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Review

Dental Trauma Associated with Anaesthesia

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SUMMARY

Damage to teeth is the most common complaint against anaesthetists. A dental history and oral examination are important before anaesthesia. Pre-existing dental pathology or the presence of prostheses makes damage more likely but sound teeth may be affected. The maxillary central incisors are most at risk. Certain diseases and drugs should alert anaesthetists to increased likelihood of dental pathology. The flange of the Macintosh blade appears responsible for much damage and alternative equipment or techniques of endotracheal intubation should be considered, particularly when risk factors are present. Manoeuvres to protect teeth must not impact adversely on airway management. Custom mouthguards can be useful. A management plan can help control losses if damage does occur. Patients should be warned about the possibility of dental trauma.

Key Words: ANAESTHESIA: endotracheal intubation, complications, adverse outcomes, dental trauma, negligence, risk, malpractice

Damage to teeth has long been associated with general anaesthesia and especially endotracheal intubation. Over sixty years ago, Magill recommended using a piece of adhesive plaster to protect the teeth when using the laryngoscope, and noted that with "blind (nasal) intubation" there was no risk of damage to teeth[1]. In 1943 Macintosh described the curved blade most widely used today, observing that the straight blade occasionally "jeopardizes the patient's upper teeth"[2]. It was claimed that the open top of the curved blade decreased the risk of dental injury[3]. The plethora of subsequent descriptions of devices and techniques to facilitate endotracheal intubation prompted Sykes to write "There is no living anaesthetist who holds the distinction of not having designed one or more"[4]!

Despite the progress in intubation techniques, damage to teeth is still the commonest cause of complaint against anaesthetists. Perhaps "routine" intubation should be approached differently. Anaesthetists should know which, why and when teeth are at risk during anaesthesia and how to manage this risk. Prevention can be based on analysis, control and management of "accidents"[5]. Should damage to teeth occur, a pre-arranged management plan can minimize trauma, control losses and may avoid litigation.

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The Magnitude of the Problem

Reviews of claims made to medical defence organizations in England[6,7], data from the Risk Management Foundation[8], closed claims analysis by the National Association of Insurance Examiners in the U.S.A.[9] and a review of anaesthesia-related claims in South Australian public hospitals between 1989 and 1998 (personal communication—Dr C. Farmer, LADD Australia 1998) confirm that dental injuries are the most common anaesthetic-related event reported, accounting for up to a third of incidents.

Surveys of anaesthesia-related dental trauma show an incidence from 0.02% to 0.7%[9, 11-16] (Table 1). The incidence of dental damage in patients with otherwise "good" dentition is approximately 0.08%[16]. In these reports, dental trauma was identified by either the anaesthetist or the patient reporting damage. In one study of 745 patients undergoing endotracheal anaesthesia formally examined by a dentist preoperatively and postoperatively, the frequency of dental trauma was 12.1% and the overall incidence of oral injuries was 18%[17]. Although the relative inexperience of

TABLE 1

Year of Report	Anaesthetics	Reports of Damage	Incidence
1971[11]	47961	34	0.07%
1974[12]	5387	37	0.7%
1986[9]	135212	1 per 1000	0.1%*
1990[13]	113074	39	0.03%
1992[14]	262850	63	0.02%
1998[15]	61139	60	0.01%
1999[16]	120086	75	0.6%

*Estimate of incidence associated with intubation.

many of the anaesthetists involved was suggested as a cause, it has recently been reported that the level of training of anaesthesia residents does not influence the risk of dental injury[15].

Naming and Numbering of Teeth

A tooth may be described by its type and position in the mouth, e.g., upper left central incisor. For speed of identification of multiple teeth, identification systems are used by dentists. In Australia, a two-digit system recommended by the Federation Dentaire Internationale (FDI) is in common use. The first digit indicates the quadrant and the second digit indicates the tooth within the quadrant. The quadrants are numbered clockwise from the right upper quadrant and the teeth are numbered from the midline. Thus, the upper left lateral incisor is described as tooth "two two", and this is written as 22.

Numbering of deciduous teeth uses the same pattern but the quadrants are numbered 5 to 8.

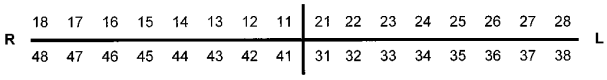

FIGURE 1A: The numbering system (FDI) usually used for permanent teeth in Australia. The quadrants are numbered clockwise from the upper right and teeth in each quadrant are numbered from the midline.

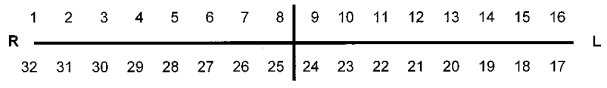

FIGURE 1B: System of numbering used in U.S.A.

The system used in the U.S.A. describes teeth numerically clockwise round the mouth. Thus, the upper right third molar tooth is number 1, the upper left third molar is number 16 (pronounced "sixteen"), tooth number 17 is the lower left third molar and the right lower third is 32. The deciduous teeth are described in an analogous fashion using letters and starting with "a". The FDI system will be used in this review.

