheek can improve one's visualization for an intraoral inspection.

Figure 5. Dental abscess—infection is endodontic or periodontal in origin and can manifest as a swelling along gingiva.

In the perioperative period, dental damage results from the coupling of a preexisting dental condition with a physical event, such as pressure or forces applied to a tooth. Newland et al.[3] found that patients with poor dentition or reconstructive work were 3.4 times more likely to have dental injuries related to anesthesia. In a retrospective analysis of incident reports of dental injury for elective intubations, 72% of the incidents occurred in patients aged 50–70 yr, likely due to the higher incidence of periodontal disease in that group.[6] An increased incidence of dental injury has also been reported in cases exhibiting the following anesthesia risk factors: general anesthesia, endotracheal intubation, emergency surgery, and a difficult airway (i.e., Mallampati Class 3 or 4).[28] The combination of a preexisting dental condition with any of the aforementioned anesthesia risk factors results in a dentition that is even more vulnerable to damage.[14]

PREOPERATIVE EVALUATION

During the preoperative assessment, an essential focus for the anesthesiologist is the patient's airway, including dentition. Determining the susceptibility of any loose teeth and taking appropriate precautions to avoid dental damage is necessary but not always sufficient. In certain instances, it would be beneficial for the anesthesiologist's attention to extend beyond asking a patient to open his or her mouth and protrude the tongue, or whether there are any loose teeth, crowns, or dentures. Using a more extensive evaluation of the patient's intraoral condition is rarely exercised by anesthesiologists, and it is surely not indicated for the vast majority of patients given the time constraints of clinical practice. However, although the suggestion to incorporate this component into one's preoperative evaluation may seem extreme, there are particular cases in which its application would be valuable.

For example, when asked by the anesthesiologist to open their mouth, some patients may demonstrate an obviously poor dentition and have extremely mobile teeth that are at risk for avulsion and aspiration during the perioperative period. Since chronic dental neglect exists in some individuals, upon their arrival for a surgical procedure they may also be harboring an unknown odontogenic infection. An untreated dental abscess that is not discovered preoperatively can contribute to unplanned and extended postoperative treatment, increased expenses, and a compromised surgical outcome. Therefore, given that it may be an anesthesiologist who is the first caregiver to look inside a patient's mouth in years or even decades, a more thorough examination of such patients' airways may be worthwhile.

If the anesthesiologist is suspicious about the existence of an intraoral abscess, a closer examination is warranted (Fig. 4). Notable redness, swelling, purulent discharge, or fistulas may be signs of an infection and can be visible along the gingiva (Fig. 5). An intraoral abscess can also aggressively tract through bone resulting in an endodontic or periodontal infection that can manifest as an extraoral swelling in the submandibular, submental, or mid-face regions. If a dubious area is detected, a consultation with a dentist should be considered before proceeding with the surgical procedure. In select situations, this small

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investment by the anesthesiologist during the preoperative evaluation can yield significant improvements in surgical outcome and overall patient health.[29]

The maxillary central incisors (#8 and #9) are in the most vulnerable position during laryngoscopy, are the most commonly injured teeth, and demand the greatest cosmetic attention. Maxillary anterior teeth tend to be restored with bonding, veneers, or crowns making them even more prone to damage because these restorations are not as resilient as natural teeth. Complicating matters is that porcelain, the restorative material of choice, is not easily recognized as being artificial.

The presentation of a patient's dentition is highly variable. Isolated teeth and abutments (i.e., teeth adjacent to an edentulous space that have been reduced to support a removable partial denture) may present with occult mobility and are more susceptible to injury.[30] Teeth are sometimes worn excessively by attrition (wear between opposing teeth), physical damage (abrasion), or chemical damage (erosion),[31] which may be caused by dietary or gastric acids.[32] Chronic use of medications can adversely affect dental and periodontal health. In adults, a plethora of medications, especially those with anticholinergic activity, are the most common cause of dry mouth (xerostomia).[33] This condition is also one of the most common complaints following radiation therapy for head and neck cancers[34] and leads to hyposalivation-induced rampant caries.[35] For such patients and in the elderly, root decay that usually presents along the gingival margins of the teeth (i.e., the junction of where a tooth emerges from the gums) can cause the crown of the tooth to be severed perioperatively.[36]

When patients present with significantly loose teeth, they are usually aware of their mobility but may not admit it because of embarrassment or their underestimation of the condition's potentially significant perioperative implications. For any suspiciously susceptible teeth noted preoperatively by the anesthesiologist, it is suggested that he or she put on a glove and slightly wiggle them to better appreciate their mobility.

