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REVIEW ARTICLE

Tooth injury in anaesthesiology

José Miguel Brandão Ribeiro de Sousa*, Joana Irene de Barros Mourão

Faculdade de Medicina, Universidade do Porto, Porto, Portugal

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Abstract

Background and objectives: Dental injury is the most common complication of general anaesthesia and has significant physical, economic and forensic consequences. The aim of this study is to review on the characteristics of dental injury associated with anaesthesiology and existing methods of prevention.

Contents: In this review, the time of anaesthesia in which the dental injury occurs, the affected teeth, the most frequent type of injury, established risk factors, prevention strategies, protection devices and medico-legal implications inherent to its occurrence are approached.

Conclusions: Before initiating any medical procedure that requires the use of classic laryngoscopy, a thorough and detailed pre-aesthetic evaluation of the dental status of the patient is imperative, in order to identify teeth at risk, analyze the presence of factors associated with difficult intubation and outline a prevention strategy that is tailored to the risk of dental injury of each patient.

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Lesão dentária na anestesiologia

Resumo

Justificativa e objetivos: A lesão dentária é a complicação mais comum da anestesia geral e apresenta importantes consequências físicas, econômicas e médico-legais. O objetivo deste estudo é fazer uma revisão sobre as características da lesão dentária associada a anestesiologia e os métodos de prevenção existentes.

Conteúdo: Nesta revisão são abordados o momento da anestesia em que a lesão dentária ocorre, os dentes acometidos, o tipo de lesão mais frequente, os fatores de risco estabelecidos, as estratégias de prevenção, os dispositivos de proteção e as implicações médico-legais inerentes à sua ocorrência.

* Corresponding author.

E-mail: miguel_sousa4@hotmail.com (J.M. Brandão Ribeiro de Sousa).

Conclusões: Antes de iniciar qualquer procedimento médico que exija o recurso à laringoscopia clássica é imperativa uma avaliação pré-anestésica minuciosa e detalhada do estado dentário do doente, de forma a identificar os dentes em risco, analisar a presença de fatores associados a dificuldades de intubação e delinear uma estratégia de prevenção que seja adaptada ao risco de lesão dentária de cada doente.

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Introduction

Dental injury has been associated with general anaesthesia since many years,¹ especially to endotracheal intubation using classic laryngoscopy.² This is the most common complication.^{1–11} The overall incidence of dental injury is estimated to be between 0.06% and 12%,^{3,11–17} and these values can be underestimated.² Therefore, this is a frequent injury in anaesthesiology, in which the aesthetic and functional consequences and the social impact are important factors.^{4,6,7,10,11,18}

Dental injury is also the most common of all forensic claims related to anaesthesia,^{1,5,19–22} the event being responsible for the largest number of complaints for medical malpractice against anesthesiologists.^{2,4–7,23} Its correction has relevant costs, which have become increasingly significant with the evolution and sophistication of technology.^{6,7,24}

Considering the magnitude of the problem and the physical, economic and legal consequences of dental injury in anaesthesiology, it is important to correspond to the need for education and training of anaesthesiologists about the anatomy of the teeth, the supporting structures, the dental pathology and techniques used in dental rehabilitation.⁹ It is also necessary to establish standardized strategies of documentation and prevention, since the knowledge and understanding of risk factors are essential to prevent future injuries.^{1,2,4,7,24}

Anaesthesia and tooth injury

Healthy teeth are very strong and designed to withstand the enormous pressures generated during mastication. However, the insertion, manipulation, or removal of any airway or suction device may cause lesions in the oral cavity.

Occurrence of tooth injury

Dental injuries occur mainly during laryngoscopy,^{2,5,12} but can occur less frequently during anaesthetic maintenance or in the emergence phase of anaesthesia.^{2,18} Although the risk of dental injury could be present also during the extubation,^{19,25} it is less important and significant than the risk during intubation.²

Most studies show that a lot of injuries occur during intubation for elective surgery and only a minority occurs in an emergency context,^{2,11,16} indicating that the care to

intubate will be the same when the patient's dental state cannot be established. Rather, some studies indicate that emergency surgical procedures are associated with an increased risk of dental lesions.^{5,12,17,26}

Adolphs et al.¹¹ report that perioperative tooth injuries occur mainly in the general surgery and trauma services, most likely because these are the services that perform the largest number of surgical procedures using endotracheal intubation with laryngoscope.