Risk Management

There are three strategies to be considered in risk management[18]:

1. Risk avoidance: Minimizes the incidence of events.
2. Damage control or loss prevention: Minimizes the magnitude of damage should an adverse event occur (especially prompt treatment of the injury).
3. Risk transfer or insurance: All or part of the economic consequences of the damage may be transferred to a third party in exchange for a premium.

Each strategy can be considered in relation to dental trauma and anaesthesia.

Risk Avoidance

Structural Risk Avoidance

Planning is an essential part of risk management. The structural interventions that are possible relate to patients, anaesthetists and the environment of the institution.

As part of preparation for elective surgery, it may be appropriate for patients with a dental condition that puts them at higher risk of dental injury to be referred to their dentist for treatment before anaesthesia. A warning of the possibility of damage to teeth despite care should be routine and a documented part of obtaining consent for anaesthesia. Written patient information such as *Anaesthesia and You* published by the Australian Society of Anaesthetists[19], (and available on the WWW[20]) may be useful in raising these issues.

There should be documentation of the dental examination in notes on the pre-anaesthetic consultation[21]. Significant findings should be noted[9], although the limitations of anaesthetists conducting dental examinations without formal training, lighting or mirrors have been highlighted[22]. Ideally a comprehensive description of which teeth are present, and whether they are loose, carious, cracked, chipped, or straight and the presence of dental restorations should be recorded. In children, the position of recently erupted incisors and any deciduous crowns about to be shed should be noted.

There should be a check for dental damage after intubation, after extubation and after recovery and any significant finding noted. Failure to notice damage and not to know when it occurred will often complicate subsequent management.

Which Teeth are at Risk of Damage?

The upper central incisors are most at risk of dental injury[5,9,17]. The left upper (maxillary) central

incisor (21) may be at greater risk[9,17], highly suggestive of laryngoscopy being a major factor.

Damage is around five times more likely when there is a pre-existing dental condition[9,17,23]. Anterior crowding increases the likelihood of damage[17] and isolated teeth appear to be at particular risk[17]. Generally only one tooth is damaged but simultaneous trauma to two, three and even four teeth has been described[24-26].

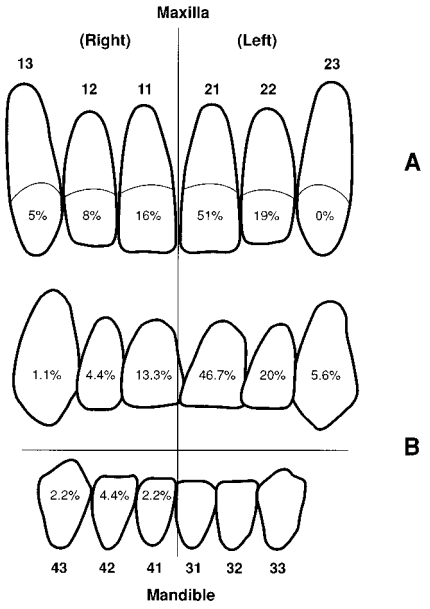

FIGURE 2: The distribution of dental damage reported by A) Lockhart et al[9], 1986 (n=20) in 20 patients and B) Jaw-Jen Chen et al[17] (n=90). The teeth are numbered using the FDI nomenclature. Tooth 21, the left upper central incisor, appears most at risk of damage.

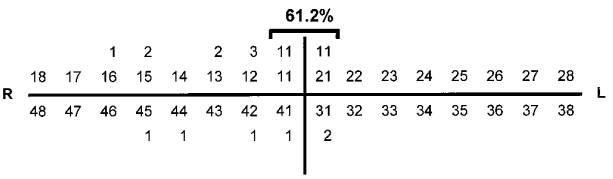

FIGURE 3: The number of occurrences of trauma to teeth in a recent report of the distribution of dental damage[15]. This report suggests both upper central incisors are at greatest risk but that even lower teeth can be damaged.

Developmental Aspects

Neonates

Laryngoscopy in neonates can result in enamel hypoplasia and dilaceration of primary incisors[27,28]. Dilaceration is the inducement of a sharp angle in the crown or root of a tooth due to a traumatic shift in the first part of the root, which is usually calcified, relative to the soft tissue forming the rest of the tooth.

Infants and Young Children

Occasional infants will have rampant caries. Care must be taken during laryngoscopy to avoid damaging delicate erupting teeth or dislodging those about to be shed. Force applied to a calcified deciduous tooth can damage the underlying developing permanent tooth. After eruption, the roots of teeth are not complete for months (deciduous teeth) or years (permanent teeth)[28]. The eruption times of the anterior teeth are listed in Table 2. Children with low birth-weight and short gestational age have delayed dental development[28]. Indigenous Australian children may have a very high incidence of dental pathology[29].