Pediatric and Adolescent Populations

Young children may present for surgery with an intraoral condition known as early childhood caries or "baby bottle" syndrome. This condition arises from the following sequence of events: To soothe a crying child at night, a parent will give the child a bottle filled with sugar-containing liquids, such as milk or juice. Night after night, repeated bathing of a young child's teeth in these acid-promoting substances leads to rampant decay.[37] The primary maxillary incisors and mandibular molars are directly subjected to the sugary liquids; consequently, they are the teeth that are most commonly affected by this decaying process (Fig. 6). Interestingly, the child's tongue tends to protect the mandibular incisors from the liquid emanating from the bottle's nipple which is positioned between the tongue and the palate. This unfortunate yet preventable situation is principally due to a lack of parental education and typically manifests in children between the ages of 18 and 48 mo. For the anesthesiologist such soft eroded enamel is highly vulnerable to crumbling during intraoral manipulation and can become an unexpected event during an intubation.

Figure 6. Early childhood (baby bottle) caries—maxillary incisors and mandibular molars are most affected by repeated nocturnal bathing in sugary liquids.

Eruption of primary teeth usually begins at about 6 mo of age and most children have a complete set of these teeth by the age of 3 yr.[38] Primary teeth exhibit long slender roots that are less likely to withstand excessive physical forces, rendering them vulnerable to dislodgement perioperatively. If trauma is sustained to a primary tooth, the development of the underlying permanent successor can be adversely affected.[30] The natural exfoliation of deciduous teeth usually commences at the age of 5 or 6 yr when the primary mandibular central incisors are replaced by their permanent analogues. As adult teeth begin to erupt into a child's mouth, they resorb the roots of the baby teeth that they are succeeding, causing mobility, and eventual exfoliation. This period of tooth turnover commonly occurs during the ages of 5 through 12 yr, producing a "mixed" dentition of primary and permanent teeth. Children in this age group are more susceptible to tooth injury.[39] For example, newly erupted permanent incisors may be readily avulsed in children aged 6–8 yr because their immature roots may not fully develop for another 3 yr.[30]

The presence of any intraoral appliances should also be confirmed during the preoperative assessment of this patient population. Devices used for breaking the childhood habits of tongue thrusting and thumb sucking often suspend from the hard palate and may interfere with laryngoscopy.[40] Due to imperfect eruptions, children may exhibit crowding of teeth or an extra (i.e., supernumerary) tooth. A patient's history of a cleft palate may yield a narrow maxillary arch that can also lead to crowding of teeth upon their eruption in the maxilla (Fig. 7). Adolescents (and adults) may

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Figure 7. Crowded maxillary dentition—sequelae of a cleft palate include a narrow maxillary arch and compromised tooth eruption.

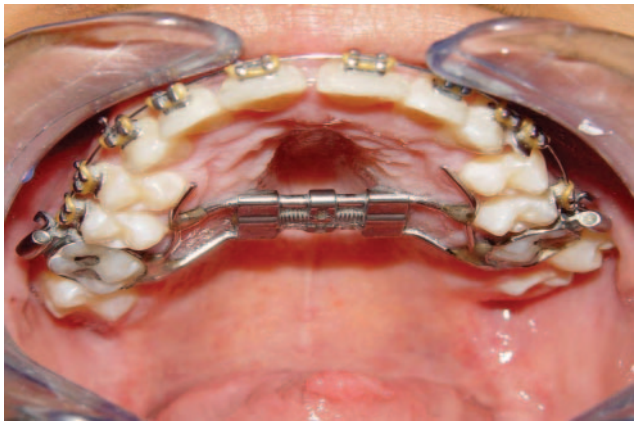

Figure 8. Palatal appliance—fixed, and hidden from facial view, it can be damaged, limit space for laryngoscope placement and increase risk of a traumatic intubation.

present with orthodontic appliances that are removable, such as a biteplate (retainer) or fixed such as brackets (braces). Another fixed appliance known as a palatal expander is designed to promote widening of the maxilla. This device can limit the space available for a laryngoscope and can increase the likelihood of dental damage or a traumatic intubation (Fig. 8).

