



Evaluation of dental status using a questionnaire before administration of general anesthesia for the prevention of dental injuries

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Background: Dental evaluation and protection are important for preventing traumatic dental injuries when patients are under general anesthesia. The objective of the present study was to develop a questionnaire based on dentition-related risk factors that could serve as a valuable tool for dental evaluation and documentation.

Methods: We developed a questionnaire for dental evaluation before administration of general anesthesia, investigated the association between patient-and-dentist responses and mouthguard fabrication, and assessed response agreement between 100 patients.

Results: Protective mouthguards were fabricated for 27 patients who were identified as having a high risk of dental injury. There was a strong association between dentists' responses and mouthguard fabrication, depending on the general oral health status, use of ceramic prosthesis, presence of masticatory pain related to periodontal diseases, gingival edema, and implants ($P < 0.05$). Response agreement between patients and dentists for items related to dental pain, loss of dental pulp vitality, root canal therapy, dental trauma, aesthetic prosthesis, tooth mobility, and implant prosthesis was high (Cohen's kappa coefficient $\kappa \geq 0.6$).

Conclusions: A high agreement was observed between patient-dentist responses and a strong association with mouthguard fabrication for items pertaining to ceramic prosthesis, masticatory pain, and dental implants. Patients with a "yes" response to these items are recommended to undergo a dental evaluation and use a dental protective device while under general anesthesia.

Keywords: Anesthesia, General; Mouth Protectors; Surveys and Questionnaires.



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INTRODUCTION

The incidence rate of dental injuries during surgeries that require the establishment of general anesthesia is 0.02-0.7%; however, the actual incidence rate is anticipated to be higher, up to 12.1% [1-3]. Generally, these injuries occur when laryngoscope is used during tracheal intubation and sometimes during extubation or

in the recovery phase [4-7]. They most commonly occur in the anterior maxilla area, particularly the upper left central incisors [8,9], with the most common types of injuries being tooth luxation, tooth fracture, and damaged prostheses, with rates for each varying across studies [5,8,10].

Risk factors for dental injury when the patient is under general anesthesia include patient-related factors such as poor dentition, limited mouth opening, poor visibility in

Received: November 25, 2022 • Revised: January 9, 2023 • Accepted: January 15, 2023

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the hypopharynx, and narrow thyromental distance [7], as well as surgery-related factors such as aggressive laryngoscopy, anesthesiologist's lack of experience, emergency intervention, insufficient anesthesia dose, and curarization [11]. Patient-related factors can be broadly divided into dental disease, prosthesis use, and skeletal factors. In terms of dental diseases, patients with periodontitis, dental caries, and devitalized teeth with root canal therapy have an elevated risk of dental injuries [1]. Similarly, those with dental prostheses, such as crowns, bridges, and implanted dentures, as well as those with isolated teeth, proclined teeth, or airway difficulty due to micrognathism and a short neck have a higher dental injury risk [10]. In addition, hepatitis, neurological disease, and alternative airway devices other than the laryngoscope have been reported to act as risk factors for dental injury [12].

Protective devices such as mouthguards are recommended to prevent dental injuries caused by poor dentition [13]. Although the use of mouthguards has been documented to reduce the force inflicted upon the anterior dentition during laryngoscopy [14], the effectiveness of a mouthguard as a preventive tool against dental injuries remains controversial [13,15,16].

Dental injuries can occur even when a skilled anesthesiologist establishes anesthesia in a patient with healthy teeth and periodontal tissue [17]. Thus, it is important to provide patients with a detailed explanation of the risk of dental injury preoperatively, perform meticulous dental evaluations, and document the relevant processes. Although dental recording charts for anesthesiologists have been previously introduced [17-19], studies on anesthesiologists have shown that the perceived need for dental risk evaluation and management is high among anesthesiologists [6,7], and approximately 20% of cases of dental injury that progressed to legal actions were found to have inadequate records considering preoperative dental conditions [17]. Inadequate records hinder proper reactions to dental injuries and may impair the relationship between the clinician and patient.

In this study, we developed a questionnaire based on dentition-related risk factors, examined the agreement between patients' and dentists' responses, and evaluated the indicators perceived as important by dentists when fabricating protective mouthguards. The aim of this study was to develop a questionnaire for self-evaluation of dental status, acquisition of patient history, and facilitation of good communication between physicians and patients should dental injuries occur.

METHODS

1. Questionnaire

Fig. 1 illustrates the questionnaire used in this study. The questionnaire was designed based on risk factors for dental injury during general anesthesia and comprised five domains: general oral health, teeth, periodontal health, implants, and dentures.