TABLE 2
Eruption and development of teeth (adapted from reference 28)

Tooth	Eruption Times	Root Completed
Deciduous teeth		
Central Incisor	~10 months (8-12)	18 months
Lateral Incisor	11 months (9-13)	2 years
Canine	19 months (16-22)	3.25 years
Permanent dentition		
Central Incisor	7-8 years	10 years
Lateral Incisor	8-9 years	11 years
Canine	11-12 years	13-15 years

Adolescents and Young Adults

Caries may still be a problem in some groups but, in Australia at present, most of this age group has a full set of teeth and few restorations. Many will have had orthodontic treatment to align their teeth. Orthodontic treatment may induce tooth mobility and root resorption. An arch wire may provide only limited support. The most likely damage to be noticed in this group of patients is enamel infraction of central upper incisors. These patients are usually very concerned about the appearance of their teeth and may be more likely to submit claims beyond simple repair.

Middle Age

The current generation of middle-aged Australians are likely to have a full set of teeth, often with much restorative dentistry and abnormal alignment. Periodontitis is common. In a survey from the U.S.A., an average of three to four teeth were affected in about 30% of adults and 40% had attachment loss[30].

The Elderly

Elderly patients are more likely to be edentulous but, increasingly, older Australians are seeking to retain even a few teeth and isolated teeth are more at risk of dislodgement. Gums require as much protection as teeth, as damage to gums may prevent den-

tures being worn after surgery. Old age is associated with decreased salivary flow and the elderly are more likely to have been prescribed drugs that contribute to xerostomia (Table 3). Both can lead to periodontal disease and loose teeth. Teeth may be brittle, weakened by restorations, attrition or erosion. The palatal surface may be particularly worn, leading to increased risk of enamel infraction or enamel fracture. Osteoporosis is associated with resorption of tooth-supporting alveolar bone[31].

TABLE 3
Classes of drugs that may give rise to xerostomia

Anticholinergics
Anticonvulsants
Antidepressants
Antihistamines
Antipsychotics
Antiparkinsonian medication
Antihypertensives
Diuretics
Opioid analgesics
HIV—AIDS therapy
Immunomodulators

When and Why Are Teeth Damaged During Anaesthesia?

Healthy teeth are very strong and are designed to withstand the enormous pressures generated during biting and chewing. The structure of a normal tooth is shown in Figure 4. Insertion, manipulation or removal of almost any airway or suction device in the mouth can result in damage[32]. Biting and grinding of teeth during recovery may also cause dental and oral injuries.

Risk will vary not only with different equipment but also with the technique with which it is used. Damage to teeth is more likely in a number of circumstances:

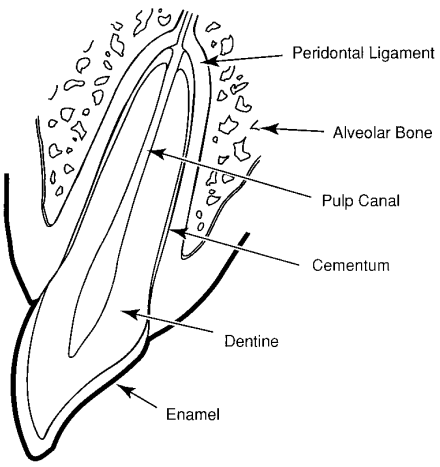

FIGURE 4: The structure of a normal tooth.

1. Pathologically weakened teeth (e.g., caries or restorative dentistry) may be damaged by small forces that would be expected to leave healthy teeth intact.
2. Poor intubating technique (e.g., using teeth to pivot the blade of a laryngoscope) can give rise to excessive forces on teeth[33].
3. Forces may be applied to teeth in directions not usually encountered in daily living (e.g., lateral), by airway or suction devices, especially if the patient is uncooperative.
4. Biting on airway or suction devices may cause damage[34]. The large forces generated during chewing are normally absorbed by the molars and premolars which are in direct opposition, whilst the upper and lower incisors slide over each other and form a "lap joint". Airways are designed to lie in the midline so that if a patient bites on one, the forces will tend to push the anterior teeth forward and may dislodge or fracture them[34,35]. Anterior crowns are at particular risk[24].
5. Deciduous teeth have shallow roots and are prone to dislodgement[11,17,23], especially between five and nine years of age, when there is root resorption and rapid development in the upper anterior region of the dental arch[34].
6. In neonates, laryngoscopy and intubation may lead to abnormal development of underlying teeth[36].
7. A number of genetic defects, diseases and drugs affect the structure of teeth or their fixation and the risk of trauma is increased. The most common of these are discussed below.

Dental Pathology

A wide range of conditions affect teeth and can lead to increased risk of damage or dislodgement. Direct questioning of the patient is important as modern dentistry is extremely sophisticated and even the trained eye may find it difficult to detect a crown or implant.

Dental caries: Cavities weaken teeth and make fracture more likely.

Periodontal disease: When the bony support of the tooth is lost due to periodontal disease, teeth are dislodged more easily.

Erosion or attrition: Old age or habitual bruxism may lead to worn or chipped teeth that may be more prone to enamel chipping.

Resorption: Resorption is a destructive process resulting in loss of tooth structure. It may be internal or external and involve the crown or the root leading to increased risk of fracture or dislodgement.