Affected teeth

Generally, only one tooth is subjected to injury,^{5,6,11} but the simultaneous trauma to two, three or even four teeth was already described.^{5,6,27} The upper (maxillary) incisors are at greatest risk of injury,^{3–7,10–12,16,28–32} particularly the upper left central incisor,^{6,11–13,19,28,33} but the lower³¹ and posterior³¹ teeth can also be injured.

Type of tooth injury

The most frequent type of dental injury is not constant across studies, and this may be due to the adoption of different methodologies for the detection and classification of lesions. However, the explanation of these criteria is not covered by these studies. The lesions most reported in the literature are: fracture, avulsion and dislocation of natural teeth or prosthetic restorations.^{3–6,10,11,16,34–36}

Risk factors

The main risk factors of dental trauma associated with laryngoscopy are difficult intubation^{3,12,15,37} and poor preexisting dental status.^{1,4–7,11,16–18,26,31,32,38,39}

Chen et al.²⁸ report that in teeth with preexisting pathology, an injury is about five times more likely,¹² and Newland et al.¹⁵ reported that patients who are difficult to intubate have a 20 times higher risk of dental lesions.

Bucx et al.²⁹ demonstrated that dental injury is more likely in situations of difficult intubation, possibly because anaesthesiologists use the upper teeth as a fulcrum when they cannot get a satisfactory view of the glottis. During laryngoscopy, the support on the upper jaw and consequently on maxillary incisors improves the line of sight and facilitates the insertion of the endotracheal tube, which explains the high incidence of dental injury during difficult

intubation. Thus, the predictors of difficult intubation also predict the risk of dental trauma.⁴⁰

On the other hand, Gaudio et al.¹⁶ report that no type of dental injury was significantly associated with an anticipated or unanticipated difficult intubation. Avulsions, fractures and dislocations occur most frequently during laryngoscopy manoeuvres described as normal procedures, as Vogel et al. also described.

The intensity of the forces exerted during laryngoscopy is also related to the potential risk of dental trauma, particularly in the presence of an inadequate technique of intubation or of a longer endotracheal intubation. The presence of prominent upper incisors, with a height exceeding 1.5 cm, is associated with increased tensile strength and duration of laryngoscopy, and contributes to increasing the risk of tooth injury. Particularly, the laryngoscopy takes longer when the excess weight is associated with a limited tongue protrusion, less than 5 cm of mouth opening, and a limited neck extension, which increases the likelihood of injury to the teeth during intubation.²

Other factors have been described in the literature as enhancers of dental injury: the impact on the dental arch during laryngoscopy, in association with a poor technique of intubation^{5,16,17,42} and patient's anatomic factors (prominent and large size teeth, small mouth opening, excess of teeth in the anterior part of the dental arch,¹⁶ isolated teeth,²⁸ difficult mask ventilation, oral diseases, presence of prostheses, previous history of difficult intubation, previous neck surgery, chemotherapy or prior radiotherapy to the oral cavity, tongue neoplasm, oral trauma, and an impaired patient).¹⁷ There are also genetic defects and pharmacological agents that affect the tooth structure and its attachment and, therefore, increase the risk of tooth damage.^{1,25}

The level of training of the anaesthesiologist does not influence the probability/risk of dental injury,^{11,16,32} so the tooth injury can occur with both the experienced anaesthesiologist as with the less experienced professional and in both scenarios of intubation (easy or difficult). However, in some studies the lack of experience has been cited as an important causative factor.^{17,26,31}

Prevention of trauma

The perioperative dental injury does not seem to be completely preventable and must be accepted, both by the anaesthesiologist and his/her patient, as an inherent risk of the procedure.^{17,26,31} However, according to Adolphs et al.,¹¹ there is a set of actions and attitudes that could reduce its frequency and minimize the damage, starting with weighing the benefits of surgery and the risk of dental injury related to general anaesthesia.

Preoperative evaluation

The preoperative visit is critical to the evaluation of two situations established by several authors as predictors of dental injury: difficult intubation and previous dental status of the patient, with the goal of developing a plan for the prevention of such injury.

