



Original Article

Quality improvement program reduces perioperative dental injuries – A review of 64,718 anesthetic patients

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Abstract

Background: Perioperative dental injury (PDI) is a common adverse event associated with anesthesia that can easily lead to medicolegal litigation. A quality improvement program was conducted with the electronic, standardized dental chart to document dentition before anesthesia and dentist consultation when necessary. This study aimed to reduce PDIs through execution of a quality improvement program.

Methods: We reviewed the 42-month interval anesthetic records of 64,718 patients who underwent anesthesia. A standardized electronic dental chart was designed to identify any dental prosthetics, fixed and removable dentures, and degree of loose teeth. The incidence of dental injuries associated with anesthesia was separated into three time periods: baseline, initiative (Phase I), and execution (Phase II). Primary outcome measurement was the incidence of PDIs related to anesthesia.

Results: The overall incidence of dental injury related to anesthesia was 0.059% (38/64,718 patients). During the baseline period, the dental injury rate was 0.108% (26/24,137 patients), and it decreased from 0.051% in the initiative period (10/19,711 patients) to 0.009% in the execution period (2/20,870 patients) during implementation of the quality improvement program. Most dental injuries were associated with laryngeal mask airway (42.1%) and laryngoscopy (28.9%). The most commonly involved teeth were the upper incisors.

Conclusion: Dental injury incidence was significantly reduced and remained at low levels after implementation of the quality improvement program. We suggest the implementation of a standardized dental examination into the preoperative evaluation system adding pathologic teeth fixed or protected devices to minimize dental injury associated with anesthesia.

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Keywords: perioperative dental injury (PDI); preoperative evaluation; quality improvement

1. Introduction

Perioperative dental injury (PDI) is one of the most common adverse events associated with anesthesia¹ that easily leads to medicolegal litigation.² The incidence of PDI has been reported to be from 0.02% to 0.1%, as determined by several large population studies.^{3–6} The most frequently reported risk factors

of PDI include preexisting poor dentition and difficult intubation.^{1,5,7} A universal dental chart has been proposed as a pre-anesthetic assessment record, to alert anesthesiologists to poor dentition.^{8,9} Adequate documentation of oral inspection enables anesthesiologists to decide whether or not to use a protective aid during the perioperative period.¹⁰ However, there is limited information focusing on use of an improvement program directly against perioperative teeth injury, with many techniques and teeth protectors to reduce the frequency of PDI.

The aim of this study was to reduce the incidence of PDI by establishing an interdepartmental quality improvement program to advance perioperative dental care. The program consisted of two consecutive interventions. The aim of the Phase I program was to increase awareness of the individual

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provider by regular quality assessment (QA) meeting and routine recording of dentition during preoperative evaluation. The aim of the Phase II program was to reduce PDI incidence by electronic standard dental documentation with preoperative dental treatment to prevent dental injury. We also analyzed all PDI cases in an attempt to identify specifically related factors and prevent PDI.

2. Methods

After obtaining approval from the Kaohsiung Medical University Hospital (Kaohsiung, Taiwan) Institutional Review Board (KMUH-IRB Number 20130280), all PDIs from a database of perioperative records covering 64,718 anesthetic cases from February 2010 through July 2013 were reviewed. This database records perioperative adverse events analyzed for the quality improvement program which were based on the reports from an institutional QA form, and teeth injury records based on the Fédération Dentaire Internationale two-digit notation. Numerals placed within the individual tooth diagram illustrate the number of injuries reported in this study for that particular tooth. The QA forms were completed by anesthesia providers and postoperative visit observers.

PDIs were defined as injuries to dentition identified by patients or anesthesia providers in the operating room, post-anesthesia care unit (PACU), ward or intensive care unit during the perianesthetic period. Patients with PDI may require dental consultation or treatment and those who did not require any intervention were also included. Patients with soft tissue or supporting structure injuries were also not included. Dental injuries were classified as damaged in the following manner: enamel fracture, enamel dentine fracture, complicated crown fracture, uncomplicated crown-root fracture, luxation injury, and tooth avulsion.