Restorations: Cavity preparation for fillings weakens the tooth as it involves removal of some of the tooth's structure[37].

Rebuilding with composite resins: This gives an excellent cosmetic result but the rebuilt tooth is weaker than a natural tooth.

Devitalized teeth and root canal therapy: "Dead" teeth are more brittle than live teeth and are more likely to fracture under load.

Crowns: Crowns (also known colloquially as "caps") are designed to withstand moderate axial loading during eating. The term "crown" encompasses a number of different techniques and materials that have different characteristics when stressed. Crowns on "short" posts may be dislodged. Full length posts are stronger but may split the tooth vertically. Porcelain jacket crowns may fracture on impact, often leaving the rest of the tooth intact, while porcelain bonded (to metal) crowns translate the force to the core resulting in a root fracture. Thus, functionally stronger crowns may translate forces of unusual magnitude or direction into unfavourable fractures of the remaining tooth[37,38] (Figure 5a and b).

Bridges: The dental bridge is a prosthetic tooth (or teeth) supported by abutments, which may be crowns. Bridgework can be extensive (Figure 6) and is prone to damage during anaesthesia. Natural teeth are used to support bonded or acid-etched bridges. A bridge is readily displaced or detached by force.

Veneers: Porcelain veneers are generally strong and dislodgement is very unlikely but they can be chipped, cracked or crazed[39]. Composite resins are now widely used to create a veneer and if this includes the incisal surface it may be prone to chipping. Patients who have veneers may be particularly concerned about their appearance and require special attention[40].

Isolated teeth: Isolated teeth are more likely to be damaged or dislodged, because forces are borne by that tooth without the support of adjacent teeth. The conditions responsible for the loss of adjacent teeth are often present in the isolated tooth.

Implants: There are several types of implant system in clinical use. Implants can be used for single tooth replacement (see Figure 7), multiple teeth replacement or even complete arch replacement. Implants should be quite strong but if damaged are expensive to replace.

Abnormally positioned teeth: These are more likely to be loaded with lateral forces and so are more likely to be loosened, fractured or avulsed, particularly if already loose.

Previous dental trauma: Injury to the jaw or face may have dental consequences. In recent injury, teeth

FIGURE 5a

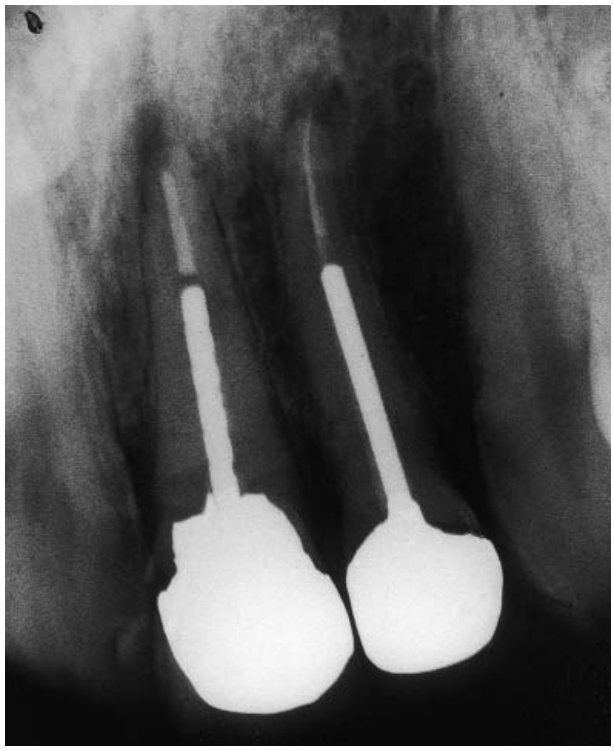

FIGURE 5b

FIGURE 5a AND 5b: These radiographs demonstrate different types of crown. The metal post and core and the root canal filling material are obvious. In Figure 5a, the crown is attached to a short post which may break under load. It may be possible to affix a new post and crown. In Figure 5b the crowns are attached to long posts in the root canal. Forces transmitted to the post and core may fracture the root longitudinally leading to loss of tooth. Functional repair will require an implant or a bridge.

FIGURE 6: A large amount of restorative dentistry is seen on this orthopantomogram. Of most significance to anaesthetists is the extensive (and expensive) bridgework including the anterior teeth.

FIGURE 7: This radiograph shows an implant replacement for a single tooth in which the prosthetic crown is cemented onto the abutment (arrowed). The abutment is attached to the threaded titanium fixture by an internal gold alloy screw. This type of prosthesis is subject to damage and failure during laryngoscopy.

may be loose. Old trauma may have left a devitalized and more brittle tooth and a fractured root would make dislodgement more likely (Figure 8).

Disease and Drugs Affecting Teeth

A number of medical conditions and treatments make teeth more likely to be damaged or lost and these include the following:

FIGURE 8: The transverse root fracture of this incisor was the result of a fall. Only minimal levering force on this tooth during a laryngoscopy would be required to dislodge the crown.