History and informed consent

During the anaesthetic consultation, medical history aspects that are recognized as factors that increase dental fragility must be identified (dental trauma, radiation therapy and chemotherapy in head, important bruxism, diabetes mellitus and autoimmune diseases, age, smoking status and early tooth decay in childhood, among others). The patient should also be asked about any previous complication during a previous anaesthetic act, the circumstances in which this happened, teeth involved and the measures that were taken in face of this event.

The anaesthesiologist should inform the patient about the risk of dental trauma, and evidence of such information must be obtained and included in the clinical process, as part of informed consent.^{1,9,16,32,34,41,42} However, the register with the delivery of this information is rarely done, which may have important forensic implications.^{4,42}

Examination of the oral cavity

The preoperative assessment should allow the anaesthesiologist to assess the conditions of intubation and the preoperative dental status of the patient.^{4,7,9,11,16-18,34,43,44} To that end, it is important that anaesthesiologists have a comprehensive knowledge of the anatomy of the teeth, of their supporting structures, of the dental pathology and the techniques used in dental restoration, in order to be able to properly identify teeth that are at risk and develop a preventive strategy.

Dental anatomy

The adult (permanent) dentition has 32 teeth, supported by two opposing bone arcs: mandible and maxilla. The dentition is divided into four quadrants, each with eight teeth (one central incisor, one lateral incisor, one canine, two premolars and three molars).

The infant (deciduous or primary) dentition consists of a maximum of 20 teeth and each quadrant is composed of five teeth (one central incisor, one lateral incisor, one canine and two molars).

The tooth is divided into two parts: the root and the crown, each with three layers. The outermost part of the crown is the enamel, which becomes fragile if it does not have a good support for the dentine, which is the yellowish intermediate layer, providing the frame of the tooth. The pulp is the innermost layer and is composed of blood vessels and nerve tissue. The root has as the outermost layer the cement, and the two innermost layers are identical to those of the crown. The periodontium is the tissue surrounding and giving support to the tooth; it is composed of gingiva, alveolar bone and periodontal ligament. The anatomy of the tooth can be seen in Fig. 1.

Dental pathology

Any disease that affects the crown, root or alveolar bone turn the tooth more vulnerable to injury and more susceptible to be fractured or dislocated, when a pressure is applied

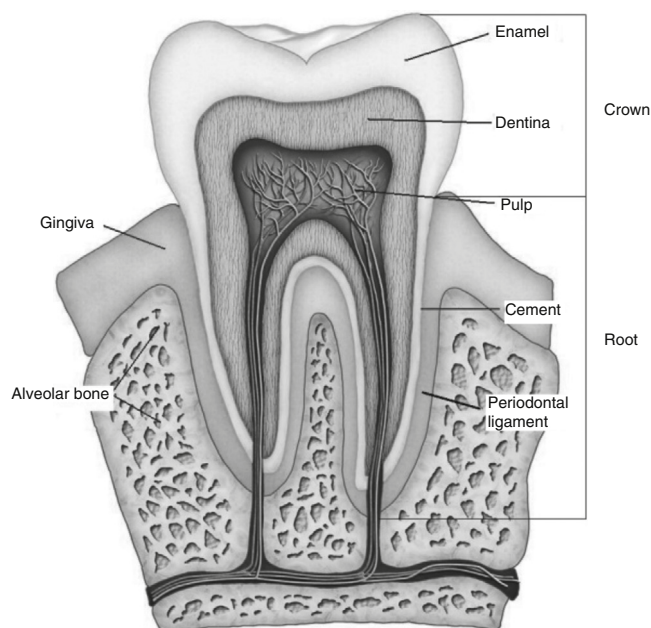


Figure 1 Dental anatomy.

on it.^{5,16,25} Therefore, it is important that the anaesthesiologist is aware of the diseases that affect teeth and be able to identify altered teeth.

The disease that most often affects teeth is dental caries. This disease involves a softening or dissolution of outer layers of the teeth by the action of acid-producing bacteria, which leads to a weakening of the tooth structure. The treatment of caries involves removal of the tooth portion with caries and its filling with restoration material; this turns the tooth physically more fragile and prone to injury.