The baseline incidence of dental injuries before the Quality Improvement Program was determined from February 1, 2010 to July 31, 2011. The Phase I quality improvement program was initiated from August 1, 2011 to July 31, 2012, and a routine dentition document was implemented into an electronic preanesthetic consultation form. A standardized dental chart was designed to identify the fixed and removable dentures, and the degree of teeth mobility, while the teeth mobility was graded as normal, mild, moderate, and severe. The dental assessments were performed by an experienced registered nurse or a dental resident. The perioperative healthcare and patients safety meeting was held once every 2 weeks in the Department of Anesthesiology to alert for PDIs. We also introduced a video stylet (Trachway video intubating stylet, Biotronic Instrument Enterprise Ltd., Tai-Chung, Taiwan), video laryngoscope (GlideScope, Verathon Inc., Bothell, WA, USA), and fiber optic intubation scope (Pentax FI-13RBS and Pentax FI-10RBS, HOYA Corporation, Tokyo, Japan) as alternative choices to laryngoscopy for patients with dental pathology.

The Phase II quality improvement program was implemented on August 1, 2012, with an advanced protocol of preanesthetic consultation evaluation and constructive

treatment being introduced. First, standardized electronic dental document was done as per the previous system. Second, after the degree of teeth mobility was assessed, if moderate or severe teeth mobility was noted, a photograph was taken and uploaded to the database. Third, for patients with moderate to severe teeth mobility, staff in the preanesthetic consultation room were instructed to consult the dentist and in the operating room to consult the oromaxillofacial surgeon. Preoperative dental treatment (extraction/fixation) such as extraction or wire fixation was performed, or dental protection devices such as impression putty and mouth guards were placed. A routine dentition evaluation was a mandatory part of preoperative evaluation. The medical record of each case was reviewed for additional details regarding the location, discovery, and classification of PDIs.

Differences in the physical and anesthetic parameters of PDI cases between baseline and the periods of quality improvement program were carried out by one-way analysis of variance using the Schiff *post hoc* test. All data were entered into a database using Microsoft Excel (Microsoft Corp., Redmond, WA, USA), with statistical analysis performed with the SPSS 14.0 statistical software package (SPSS Inc., Chicago, IL, USA). All *p* values < 0.05 were considered statistically significant.

3. Results

Between February 1, 2010 and July 31, 2013, 64,718 patients underwent anesthesia in our institute. A total of 38 cases of PDI were reported. The incidence of PDI was 0.059%, or one per 1703 anesthetics. During the baseline period, the incidence of dental injury was 10.77/10,000 anesthetics. Figure 1 depicts that the PDI incidence was found to decline with time after baseline. During the initiation (Phase I) period, the PDI incidence was 5.07/10,000 anesthetics, and the PDI incidence during the execution (Phase II) period reduced to 0.96/10,000 anesthetics (Fig. 1). The incidence of PDI was significantly lower in the Phase II stage as compared to both baseline ($p < 0.001$) and Phase I stage ($p = 0.016$). The total

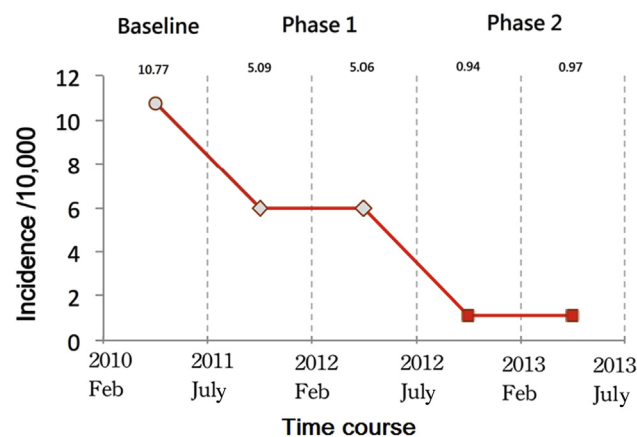


Fig. 1. The incidence of perioperative dental injuries prior to quality improvement program (baseline), initiation (Phase I) and execution (Phase II) from February 1, 2010 to July 31, 2013.

Table 1
Incidence of dental mobility and perioperative dental injury.

Time course	Case load (n)	Mobility, % (n)	Dental injury, % (n)	
Baseline	24,137	3.23 (779)	0.108 (26)	1:928
Phase I	9828	7.53 (741)	0.051 (5)	1:1966
	9883	7.04 (696)	0.051 (5)	1:1977
Phase II	10,600	9.41 (998)	0.0094 (1)	1:10,600
	10,270	9.74 (1001)	0.0097 (1)	1:10,270

case load, patients with dental mobility, and incidence of PDI in each stage are shown in Table 1.