2. Patients & procedure

This study was approved by the Institutional Review Board of the Dental Hospital of Yonsei University College of Dentistry (IRB No. 2-2016-0020).

Among the patients scheduled for surgery under general anesthesia at Yonsei University Severance Hospital, 100 patients referred to the Advanced General Dentistry at Yonsei University College of Dentistry for dental evaluation were enrolled. The study was conducted from December 1, 2016, to October 31, 2017.

Patients were asked to complete the questionnaire before their dental appointments. Panoramic and periapical radiographs were obtained for baseline radiographic examination, followed by oral examination and clinical interviews by nine dentists. The dentists then completed the questionnaire and prescribed a mouthguard to patients determined to have a high risk of dental injury during surgery.

3. Data analysis

Statistical analyses were performed using IBM SPSS

	Patient			Dentist		
	Yes	No	Unsure	Yes	No	Unsure
A. Questions about your general oral health						
1. Would you rate your oral health and management as good?						
2. Have you experienced toothache within the last year?						
3. Have you received orthodontic treatment?						
4. Have you experienced signs and symptoms of TMD (Temporomandibular Joint Disorder)? These signs and symptoms include: - pain or tenderness of your jaw joint area - problems opening your mouth wide - locking of your jaw - clicking, popping or grating sounds in the jaw joint when you open or close your mouth						
B. Questions about the current state of your teeth						
1. Do you have dark brownish spot or small hole in your teeth?						
2. Do you feel dull ache or sharp pain when drinking or eating hot or cold food and drink?						
3. Do you have a darkened tooth with frequent gum swelling?						
4. Do you have severe tooth decay?						
5. Do you have a cracked tooth?						
6. Have you received root canal therapy?						
7. Have you experienced tooth trauma or injury after an accident?						
8. Have you received treatment for tooth discoloration?						
9. Have you received treatment with ceramic dental prosthetics?						
10. Have you received tooth lamination (dental veneers)?						
C. Questions about your periodontal health						
1. Do you have loose tooth?						
2. Do you have teeth with receding gums?						
3. Are you exposed to the possibilities of root resorption or root fracture?						
4. Have you experienced gum boil (pus-filled, swollen bump on the gums)?						
5. Do you seem to keep getting food stuck in your tooth?						
6. Do you have toothache when chewing food?						
D. Questions about implants						
1. Do you have implants in your front and the teeth in front of your molars?						
2. Do you have implants that feel loose?						
E. Questionnaire about dentures						
1. Do you currently use removable denture?						
2. Do you find difficulties using your denture? - soreness or ulceration on your gum - chewing difficulty - difficulty pronouncing some words, etc.						

Fig. 1. Questionnaire used in this study.

Statistics version 25 (IBM Corporation, Armonk, NY, USA). The association between mouthguard fabrication and patient age, sex, and department were analyzed using

Student's t-test, chi-square test, and Fisher's exact test, respectively. The associations between mouthguard fabrication and patient-dentist responses were analyzed

Table 1. Characteristics of patients in the non-mouthguard group (N = 73) and mouthguard group (N = 27)

Characteristics	Non-mouthguard group (N = 73)	Mouthguard group (N = 27)	P-value
Age (y)	51.1 ± 12.9	61.1 ± 11.4	0.001*
11-19	1 (1.4%)	0 (0.0%)	
20-29	3 (4.1%)	1 (3.7%)	
30-39	10 (13.7%)	0 (0.0%)	
40-49	19 (26.0%)	3 (11.1%)	
50-59	15 (20.5%)	7 (26.0%)	
60-69	21 (28.8%)	10 (37.0%)	
70-79	4 (5.5%)	5 (18.5%)	
80-89	0 (0.0%)	1 (3.7%)	
Gender			0.096
Female	38 (52.1%)	9 (33.3%)	
Male	35 (47.9%)	18 (66.7%)	
Departments			0.791
Nephrology	9 (12.3%)	2 (7.4%)	
Gastroenterology	1 (1.4%)	0 (0.0%)	
Cardiology	47 (64.4%)	22 (81.5%)	
Transplantation surgery	8 (11.0%)	3 (11.1%)	
Hematology	6 (8.2%)	0 (0.0%)	
Pulmonology	2 (2.7%)	0 (0.0%)	

*denotes statistical significance at P < 0.05. N, number.

using the chi-square test or Fisher’s exact test.