PREOPERATIVE DISCUSSION AND DOCUMENTATION

Since dental damage is one of the most likely adverse outcomes during general anesthesia, it is recommended that the patient be made aware of this possibility during the preoperative evaluation, especially with an anticipated difficult intubation and/or a patient's vulnerable preexisting dentition. Forewarning patients about this potential adverse incident preoperatively can substantially decrease the likelihood of facing an uninformed, unprepared, or angry patient postoperatively.

Figure 9. Tied teeth—vulnerable teeth at an increased risk of avulsion and/or aspiration are secured with silk suture preoperatively.

The preoperative presentation of a poor dentition should prompt the anesthesiologist to be descriptive in documenting this condition. "None loose" or "intact" are not always appropriately illustrative. Also, a notation referring to the patient's periodontal status can be helpful. For example, "poor oral hygiene with generalized periodontal disease, multiple mobile teeth and partial edentulism in both arches" can succinctly summarize a patient's dentition that is especially vulnerable to damage. In addition, the following entry made in a patient's medical record preoperatively can save time disputing such a claim postoperatively: "the maxillary right central incisor (#8) has a fractured incisal edge which I have confirmed with the patient." Any missing, damaged, or loose teeth should be confirmed with the patient and documented accordingly. Gatt et al.[41] has proposed the introduction of a standardized uniform dental chart to accurately document the preoperative condition of a patient's dentition. Detailed documentation of the patient's preoperative dental condition also serves to minimize the potential for inflated dental treatment estimates following a perioperative dental incident.

RECOMMENDATIONS FOR PREVENTION OF PERIOPERATIVE DENTAL DAMAGE

Patients' loose teeth present the anesthesiologist with the dilemma of having the teeth extracted preoperatively or proceeding with caution. In many instances, it is not practical to obtain a dental consultation and definitive treatment immediately before surgery. Securing a loose tooth is a cautious measure to prevent aspiration and aid in a tooth's retrieval should it become dislodged. A 3–0 silk suture without the needle can be wrapped several times around the gingival margins of the mobile tooth and adjacent teeth for increased stability (Fig. 9). The suture can be secured with adhesive tape to the ipsilateral cheek and removed after the procedure upon recovery.

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The presence of any abnormalities of the tongue, lip, or palate should also be noted. Being cognizant of lesions in any of these areas can reduce perioperative trauma of oral soft tissues. Although all intraoral swellings should be investigated and documented preoperatively, they are not all indicative of an infectious process. For example, a torus is a prominently benign bony growth that can develop in a patient's palate or mandibular premolar region and would not require preoperative intervention.[42] Particularly upon inspection of the patient's maxillary anterior teeth, biting surfaces should be carefully scrutinized for any evidence of being worn, notched or chipped. Incomplete dental treatment, such as temporary crowns and implants, may become an issue perioperatively and the stability of any such provisional prostheses should be verified. Any removable prostheses (e.g., dentures, orthodontic appliances) or soft tissue piercings of the lip or tongue should be removed, labeled, and stored before the anesthetic induction to prevent any accidental loss or damage.

After induction of anesthesia when a patient's mouth is being scissored open before laryngoscopy ("cross-finger" maneuver), excessive stresses may be placed upon the mandibular anterior or maxillary right posterior teeth. During this action, one should exercise caution and subject only posterior, not anterior teeth, to minimal vertical or oblique forces to decrease the likelihood of damage. This manipulation can also cause the mandible to "lock" in an open position. This disarticulation is caused by anatomical abnormities or extreme mouth opening forces, resulting in the condyle of the mandible to slide too far anteriorly along the articular eminence of the temporal bone. A simple maneuver can correct this situation. Directly facing the patient who remains under general anesthesia, thumbs can be placed bilaterally along the biting surface of the patient's mandibular posterior teeth. The action of applying pressure inferiorly and then posteriorly (i.e., down and back) unhinges the condyle from its unnaturally anterior position, and returns the mandible to a more relaxed position (Fig. 10). In a one-sided dislocation, the mandible is deflected ipsilateral to the locked joint. To reduce the disarticulation of the condyle/disk, inferior pressure is applied to the mandible which is then moved gently in the contralateral direction.[43]