Disease and Treatment That Affect Normal Tooth Development

Many genetic abnormalities can give rise to dental pathology[41]. In Down's syndrome, the periodontal ligament is abnormal, impairing tooth fixation. Osteogenesis imperfecta may be associated with dentinogenesis imperfecta, in which the dentine is poorly formed or softer than usual. The enamel fractures readily and the roots are slender and very prone to fracture. In amelogenesis imperfecta the enamel is poorly formed or absent and the teeth are very weak. Some metabolic disorders, e.g., hypophosphataemic vitamin D resistant rickets[42], result in weak teeth through disturbed enamel formation.

HIV—AIDS

Patients with HIV—AIDS may have both loose and weak teeth from HIV periodontitis, a rapid

destruction of alveolar bone and xerostomia which results in increased caries. In these patients there are two possible causes of xerostomia, a direct effect on the salivary glands, showing multiple cysts and a T cell infiltrate[43] and drug therapy. (See below).

Disease or Treatment That Reduces Salivary Flow

Xerostomia may be due to drugs or disease and can lead to rampant decay (caries) and to loss of teeth. Causes of xerostomia are listed in Table 4. The decay can rapidly undermine the whole crown of the tooth so that it fractures when a small force is applied to the tooth. Detailed visual inspection may reveal a large carious lesion near the gingiva but lesions may not be obvious unless overlying plaque is removed. Many drugs reduce salivary flow[43] and can have a significant deleterious effect on teeth, particularly when multiple drugs are used and in the elderly. Classes of drugs that may cause xerostomia are listed in Table 3.

TABLE 4
Causes of xerostomia

Sjögrens syndrome
Drugs
Diabetes mellitus
Therapeutic irradiation
HIV—AIDS
Sarcoidosis
Amyloidosis
Absent or abnormal salivary glands

Blood Disorders

A number of blood dyscrasias, particularly leucocyte adhesion deficiency, are associated with early onset periodontitis and loose teeth[44].

- Difficult intubation
  Tooth damage is more likely when intubation is difficult[9]. When factors that might make intubation difficult are present[45-49], this should be explained to the patient. Emergency surgery also appears to be associated with increased risk of dental damage[9,24].
- Process risk avoidance
  A consistent procedure for documenting dental checks and warnings and advice given to patients will aid risk avoidance.

What Anaesthetic Techniques Might Reduce Dental Trauma?

The majority of anaesthesia-related dental trauma is associated with intubation. Training in intubation should emphasize minimization of the forces[50] applied to teeth but not compromise safe airway management.

Use of a Technique That Does Not Involve Using a Laryngoscope

Blind nasal intubation. One of the reasons given by Magill for developing this technique was to avoid damage to teeth[1].

LMA or COPA®. The use of the LMA or COPA® as an alternative to intubation may decrease the incidence of dental trauma. Forceful removal or the use of an oropharyngeal airway as a "bite-block" makes damage to anterior teeth and other complications more likely[35,51].

Light intubating stylets. The Trachlight® and Lightwand® avoid the need for direct visualization of the larynx and can reduce the incidence of trauma to teeth[52-54].

Fibreoptic intubation. The use of a "fibrescope" for endotracheal intubation has been recommended to reduce the incidence of damage to teeth during difficult intubation[24]. Fibreoptic intubation is used routinely in some institutions[55].

The Augustine Guide. The Augustine Guide, developed to facilitate intubation in patients with difficult airways[56], has been described as "non-traumatizing" in trials in both routine and difficult airways[57].

- Techniques of intubation that reduce contact with incisors

Videotape assisted training can provide feedback about intubation[58] and may be used to rectify errors in technique[59].

The lateral approach for difficult intubation may reduce contact with the incisors[60].

Equipment Designed to Reduce Contact with Teeth

Modifications of Laryngoscope Blades

The straight Magill blade (Figure 9a) and curved MacIntosh blade (Figure 9b) are both associated with damage to teeth. There are a number of modifications, particularly of the flange or vertical component, that may decrease contact with the incisors.

The Bizzari-Guffrida[61] blade has no flange at all (Figure 9c). The Bucx modification[62] of the Macintosh blade removed the section of flange that makes contact with the upper teeth. The Bellscope blade has a flange but "can be considered a short straight blade (to get around tight corners) with an offset handle designed to avoid contact with the upper teeth"[63]. Of four laryngoscopes studied, the Bellscope had the largest distance between the upper teeth and the posterior end of the blade[64], potentially reducing the risk of damage to teeth. Dental injuries