Demographic data, American Society of Anesthesiologists physical status, anesthetic techniques, and reasons for PDIs made are shown for patients with PDI (Table 2). Most PDI cases underwent general anesthesia with either endotracheal intubation ($n = 17$) or laryngeal mask airway (LMA) placement ($n = 19$). Two cases underwent total intravenous anesthesia with oxygen delivered via nasal cannula. Most PDIs were caused by LMA insertion (31.6%), followed by laryngoscopy insertion (28.9%). Additionally, most PDIs were reported by the anesthesia provider in the operating room (Table 3). Only six (15.8%) dental injuries were discovered by patients themselves, and four (10.5%) cases were reported after being transferred to ordinary wards. These four events were

Table 2
Characteristics of perioperative dental injury (PDI) cases in time course. Data are presented as n (%).

Characteristic	Baseline (n = 26)	Improvement program (n = 12)	Overall (n = 38)	p
Age (y)				0.65
< 40	5 (19.2)	1 (8.3)	6 (15.8)	
40–65	14 (53.9)	8 (66.7)	22 (57.9)	
> 65	7 (26.9)	3 (25)	10 (26.3)	
Gender				0.16
Male	15 (57.7)	4 (33.3)	19 (50)	
Female	11 (42.3)	8 (66.7)	19 (50)	
ASA classification				0.36
II	13 (50)	7 (58.3)	21 (55.3)	
III	9 (34.6)	5 (41.6)	10 (26.3)	
IV	4 (15.4)	0 (55.3)	6 (15.8)	
Dental mobility	7 (26.9)	2 (16.7)	9 (23.7)	0.49
Anesthetic technique				0.3
ETGA	13 (50)	4 (33.3)	17 (44.7)	
LMA	11(42.3)	8 (66.7)	19 (50)	
TIVA	2 (7.7)	0 (0)	2 (5.2)	
Regional anesthesia	0 (0)	0 (0)	0 (0)	
Cause of PDI				0.35
Mouth opening	4 (15.4)	0 (0)	4 (10.5)	
Laryngoscopy	8 (30.8)	3 (25)	11 (28.9)	
LMA insertion	7 (26.9)	5 (41.7)	12 (31.6)	
LMA removal	2 (7.7)	2 (16.7)	4 (10.5)	
Oral airway	0 (0)	1 (8.3)	1 (2.6)	
Lightwand	1 (3.8)	0 (0)	1 (2.6)	
Trachway	1 (3.8)	0 (0)	1 (2.6)	
Others ^a	3 (11.5)	1 (8.3)	4 (10.5)	

ASA = American Society of Anesthesiologists; ETGA = endotracheal general anesthesia; LMA = laryngeal mask airway; TIVA = total intravenous anesthesia.

^a Others: one mask ventilation, two undergoing TIVA with nasal cannula only, one undergoing laryngeal microsurgery via mouth retractor.

Table 3
Perioperative dental injury (PDI): discovery and classification.

	n = 38	%
Discovery of dental injury		
By provider	32	84.2
By patient	6	15.8
Location of discovery		
In operation room	26	68.4
In PACU	8	21.1
In ward	4	10.5
	n = 40	%
Classification of dental injury ^a		
Subluxation	8	20
Luxation	2	5
Avulsion	14	35
Crown fracture	6	15
Damage to fixed partial denture	5	12.5
Missing tooth	1	2.5
Other injury	4	10

PACU = postanesthesia care unit.

^a Total number more than 38 due to multiple injuries. Other injury included damage to dental restorations, prosthetic crowns and dislodgment of veneers.

unable to be traced to a precise cause, and were classified into other items.

The most frequently injured teeth were the central maxillary incisors, with 15 injuries to the left upper maxillary tooth (number 21) and nine injuries to the right upper maxillary tooth (number 11). The right and left maxillary lateral incisors (tooth number 12 and tooth number 22), were less frequently injured, with three and five reports, respectively, followed by the left mandibular incisors, (tooth numbers 31 and 32) with four and two reports, respectively (Table 4).

In ranking order, the incidence of teeth injury was tooth avulsion, subluxation, crown fracture, damage to fixed partial denture, luxation, and missing tooth. Patients with damage to dental restoration, prosthetic crown, and dislodgement of veneers were included in items of other injury (Table 3).