Since laryngoscopy is the most common procedure that may lead to dental damage, prevention of such an injury during this time warrants particular attention. Obviously, a technique involving gentle blade placement and motion, along with carefully applied forces, should be used. One maneuver that minimizes contact with teeth entails placing the right hand on the patient's occiput and extending the neck, while the left little finger pushes down the chin, opening the mouth and creating access. Careless placement of the laryngoscope blade can cause laceration or abrasion of the lips, palate, and cheeks with possible ulceration and infection.[40] Suctioning intraorally should be done with great care, preferably with the use of a 14F soft plastic catheter.

Figure 10. Temporomandibular joint disarticulation—pressure applied inferiorly and posteriorly to the mandible can reposition it to a more natural, relaxed position.

Patients with a Mallampati score of 3 and prominent "buck" teeth have been reported to experience blade-tooth contact in more than 90% of intubations,[16] prompting the modification of the laryngoscope blade to avoid dental damage.[44] Lee et al.[16] reported that using a Macintosh blade with a low-height flange (i.e., Callander modification) reduced the frequency of direct contact between the blade and the maxillary teeth by more than 80%. In contrast, a similar modification of a Miller blade was found to decrease the blade's effectiveness for laryngeal visualization.[45] Angulated blades, such as the McCoy and the Belscope, have been reported to provide greater tooth-blade distances and better visibility than regular curved or straight blades.[46,47]

Several studies have examined the preventive use of devices that protect teeth during laryngoscopy.[48] Various prefabricated or custom-made mouthguards (i.e., those used preventively in sports) do not guarantee an endotracheal intubation free of dental trauma.[21] Burton and Baker[8] found that the vast majority of anesthesiologists did not use a protective guard routinely, and 45% had never used one. The use of mouthguards has no significant effect on the incidence of dental injury.[49] The main disadvantage of these tooth protectors is that their thickness decreases the amount of space within the oral cavity, leading to poor visibility and increased difficulty in guiding the endotracheal tube into the larynx. They also prolong the intubation time, increase the likelihood of oral trauma, and create additional hazards, including aspiration of the appliance. However, for bronchoscopists and endoscopists who tend to use a rigid scope for their procedures, mouthguards have been recommended.[49]

The oral airway has been found to be a major cause of injury to teeth[50,51] and 20% of dental injuries were reportedly caused by Guedel oral airways.[18] Oropharyngeal airways should be used with caution for

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patients with vulnerable anterior teeth and should not be used as a bite block.[52,53] Nasopharyngeal airways are a better choice for those patients who are especially at risk for dental injury.[30]

In preparation for extubation, a soft roll of gauze can be placed on the biting surfaces of the patient's mandibular premolar/molar region. It should be large enough to be easily retrieved. A bite block can also be made from a wooden tongue depressor, wrapped several times at one end with 1 in. or 2 in. cloth adhesive tape, and inserted with the bundle positioned between the mandibular and maxillary molars on either side of a LMA or opposite to a unilaterally positioned endotracheal tube. When a patient involuntarily bites during emergence from anesthesia, forces will be dissipated throughout stronger multirooted molars rather than weaker single-rooted incisors. Functioning as a fulcrum, this posteriorly positioned roll will also indirectly open the anterior of the mouth, preventing contact and damage to anterior teeth and/or any of their cosmetic restorations upon removal of the airway device. During emergence from anesthesia, the gauze roll will also prevent the patient from clenching down on an endotracheal tube or LMA, which could adversely affect oxygenation. Adequately controlling postoperative shivering will lessen excessive teeth clenching, grinding, or masseter muscle spasm.