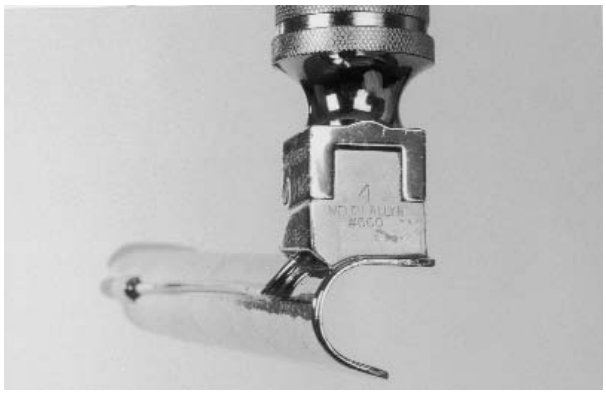

FIGURE 9a

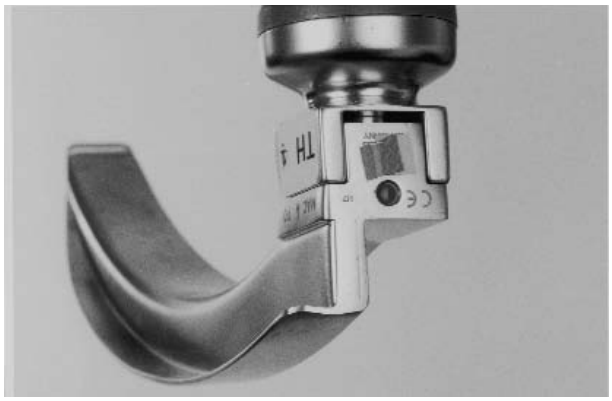

FIGURE 9b

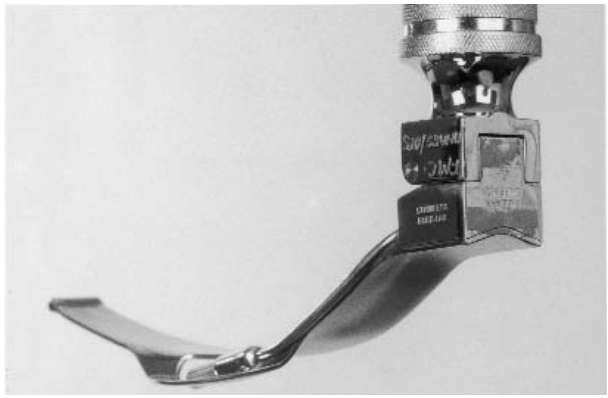

FIGURE 9c

FIGURE 9: Both the straight Magill blade (Figure 9a) and the curved Macintosh blade (Figure 9b) have flanges that are associated with damage to teeth. The Bizzari-Guffrida blade (Figure 9c) has been specifically designed to reduce dental trauma; it has no flange at all and has less of a curve than the Macintosh blade.

only occurred with the blade with the highest heel (two in 88 laryngoscopies, 2.3%)[19].

The McCoy blade[65] retains the flange of a standard Macintosh blade but the angulation of the blade tip is controlled by a lever on the handle of the laryngoscope. The ArcoMedic Flexiblade™ is similar in concept[66]. The blade can be held away from the teeth while manipulating the tip.

Other Devices

A dental protector which sits across the mouth to hold the laryngoscope blade away from the incisors and transmit forces safely to the premolars has been described[67].

Devices That Absorb or Distribute Forces on the Teeth Over a Larger Area

Adhesive plaster. Adhesive plaster can be applied to the laryngoscope blade[68] or to teeth as described by Magill in 1936[1]. Tape has minimal impact on visibility of the larynx and may reduce trauma to enamel but does not protect teeth from luxation by levering forces.

Orahesive®, an adhesive dressing designed for intra-oral use, can protect teeth and gums[69,70]. Teeth may be extracted accidentally when the adhesive bandage is removed (the authors noted that this prevents aspiration of the tooth!).

Gauze rolls and folded tape are readily available and may reduce the likelihood of chipping enamel but do not provide protection against levering forces[24].

Rubber, plastic, foam or silicone cushions. Materials that absorb force can be fixed to the laryngoscope blade[71,72] and may reduce enamel damage but will not protect against sustained force. They may create an additional airway hazard unless firmly fixed. Marks left on foam cushions after intubation may be used to indicate whether the anaesthetist has used the incisors as a fulcrum[72].

Maleable material. Lead foil[73] and thermoplastic Orthoplast® (Johnson and Johnson) have been used during endoscopy but would not be easy to use during intubation and the degree of dental protection is unknown.

Tooth protectors (mouthguards). Variability in dentition means that the fit of generic mouthguards is often imperfect. They may slow intubation[74], make it more difficult, create additional airway hazards and not provide reliable protection (four of 300 cases had dental trauma)[75]. Between generic and custom tooth-protectors are mouthguards made of a strong plastic case and a soft inner liner that can be softened in hot water allowing a personal fit, (e.g., Leuko® by Biersdorf Australia, North Ryde, N.S.W.), but their usefulness in anaesthesia has not been determined.

A custom tooth protector, professionally made from an impression of the patient's teeth, can provide significant protection against dental trauma[72,73,76,77]. They protect against tooth fractures and dislodge-

ment by both absorbing impact forces and by spreading loads across several teeth[78]. The following indications for a custom tooth protector have been suggested[76]:

- Presence of anterior crown(s) or bridgework
- Presence of "periodontally weakened" teeth
- In the five to nine years age group
- Malaligned maxillary anterior teeth
- Edentulous patients, to prevent gum lacerations.