Furthermore, percent agreement and Cohen’s kappa statistics were used to examine the agreement between dentist and patient responses for each item on the questionnaire.

RESULTS

1. Characteristics of the non-mouthguard group and mouthguard group

Between December 1, 2016, and October 31, 2017, 100 patients (53 male and 47 female) participated in the study. Twenty-seven patients were prescribed mouthguards. The mean age in the non-mouthguard group was 51.1 (± 12.9) years of age while the mean age in the mouthguard group was 61.1 (± 11.4) years of age, showing that the group of patients prescribed a mouthguard was roughly 10 years older than the non-mouthguard group (P = 0.001). The non-mouthguard group included 38 women (52.1%) and 35 men (47.9%), whereas the mouthguard group included 9 women (33%) and 18 men (66.7%). In terms of the

specialty that requested the dental consult, the non-mouthguard group was mostly referred from cardiology, followed by nephrology and transplantation surgery, while the mouthguard group was mostly referred from cardiology, followed by transplantation surgery and nephrology. However, the relationship between mouthguard prescription with patient sex and department was not statistically significant (Table 1).

2. Measuring the association between patient /dentist responses and mouthguard fabrication

Dentists’ responses pertinent to the evaluation of overall oral health (A-1), fabrication of aesthetic prostheses (B-9), oral symptoms caused by periodontal diseases (C-4, 6), and implants (D-1) were significantly associated with mouthguard fabrication (P < 0.05).

Response agreement between 100 patients and their dentists was assessed using percent agreement and Cohen’s kappa statistic. Since the dental history item in general dental health (A), as well as items pertinent to dentures (E), were only completed by the patients, only the remaining items were statistically analyzed.

Table 2. Statistics for agreement of responses between patients and dentists and association between patients' and dentists' responses and mouthguard fabrication

	Chi-square test (P-value)		Percent agreement (%)	Cohen kappa coefficient
	Patient MG	Dentist MG		
A. Questionnaire about your oral health in general				
1. Would you rate your oral health and management as good?	0.234	0.003*	76	0.567
2. Have you experienced toothache within the last year?	0.119			
3. Have you received orthodontic treatment?	1.000 [†]			
4. Have you experienced signs and symptoms of TMD (Temporomandibular Joint Disorder)?	0.572			
B. Questionnaire about your current tooth				
1. Do you have dark brownish spot or small hole in your teeth?	0.312	0.062	78	0.585
2. Do you feel dull ache or sharp pain when drinking or eating hot or cold food and drink?	0.632 [†]	0.617 [†]	91	0.810
3. Do you have darkened tooth with frequent gum swelling?	0.891 [†]	0.649 [†]	90	0.638
4. Do you have severe tooth decay?	0.222	0.245	78	0.566
5. Do you have cracked tooth?	0.392	0.051	80	0.577
6. Have you received root canal therapy?	0.302	0.446	85	0.718
7. Have you experienced tooth trauma or injury after accident?	0.823 [†]	0.754 [†]	97	0.787
8. Have you received treatment for tooth discoloration?	0.111 [†]	1.000 [†]	92	0.381
9. Have you received treatment with ceramic dental prosthetics?	0.103 [†]	0.003*	87	0.749
10. Have you received tooth lamination (dental veneers)?	0.379 [†]	-	90	-
C. Questionnaire about your periodontal health				
1. Do you have loose tooth?	0.761 [†]	0.063	88	0.64
2. Do you have tooth with receding gums?	0.514	0.256 [†]	73	0.527
3. Have you heard about possibilities of root resorption or root fracture?	0.439 [†]	0.059 [†]	82	0.215
4. Have you experienced gum boil (pus-filled, swollen bump on the gums)?	0.394 [†]	0.043*	80	0.464
5. Do you seem to keep getting food stuck in your tooth?	0.547 [†]	0.974	86	0.548
6. Do you have toothache when chewing food?	0.020 ^{†*}	0.032*	96	0.885
D. Questionnaire about implant				
1. Do you have implant in your anterior and premolar teeth?	0.043*	0.027*	98	0.940
2. Do you have implant that feels loose?	1.000 [†]	1.000 [†]	99	0.795
E. Questionnaire about denture				
1. Do you currently use removable denture?	0.176			
2. Do you find difficulties using your denture?	0.480			

*denotes statistical significant at $P < 0.05$. [†]Fisher's exact test was performed if more than 20% of the cells had a value of less than 5 in the contingency table.