Periodontal disease is a common dental pathology, characterized by a painless inflammatory process, which involves bacterial infection of the periodontium and that usually manifests in adults in the form of inflamed gums, gingival recession and accumulation of tartar. The pathophysiologic mechanism involves the slow dissolution of the bone supporting the teeth and of periodontal ligament, and leads to increased tooth mobility. Consequently, the affected teeth exhibit greater vulnerability to subluxation or avulsion, even when exposed to minor forces. The evaluation of tooth mobility is an important aspect in the examination of the condition of the periodontium and may be made by palpation of each individual tooth. The systematic use of preoperative tests for detection of periodontal disease, as Periotest Technique, is not indicated.^{31,35} In the presence of an advanced periodontal disease, tooth extraction is usually the treatment of choice to prevent avulsion.⁴⁵

Patients who present with decayed or restored teeth in some way (filling with composite, prostheses, crowns, etc.), as well as those with significant periodontal disease, are classified as people with existing dental abnormalities.

Odontogram

The result of the preoperative assessment of the oral cavity status should be documented in a simple, objective and easy to understand way. Although there is not yet a standardized

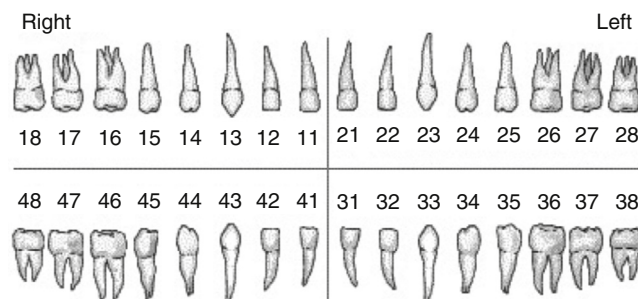


Figure 2 Numbering system of the Fédération Dentaire Internationale (FDI) – the most widely used system in the numbering of teeth in Portugal.

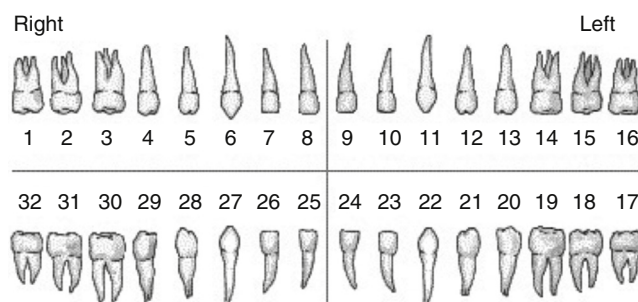


Figure 3 Universal numbering system.

and universal method for this procedure, several authors have proposed a model of documentation.^{1,2,17,33} A simple diagram with a brief written description of the altered teeth may be sufficient.⁹ The numbering systems illustrated in Figs. 2 and 3 can be used as a basis for this description. In Portugal, the most used system in numbering of teeth is that of the Fédération Internationale Dentaire (Fig. 2), in which each tooth is designated by two digits: the first determines the quadrant to which the tooth belongs, and the second digit corresponds to the number assigned to the tooth. The quadrants are determined clockwise, starting by the quadrant corresponding to the right half of the jaw.

In the United States of America the Universal Numbering System (Fig. 3) is used. In this system, the teeth are sequentially numbered from 1 to 32, being present or not. The numbering of the teeth is taken as if we were facing the patient, beginning in the right (quadrant) upper (maxillary) third molar, proceeding clockwise through the left maxillary quadrant and then through the left mandible quadrant, ending in the right lower (mandible) third molar.

Despite performing a leading role in the prevention of trauma, studies reveal that the written documentation for the preoperative assessment of the patient's dental condition is rarely found in anaesthetic dossiers.^{4,11,15,19,25}

Preexisting dental abnormalities and type of resulting injury

Dental injuries can be caused by several mechanisms.² Thus, the dental abnormalities noted during the anaesthetic consultation expose teeth to varying degrees of risk and different types of injury.