Tooth protectors have been suggested as a "standard of care"[9]. A preoperative examination by a dentist in any patient with an increased risk of dental damage can allow remedial work to be carried out and customized mouthguards to be constructed[79]. The cost effectiveness of these interventions is uncertain. Over three years in one hospital where specialist preoperative dental examinations were performed whenever dental problems during anaesthesia were anticipated, 2162 dental protectors were made and a similar number of extractions or other dental treatments were undertaken in association with 47,061 anaesthetics. There were 34 instances of dental damage during this time, but none in patients who had received dental treatment preoperatively or had a dental protector[11]. A 10-year review of dental injury in this hospital[16] revealed 75 cases of dental trauma (0.06% incidence), eight occurring in patients where mouthguards had been used. The conclusion was that that use of a mouthguard had no significant effect on dental trauma associated with anaesthesia. A role was suggested for high risk cases undergoing endoscopy.

Oropharyngeal airways produce up to 55% of anaesthesia-related dental complications[80,81]. The oropharyngeal airway was first described by Hewitt and subsequently modified by the addition of a piece of rubber tube in an attempt to protect the teeth[82]. The Guedel airway should not be used as a bite block to protect an endotracheal tube or LMA[51], and should be removed during the convulsion associated with electroconvulsive therapy[83]. Use of an oropharyngeal airway during recovery from anaesthesia is particularly hazardous to teeth[9], especially if shivering occurs. Bruxism associated with shivering can cause dental injury even in the absence of an oropharyngeal airway[84].

Bite-blocks should sit between the posterior teeth. The bicuspid teeth are designed to tolerate axial loading whereas the forces applied to incisors during biting on a hard airway tend to produce fracture or subluxation[9,24,34].

Nasopharygeal airways cause less dental trauma during recovery than oropharyngeal airways[35,82], but have their own complications such as epistaxis.

Outcome Risk Avoidance

The occurrence of anaesthesia-related dental injury should prompt review and analysis with associated staff education and departmental policy changes to minimize the risk of recurrence and optimize the management of dental trauma (see below).

Damage Control

Dental injuries can be classified by the extent of damage[83].

- Enamel infraction: Incomplete fracture (crack) of the enamel without loss of tooth substance.
- Enamel fracture (uncomplicated crown fracture): Involves loss of tooth substance confined to the enamel.
- Enamel dentine fracture (uncomplicated crown fracture): Involves loss of enamel and dentine but not involving the pulp.
- Complicated crown fracture: Involves enamel and dentine and exposes the pulp.
- Uncomplicated crown-root fracture: Involves enamel, dentine and cementum but not involving the pulp.
- Complicated crown-root fracture: Involves enamel, dentine and cementum and exposes the pulp.
- Luxation injury: Physical movement of the tooth.
- Tooth avulsion: Loss of tooth.

A well-formulated strategy for managing dental trauma associated with anaesthesia can minimize losses. The following protocol has been suggested[86]:

- Locate the tooth or fragment as soon as safely possible and institute immediate appropriate management of the dental trauma (see below).
- Explain to the patient and (or family members as appropriate) how the damage occurred, without self-blame, and describe any efforts made to avoid the injury .
- Make an accurate report of the damage and the events surrounding the incident in the patient's record.
- Notify your own medical indemnity organization and the hospital's risk manager.
- Seek permission to arrange any dental therapy immediately required.

Generally, the anaesthetist should *not*[86]:

- Attempt to conceal or deny dental damage.
- Introduce the subject of expense or offer to pay for treatment.
- Offer to arrange non-urgent dental treatment for the patient.
- Offer an explanation if the teeth were intact when

the care of the patient was passed to the recovery room staff.

If the anaesthetist is a trainee, a supervisor should co-ordinate damage control.

Some hospitals have an arrangement where the dental department treats all dental trauma that has arisen during anaesthesia. This may result in damage being inappropriately ascribed to the anaesthetist or anaesthetic technique.

Dental Management: Avulsion or Subluxation of a Tooth

- Locate the tooth immediately to minimize risk of aspiration. This may require X-rays of the neck and chest. If the tooth has been aspirated, a bronchoscopy should be undertaken as soon as practical to recover it.
- Where possible, reimplant the tooth immediately[85], holding it in its original position by digital pressure with compression of the bone on either side. Dry storage or storage in water or saline usually results in root resorption[87].
- Seek a dental opinion as soon as possible as splinting may be required to stabilize the position of the tooth and prevent further damage to the pulp and periodontal tissues.

Healing of luxated teeth may be complicated by pulp canal obliteration, necrosis and root resorption; however, young permanent teeth subjected to luxation injury will usually heal[88].

Chipped or Fractured Tooth

The fragment(s) should be recovered and retained. The tooth remnant should be carefully examined.

- If only enamel is involved immediate dental treatment is not required.
- If dentine or pulp is exposed urgent dental treatment is required to prevent pain and infection.