MANAGEMENT PLAN: WHEN DENTAL DAMAGE DOES OCCUR

When an incident of perioperative dental damage occurs, documentation of the injury is imperative. An evaluation of the damage by a dentist should be obtained as soon as possible to determine the extent of the injury and provide potential options for postoperative treatment. Confirming the location and ensuring the successful retrieval of any avulsed or broken teeth is also essential. If a tooth, crown, or other prosthesis is avulsed and its location is unknown, a chest radiograph should be obtained without delay to determine whether it has been aspirated or is on a passage to the stomach. Although most dental fragments will pass through the gastrointestinal tract without causing harm, large prostheses have the potential to obstruct and perforate.[39] If the object has not been retrieved, intraoperative intervention may be necessary. The ingestion of a fixed partial denture followed by subsequent recovery with endoscopy during general anesthesia has been reported.[54]

If a permanent tooth is displaced from its socket, it should be stored in normal saline or cool fresh milk until it can be splinted or reimplanted.[39] The success of reimplantation of an avulsed tooth after a traumatic intubation is primarily determined by the elapsed time since injury. If reimplanted within 30 min, the success rate has been reported to be as high as 90%.[55]

It should be noted that it is not always the anesthesiologist who is responsible for dental damage in the operating room. Surgeons, such as otolaryngologists, may inadvertently cause such an injury during rigid laryngoscopy. Also, endoscopists and bronchoscopists have caused trauma to a patient's dentition. Determining which practitioner was directly involved with the dental trauma is suggested before a discussion with the patient.

Once the patient is sufficiently awake, a discussion of the perioperative dental incident should occur. Patients are more likely to become upset if they feel that this incident has been ignored or practitioners have refused to acknowledge any responsibility. Facilitating prompt attention to the dental damage before the patient's discharge will ameliorate convenience and reduce expenses. At some health care facilities, dental clinics are on site that can provide an immediate assessment of the injury and suggest appropriate treatment. Due to the relatively small financial payout for repair, it is often not worth the time or expense to prolong a legal dispute over the incident.

If the injury has not been resolved before discharge, patients will typically seek dental treatment with their private dentist and submit a claim for reimbursement. In the case of patients who have not visited a dentist in several years, the treatment plan may also address some unrelated chronic intraoral conditions, culminating in a significantly increased cost estimate. Extractions, periodontal therapy, insertion and restoration of implants, crown and bridge fabrication, etc. may all be necessary measures for improving a patient's overall dental condition. A reasonable reimbursement by the health care facility should only include the repair costs of the dental damage that was sustained perioperatively. A mediator, such as a hospital risk management member, can investigate patients' claims of dental injuries; however, ideally the reimbursement process should include an independent dentist to evaluate the treatment plan and fees. Rather than relying upon the assessment of the injury by an administrator, review of the claim by a more appropriately educated individual can ensure an impartial judgment. It also diminishes the potential for the payer to be financially responsible for any extraneous treatment and inflated costs.

CONCLUSIONS

Perioperative dental damage is one of the most common anesthesia-related adverse events leading to claims. Understanding and recognizing the multiple risk factors associated with such injuries leads to prevention. During the preoperative evaluation, information about the patient's intraoral soft and hard tissues should be obtained by the anesthesiologist. Adoption of a more extensive intraoral examination into one's preoperative evaluation is not suggested for most patients, but in some instances a "hands-on"

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examination of the patient's dental status is recommended to properly appreciate any vulnerable teeth or soft tissues. Patients exhibiting very poor oral hygiene and chronic oral neglect may be harboring an unknown odontogenic infection that can compromise surgical outcome, and those with known mobile teeth are at an increased risk for tooth avulsion and/or aspiration. Decayed, restored, or periodontally involved teeth are more susceptible to becoming damaged perioperatively than a natural dentition. A preoperative discussion with the patient of the risk of dental injury and clear documentation can significantly reduce the magnitude of postoperative disputes and costs. If indicated, securing loose teeth can help reduce dental injury, as will other preventive measures, such as careful mouth opening, laryngosope placement, suctioning, and extubation maneuvers. Following an incident of perioperative dental damage, the goal is to obtain an immediate assessment and provide a fair reimbursement for treating the injury. Enhancing one's awareness of the various perioperative dental considerations described in this article can minimize costs, while improving anesthetic outcome and patient satisfaction.

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