In a patient with healthy teeth, the risk of dental injury is mainly associated with intubation difficulties. In these cases, the lesions most frequently observed are fractures. Dental cracks often go unnoticed during the clinical examination and when they are not detected, this exposes the patient to the risk of major dental fractures during laryngoscopy. When the patient uses a prosthesis or has dental restorations, usually the injury caused by trauma is a loosening of the prosthesis or a deterioration of the restoration material, eventually in association with tooth fracture.²

In case of periodontal disease, the lesions resulting from laryngoscopy are more likely tooth subluxations or dislocations. Studies show that in the case of periodontal disease affecting maxillary teeth, the risk is associated to difficulties in intubation, not to the disease. In mandible teeth, the periodontal disease is associated to damage from biting the oropharyngeal airway, tracheal tube or a supraglottic device, not to the laryngoscopy.²

Protection

The initial preoperative evaluation determines the strategy to be followed in the handling of the airway, from the choice of the blade and laryngoscope type to the type of anaesthesia and the possible implementation of a device for dental protection. According to Nouette-Gaulain, this kind of approach is important for the prevention of dental injuries, reducing the number of claims and the costs of the litigation process.²

Having evidence of high risk of dental injury, it is important that a strategy of prevention that takes into account the time between consultation and surgery be defined. In non-urgent cases, the anaesthesiologist may suggest a consultation with a stomatologist/dentist,^{1,9,13,42} in which dental and periodontal care can be provided, or a occlusal gutter can be used. The close cooperation between dentists and anaesthesiologists have been advocated,^{10,13,16} although without eliminating the risk of dental trauma.

Occlusal gutters

Occlusal gutters (Fig. 4) are devices manufactured of various materials, which can be of standard size or custom-made by means of an exact mould of the dental arch. The gutters diminish the risk of dental injuries by reducing the forces exerted on the upper incisors during laryngoscopy.^{2,17} However, their use seems to be feasible only in the absence of difficult intubation criteria, since they reduce the opening of the mouth, limit the visualization of the larynx and increase the difficulty of tracheal intubation.³⁶ In addition, the instability of some protectors during intubation procedures can function as a distraction, causing poor visualization and a reduced space for the introduction of the blade. Its manufacturing requires a period of time which may be important, depending on the urgency of the surgical procedure.³⁹ The use of these devices does not extend significantly the duration of intubation,²⁰ and the relationship between the applied force and the force required to cause tooth injury remains unclear.³⁹ The manufacture of a custom-made gutter allows a better quality protection



Figure 4 Occlusal gutter.

of maxillary teeth compared to standard gutters,³⁹ without aggravating the intubation conditions.²⁰

There is no consensus regarding the recommendation to the use of occlusal gutters. Some studies reserve their use for specific situations of greater risk (teeth in very poor condition),^{7,14,31,34,36,39} while others advocate the thesis that the gutters should be routinely used in all patients,^{11,17} even suggesting that its use may come to be considered as the standard of good medical practice.

Positioning of the head and neck

The theoretical obstacles to view the glottis during direct laryngoscopy are assigned to two groups of elements: posterior and fixed, including teeth of upper jaw, and anterior and mobile, including tongue, epiglottis and jaw. The upward and forward mobilization of the mandible and base of the tongue routinely performed by simple extension of the neck, or the mobilization to the sniff position in obese patients or with blockage of the column, increases the distance among the anterior and posterior obstacles and the sub-mandibular space, facilitating the laryngoscopy. The tensile forces required for laryngoscopy in the presence of a pronounced head tilt are less important than those in the sniff position, probably due to the reduction of the tongue volume for its mobilization during laryngoscopy.²

In general, the large inter-individual variability in the degree of traction force experienced with certain head positions forces the anaesthesiologist to change the head position, as soon as the level of traction appears exaggerated in his/her opinion, or if a tooth contact with the blade was perceived.

Available blades in new devices

The number 3 Macintosh blade is classically used for tracheal intubation,⁴⁶ whatever the risk of dental trauma. However, a range of other blades and new intubation devices, whose characteristics can present interesting advantages in the

reduction of dental trauma associated with laryngoscopy, is available.

The non-collared- (Bizzarri-Guiffidra) or low collared- (Cranwall) blades were designed to minimize the risk of injury of the upper incisors, but these devices are not much widespread. A modified Macintosh blade with a more reduced heel at the proximal end increases the distance between the blade and the teeth and reduces the number of contacts without changing the view of the larynx; therefore this device may be a good choice to the classic Macintosh blade in selected cases.⁴⁰

Compared to Miller blades (straight), the Macintosh blades facilitate the intubation, because these devices provide a larger space for the passage of the endotracheal tube in patients with predictive criteria for difficult intubation. However, the straight blades provide better line of glottic sight and may be advantageous in certain situations. Watanabe et al.⁴⁷ report the use of the Belscope blade (angled blade) as an absolute indication in patients with only one tooth.