If the only injury to a permanent incisor is enamel fracture, less than 2% will develop pulpal necrosis, but the prognosis is much less favourable if there is also mobility (8.5% pulpal necrosis)[89].

Broken or Dislodged Bridge, Crown or Implant

- Fragments should be recovered and retained.
- If soft tissue or pulp is exposed urgent dental treatment is required.

What Should Patients Be Told About the Possibility of Damage to Teeth During Anaesthesia?

The risk of damage to teeth should be explained to patients. Patients prefer to be informed of such risks[90] (90% in an Australian sample[91]) and this information does not increase anxiety[92,93]. Lack of information frequently gives rise to emotional problems[94]. Only in exceptional cases can pertinent information be withheld in the interests of the patient's well-being (therapeutic privilege). Whether medical practice reached the "standard of reasonable care demanded by the law … is a question for the court", not the medical profession[95]. Patient's recall of risk discussion may be poor[96], so a written record should be kept.

The patient's coping style appears to be an important determinant of the amount of information that is beneficial[83]. Good communication has the potential to decrease litigation[90,97]. Pre-admission clinics may improve disclosure of risk associated with anaesthesia[98].

Guidance by the Australian courts on the information that should be given to patients was summarized in the 1989 joint report of the Australian, Victorian and New South Wales Law Reform Commissions on Informed Decisions on Medical Procedures:

> "Information about the possibility of serious harm should normally be given even if the chance of it occurring is slight. Similarly, information should be given if the potential for harm is relatively slight, but the risk of it occurring is great." (Cited in Reference 91.)

Similar advice is given in the Australian and New Zealand College of Anaesthetists' document "Guidelines on Providing Information about Anaesthesia"[99]. Dental damage is not mentioned in this document, although other examples of adverse effects of general anaesthesia are. Despite this advice and that of Medical Defence Associations, anaesthetists in Australia do not generally disclose the risk of dental damage and even fewer document the discussion[98,100].

In New Zealand, the Accident Compensation Corporation considers that damage to teeth is an accepted risk of general anaesthesia and does not meet the criteria for personal injury by accident[24].

A review of the attitudes of U.S. courts to dental damage during anaesthesia confirmed that full preoperative disclosure of risk was appropriate[101]. The Australian High Court, in Rogers v Whitaker[102], noted that expert professional opinion will influence court judgements as to whether a practitioner has been negligent in treatment. Whether the practitioner was negligent in the *provision of information* to the patient would be decided by the court on the facts of each case. This, and subsequent judgements, such as Chappel v Hart[103], confirm the duty to inform the patient not only of risks but of alternative treatments (Marchlewski v Hunter Area Health Authority[104]) and even the risk associated with the practitioner performing the procedure compared to other prac-

titioners. Informing the patient will not protect the practitioner from liability if their practice is considered negligent[105]. Special care taken when increased risk is noted should be apparent and documented.

Who Pays for Damage to Teeth?

The anaesthetist is not responsible for the cost of managing complications of properly conducted anaesthesia[85,86]. This is also true of the anaesthetist's medical defence organization. However, even where there is no negligence, the costs of defending a claim for repairing damage to teeth are such that it will usually be settled by insurers. Claims against anaesthetists for dental damage are common but may account for only 1% of liability[106].

Usually, for a claim against an anaesthetist to succeed in court, negligence must be demonstrated. This requires that the plaintiff's lawyers show that the anaesthetist failed to meet the accepted standard of care[107]. A preoperative dental examination may be considered the standard of care[21]. Absence of a record of dental examination may make a claim difficult to defend. The doctrine of *res ipse loquiter* "the thing speaks for itself" has been used[26,101] but courts have also concluded that broken teeth are an accepted risk of laryngoscopy and not evidence of negligence per se[24,101].

The anaesthetist has a duty to ensure that avulsed teeth or dental fragments are located and removed. Failure to do so is likely to be considered negligent, even if the initial injury was not[26]. Even when bronchoscopy for retrieval of the avulsed tooth resulted in avulsion of another tooth, appropriate management has been found not to be negligent[25].

Clinical Guidelines

Guidelines on preoperative dental examinations and warnings about damage are likely to reduce the number of claims[108], particularly if the guidelines are followed. Hospitals should provide anaesthetic equipment that can reduce the likelihood of damage to teeth and anaesthetists should use it when indicated.

CONCLUSIONS

A secure airway is paramount for patient safety during anaesthesia and recovery, but any airway device may cause dental trauma. Three major risk factors for dental damage associated with anaesthesia have been reported:

- Dental pathology or the presence of dental prostheses.
- Abnormal jaw relationship and tooth alignment (which may make intubation difficult).
- Emergency surgery.

The authors add two more:

- The Macintosh laryngoscope blade.
- The oropharyngeal airway.

Dental damage may be prevented by understanding the causes and the techniques for minimizing it. Anaesthetists should warn their patients of the risk of dental trauma associated with anaesthesia. Where there are factors which increase the risk, appropriate measures to reduce the risk should be considered, applied and documented.

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