Note: Associations between mouthguard fabrication and responses by item were analyzed based on the p-values in the chi-square tests. Agreement of responses was assessed based on percent agreement and Cohen's kappa coefficient. For B-10, the value did not come out due to the chi-square test and Cohen's kappa coefficient statistical calculation.

MG, Mouthguard; TMD, temporomandibular disorder.

Furthermore, items without statistical significance were not presented (Table 2).

In terms of percent agreement, the agreement was 70% or higher for all items, and particularly, items pertinent to patients' subjective dental pain (B-2, C-6), loss of tooth vitality and root canal treatment (B-3,6), dental trauma (B-7), aesthetic prostheses (B-9,10), tooth mobility (C-1), and implant prostheses (D-1,2) showed 80% or higher percent agreement and 0.6 or higher Cohen's kappa statistic.

DISCUSSION

While the best way to prevent dental injuries when patients are under general anesthesia is to perform a dental evaluation on all patients scheduled for surgery. Dental evaluations cannot be performed in emergency cases and can be hard to carry out in patients who have difficulty moving and cannot visit a dental clinic. Moreover, mouthguards are not universally preferred among anesthesiologists due to issues regarding the

effectiveness of anesthesia and obstruction of the surgical field of view [10,20]. Nevertheless, preoperative dental evaluation and the use of protection methods aid in the prevention of dental injuries, as well as the resolution of patients' claims and legal issues [11]; therefore, proper documentation and evaluation-based decisions regarding the use of mouthguards are crucial.

Dental recording charts that have been previously introduced are based on dental formulas and thus their main benefit is the recording of the presence of dental diseases and prostheses by tooth number [17-19]; however, the charts may be inaccurately or inadequately used if the clinician lacks an understanding of the pathology of dental disease. Furthermore, adequate acquisition of dental history records is difficult due to the increased rates of dental treatments, such as aesthetic prostheses in the anterior teeth, orthodontic treatment, and implants. In addition, patients may be embarrassed to disclose their tooth mobility despite being aware of it, and may neglect dental injuries that occur while under general anesthesia [17]. Therefore, it is important to examine the dental status of these patients [21].

1. Questionnaire items

The questionnaire included items on potential risk factors related to teeth, periodontal tissue, and prostheses, and was designed to enable dental history taking and identify present dental illnesses. Since dental pain (A-2) is a chief complaint and patient history taking is more important for orthodontic treatment (A-3), temporomandibular disorders (A-4), and denture-related items (E-1, E-2), these items were removed from the dentists' questionnaire.

Category A (general) included items on patients' awareness of their overall oral health (A-1), presence of pain (A-2), history of orthodontic treatment (A-3), and presence of temporomandibular disorders (A-4). Dental pain can be used as an index to compare pain before and after general anesthesia, and patients with tooth pain need to be under close supervision because of the possibility of dental caries or periodontitis. Orthodontically treated

teeth may show mobility due to movement of the tooth during treatment; maxillary and mandibular anterior teeth are at a particularly greater risk for mobility and dental injury due to resorption of their short roots. Temporomandibular disorders must also be identified as they can be exacerbated if the mouth remains open for prolonged durations, even in the absence of temporomandibular disorders. There has been a case in which temporomandibular joint locking occurred during surgery which eventually led to temporomandibular disorders [22,23].

Category B (teeth) included items on symptoms related to dental caries (B-1,2,4), loss of pulp vitality due to necrosis of the pulp tissue (B-3), cracked teeth (B-5), history of root canal therapy (B-6), history of dental trauma (B-7), history of teeth whitening (B-8), aesthetic ceramic prosthesis in the anterior teeth (B-9), and history of laminates (B-10). Patients who have undergone root canal therapy, tooth bleaching following root canal treatment, or have a history of dental trauma may have weaker teeth and thus be more vulnerable to dental injuries. While aesthetic prostheses in the anterior teeth can be fractured or broken off, they cannot be visually identified in some cases, highlighting the importance of history taking.

Category C (periodontal tissue) included items about the common clinical symptoms of periodontitis, such as tooth mobility (C-1), gingival recession (C-2), periodontitis-induced gum swelling or pus (C-4), food impaction due to alveolar bone loss (C-5), and masticatory pain (C-6).

Category D (implant) included items regarding the history of implant therapy (D-1). For dental implants, the upper prosthesis is connected to the implant fixture by using a screw. Damage to the prosthesis (screw loosening, abutment, or screw fracture) or failure of osseointegration of the implant fixture due to peri-implantitis may trigger clinical symptoms such as increased mobility. (D-2) A dental injury on dental implants requires more complex treatment and greater financial compensation; therefore, precautions should be taken in the presence of dental implants.