4. Discussion

In this study, the quality improvement program was demonstrated to increase awareness of PDI by preanesthetic denture examination, and to decrease the incidence of PDI by using alternate airway-assisted instruments, as well as fixed and protective devices for pathologic teeth. To initiate the Phase I improvement program, the incidence of PDI decreased from 10.77/10,000 to 5.07/10,000 and the incidence of PDI further declined to 0.96/10,000 anesthetics following execution of the Phase II improvement program. The baseline frequency of PDI (0.108%) in our institution was high as compared to previous clinical reports;^{4–6} however, following denture examination and careful airway establishment, the PDI incidence turned out to be very low (0.0096%) at the Phase II improvement program. To prevent tooth injury during the operation, simply recording the denture examination is inadequate. The anesthesiologist should not only be considerably experienced in the use of alternate airway instruments, but ask patients to have protective devices as well.

Table 4

Location of perioperative dental injuries. Numerals placed within the individual tooth diagram depict tooth injury in this study.

	Upper right (Zone 1)								Upper left (Zone 2)							
Teeth No.	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
No. of dental injury	0	0	0	0	0	1	3	9	15	5	1	1	1	1	1	0
No. of dental injury	0	0	0	0	0	1	0	1	4	2	1	1	1	1	0	0
Teeth No.	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
	Lower right (Zone 4)								Lower left (Zone 3)							

We noted a particular phenomenon that the incidence of dental motilities increased during processing of the quality improvement program (from 7.53% to 9.74%). This phenomenon might be explained by the precise examination of the denture at the preoperative evaluation clinic. Therefore, many patients who suffered from poor dentures were identified before anesthesia. However, the incidence of PDI was reduced (from 0.051% to 0.0097%) under our quality improvement. In most studies, poor dentition was considered an important risk factor to anesthesia-related dental injury.^{5,7,11,12} The incidence of dental injury is nearly five times higher in patients with pre-existing unhealthy dental conditions;¹¹ however, we found that most of the PDI events were not associated with the grading of poor dentition (even severe mobility) because the anesthesia providers were well aware of perioperative dental care, and tried to use alternate tools instead of laryngoscopy to mitigate PDI.

In the current study, PDIs appeared to be primarily associated with LMA (42.1%), either during insertion or removal. Tracheal intubation with laryngoscopy (28.9%) was the second cause of dental injuries. In previous studies, tracheal intubation with laryngoscopy was considered a leading cause of PDIs,^{4,5,7,12,13} particularly when a glottis view was difficult to obtain. In a 14-year report of 161,687 anesthetic cases, most dental injuries occurred during oral intubation (98.7%) and only minimal dental injury was associated with LMA (1.3%).¹⁴ This discrepancy may be explained by the application of an advanced airway management device. For example, the lightwand and the Trachway intubating stylet was introduced and widely used for clinical practice and education in our department.¹⁵ When dental pathology was found during preoperative evaluation, the Trachway intubating stylet or fiberoptic intubation scope was chosen to replace direct laryngoscopy. The dental injuries due to direct laryngoscopy decreased gradually; hence, the majority of dental injuries were associated with LMA.

Upper incisors were the most frequently injured teeth (87%) related to intubation.¹ Newland et al¹⁴ reviewed 161,687 anesthetics from 1989 to 2003, and reported that 62% of the injured teeth were upper incisors and 61.5% of dental injuries were in patients aged ≥ 40 years. In that report, minor injury such as enamel fracture (32.1%) accounted for the majority of PDIs. We also found that the upper incisor teeth were the most commonly injured (63%), and 84.2% were in patients aged ≥ 40 years. However, the most frequent type of PDI was avulsion (35%), rather than enamel fracture/subluxation in our finding; 31.6% of dental injuries were discovered

in the PACU or ward rather than 9–20% of PDIs currently reported during emergency or in the PACU.^{16–19} This might be explained by the less frequent use of direct laryngoscopy in patients of dental mobility.

This quality improvement program has emphasized the assessment and prevention of dental injury to our anesthesia providers and trainees. A dental assessment is a mandatory part of our electronic preoperative evaluation system, and a standardized dental diagram is included online. To ensure the complete dental and airway assessment, we have prepared an independent trainee to develop the dental diagram and difficult airway parameters of each patient before preoperative evaluation visit. After the completion of dental and airway assessments, our anesthesiologists will decide the dentistry consultation when appropriate in the preoperative evaluation clinic. Yasny¹⁹ suggested a 3-0 silk suture for prevention of dental injury. In our institution, a wire suture is commonly used to wrap around the gingival margins of the mobile and adjacent teeth for better stability.