The plastic blades have a lower potential for tooth fracture compared to metal blades. Nevertheless, they are not indicated for difficult intubations, because of the greater degree of force required in these situations.⁴⁸

The supraglottic devices (laryngeal tube and mask) are of size, shape and composition quite different, according to the manufacturer. The laryngeal mask produces an incidence of dental injuries up to six times lower than laryngoscopy.^{1,10,31,49,50}

More recently, a large number of new devices for intubation has been introduced in the market.⁵¹ One of the options are the videolaryngoscopes, among which the indirect laryngoscopes such as GlideScope, EVO2 Truview and McGrath Series 5, allow the visualization of the glottis without aligning the oral axis with the pharyngeal and tracheal axes and appear to have advantages in relation to the Macintosh laryngoscope.^{52,53} These devices require the use of a preformed endotracheal tube with a stylus, unlike the Airtraq and Pentax AWS devices, which are also indirect laryngoscopes available in various sizes, but having a channel that guides the endotracheal tube towards the glottic opening. We can count also with the Storz V-MAC/C-MAC and the MacGrath MAC laryngoscopes, which combine blades identical to the Macintosh with videotechnology and can be used for conventional direct laryngoscopy, or as an indirect videolaryngoscope.

The Bonfils videolaryngoscope is a device that can be used with a retromolar introduction in cases of a limited mouth opening and of vertebral column at risk.

Available information suggests that new devices may come to play a key role in handling the airway, especially as an option in cases of planned or unplanned difficult intubation, or in the event of a failed intubation.⁵¹ It is also suggested that these devices will be able to reduce the risk of dental trauma associated with orotracheal intubation.^{2,17,51,52} However, studies that establish in a clear and objective manner the exact role of these devices in dental trauma are still in need, especially when compared to the classic laryngoscopy with the Macintosh blade. The acquisition of skills and experience in their handling is essential for their use to be successful in any clinical setting.⁵¹

Forensic implications of tooth injury

Perioperative dental injuries, as well as all iatrogenic injuries, raise the problem of forensic liability, in this case with the utmost importance, since these are the most frequent of all forensic claims related to anesthesia^{1,5,19–22} and the event also includes the largest number of complaints against anaesthesiologists for medical malpractice.^{2,4–7,23}

Although the incidence of dental injuries is important, only a third of them result in complaints⁴ and only a minority is entitled to compensation, with a low financial impact.^{4,7} This contrasts with the common idea that these injuries cost little money to the hospital, but considering its frequency the overall cost would be high.⁴

The discrepancy between the incidence of injuries and the number of complaints may be linked to the fact that patients do not know about the opportunity to do so, or that they are discouraged by the legal and administrative complexity associated with all this process. On the other hand, some patients are aware of their previous poor dental status and believe that the occurrence of injury is not the direct responsibility of the health unit; besides, the patient may feel that his/her dental injury is just a collateral damage in the treatment of an often complicated condition. The inability to evaluate the quality of explanations given to the patient and the psychological care offered by the anaesthesiology team after the accident constitute a difficult to evaluate and potentially relevant factor in the decision to make a contestation.⁴

The dental injury occurs even in the absence of negligence;^{16,17} to prove that the anaesthesiologist did not pay the elementary health care can be a difficult and expensive task.^{1,41}

Conclusion

In general, the studies support the conclusion that, before initiating any medical procedure that requires the use of classic laryngoscopy, a thorough and detailed pre-anesthetic evaluation of the patient's dental condition is imperative. This assessment should identify teeth at risk, analyze the presence of factors associated with difficult intubation and outline a prevention strategy that is tailored to the risk of dental injury of each patient. It is also essential that the patient be informed of the risk of tooth injury associated with laryngoscopy; on the other hand, it must be registered in writing that this information was conveyed to him/her. The adoption of these measures is crucial for the prevention of dental injuries, for the defence of the physician in any forensic conflict, and to reduce costs associated with the treatment and litigation process.^{2,4,7,17}

Conflicts of interest

The authors declare no conflicts of interest.

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