Several limitations of the study are as follows. Although the dental injury data was gathered prospectively, this observational study was a retrospective design. The data after the quality improvement program was not shown; therefore, it was not clear whether the method continued to maintain a low incidence of dental injury.

In conclusion, PDI incidence was significantly reduced after implementation of a dental care quality improvement program. In our department, education and promotion of perioperative dental assessment and protection may further maintain an already-low frequency of PDIs.

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References

- Givol N, Gershtansky Y, Halamish-Shani T, Taicher S, Perel A, Segal E. Perianesthetic dental injuries: analysis of incident reports. *J Clin Anesth* 2004;**16**:173–6.
- Cass NM. Medicolegal claims against anaesthetists: a 20 year study. *Anaesth Intensive Care* 2004;**32**:47–58.
- Adolphs N, Kessler B, von Heymann C, Achterberg E, Spies C, Menneking H, et al. Dentoalveolar injury related to general anaesthesia: a 14 years review and a statement from the surgical point of view based on a retrospective analysis of the documentation of a university hospital. *Dent Traumatol* 2011;**27**:10–4.
- Lockhart PB, Feldbau EV, Gabel RA, Connolly SF, Silversin JB. Dental complications during and after tracheal intubation. *J Am Dent Assoc* 1986;**112**:480–3.

5. Warner ME, Benenfeld SM, Warner MA, Schroeder DR, Maxson PM. Perianesthetic dental injuries: frequency, outcomes, and risk factors. *Anesthesiology* 1999;**90**:1302–5.
6. Gaiser RR, Castro AD. The level of anesthesia resident training does not affect the risk of dental injury. *Anesth Analg* 1998;**87**:255–7.
7. Owen H, Waddell-Smith I. Dental trauma associated with anaesthesia. *Anaesth Intensive Care* 2000;**28**:133–45.
8. Gatt SP, Aurisch J, Wong K. A standardized, uniform and universal dental chart for documenting state of dentition before anaesthesia. *Anaesth Intensive Care* 2001;**29**:48–50.
9. Gaudio RM, Feltracco P, Barbieri S, Tiano L, Alberti M, Delantone M, et al. Traumatic dental injuries during anaesthesia: part I: clinical evaluation. *Dent Traumatol* 2010;**26**:459–65.
10. Gaudio RM, Barbieri S, Feltracco P, Tiano L, Galligion H, Uberti M, et al. Traumatic dental injuries during anaesthesia. Part II: medico-legal evaluation and liability. *Dent Traumatol* 2011;**27**:40–5.
11. Vogel J, Stubinger S, Kaufmann M, Krastl G, Filippi A. Dental injuries resulting from tracheal intubation—a retrospective study. *Dent Traumatol* 2009;**25**:73–7.
12. Burton JF, Baker AB. Dental damage during anaesthesia and surgery. *Anaesth Intensive Care* 1987;**15**:262–8.
13. Chadwick RG, Lindsay SM. Dental injuries during general anaesthesia. *Br Dent J* 1996;**180**:255–8.
14. Newland MC, Ellis SJ, Peters KR, Simonson JA, Durham TM, Ullrich FA, et al. Dental injury associated with anesthesia: a report of 161,687 anesthetics given over 14 years. *J Clin Anesth* 2007;**19**:339–45.
15. Tseng KY, Chau SW, Su MP, Shih CK, Lu IC, Cheng KI. A comparison of Trachway intubating stylet and Airway Scope for tracheal intubation by novice operators: a manikin study. *Kaohsiung J Med Sci* 2012;**28**:448–51.
16. Aromaa U, Pesonen P, Linko K, Tammisto T. Difficulties with tooth protectors in endotracheal intubation. *Acta Anaesthesiol Scand* 1988;**32**:304–7.
17. Rosenberg MB. Anesthesia-induced dental injury. *Int Anesthesiol Clin* 1989;**27**:120–5.
18. Chadwick RG, Lindsay SM. Dental injuries during general anaesthesia: can the dentist help the anaesthetist? *Dental Update* 1998;**25**:76–8.
19. Yasny JS. Perioperative dental considerations for the anesthesiologist. *Anesth Analg* 2009;**108**:1564–73.