Category E contained items about dentures, such as the use of dentures (E-1) and the presence of common complaints from denture use (e.g., gingival pain and masticatory or pronunciation difficulty) (E-2). The mobility of the abutment teeth and recession tend to increase with prolonged use of a partial denture, and among patients with poor oral hygiene, the risk of periodontitis and dental caries is elevated, aggravating the discomfort caused by a partial denture. This further increases the risk of dental injuries. While patients with dentures are recommended to remove them prior to anesthesia, patients using partial dentures are recommended to retain the denture during laryngoscopy to preserve their natural teeth and remove them during intubation because of the risk of dislodgment [1].

2. Characteristics of the non-mouthguard and mouthguard groups

Table 1 shows the characteristics of the study sample. The mouthguard group was older on average, and consequently had a higher risk for periodontal disease and more commonly used prostheses. This, in turn, increases the risk of dental injury during surgery when the patient is under general anesthesia [1]. In terms of sex, mouthguard prescription was more common among men ($n = 18$, 66.7%) than women ($n = 9$, 33.3%), which is in line with previously reported trends [12]. However, there was no statistical significance in this study.

Dental consultation was most frequently requested by the cardiology department, followed by nephrology, transplantation surgery, hematology, pulmonology, and gastroenterology in the non-mouthguard group, and cardiology, followed by transplantation surgery and nephrology in the mouthguard group. Overall, results show that the highest percentage of patients were referred from the cardiology department. A retrospective study showed that the operating clinic and type of surgery vary across studies [12,20,24].

3. Measuring the association between patient /dentist responses and mouthguard fabrication

We conducted a chi-square test to examine the

association between mouthguard fabrication and patient/dentist responses. In terms of patients' responses, responses to items on masticatory pain (C-6) and implants (D-1) were significantly associated with mouthguard use ($P < 0.05$), as evidenced by the fact that patients who answered 'yes' to these questions were more commonly prescribed mouthguards. In terms of dentists' responses, responses to items on general oral health (A-1), use of ceramic prosthesis (B-9), gum-boil (C-4), masticatory pain (C-6), and implants (D-1) were significantly associated ($P < 0.05$) with mouthguard use, suggesting that these were the criteria by which dentists determined the need for a mouthguard. Patients who normally experience dental pain or gumboil formation may have periapical or periodontal lesions and are likely to be vulnerable to dental injury. Ceramic prostheses and dental implants are important indications for mouthguards to prevent damage to these prostheses.

To assess the reliability of patients' responses to the questionnaire, we evaluated the agreement between the patients' and the dentists' responses to the same questions following oral examination (Table 2) and using percent agreement and Cohen's kappa coefficient. Percent agreement is simply the agreement between the responses, and Cohen's kappa is a statistic adjusted for accidental agreement between responses; hence, the percentage agreement is generally higher [25].

Cohen's kappa coefficient was 0.6 or higher for items about dental pain upon hot or cold stimuli (B-2), history of root canal therapy (B-6), dental trauma history (B-7), use of ceramic prosthesis (B-9), tooth mobility (C-1), masticatory pain (C-6), and implant treatment and mobility (D-1,2). These items had a percentage agreement of 80% or higher. The high consistency between dentists' and patients' responses for items pertaining to dental implants or ceramic prostheses, which are generally applied on the anterior teeth, seems to be attributable to the fact that these dental procedures are more accurately remembered because of aesthetic and financial reasons. Similarly, items about dental pain had a high agreement, presumably because patients provide consistent

responses, since dentists directly ask about patients' symptoms. Although we did not calculate Cohen's kappa for statistical reasons, the item about the history of laminates, which are frequently utilized in aesthetic prostheses (B-10), showed a 90 percent agreement, again confirming a high agreement between patients and dentists regarding the history of aesthetic-related prosthetics.

Prevention of surgical injuries when patient is under general anesthesia does not require precise dental diagnosis, preoperative dental evaluation is still crucial for identifying and documenting the patient's status. Patients should be reminded to examine their own oral health status, and a mouthguard is recommended for patients who indicate "yes" to having toothaches, dental implants, or anterior prostheses in the questionnaire in order to prevent dental injuries.

Dental evaluation of patients scheduled for surgery under general anesthesia is crucial for preventing dental injuries and resolving issues with patients upon the onset of injury. The questionnaire developed in this study enables patients to perform self-evaluations and provides a template for history taking. This is also significant in terms of documentation.

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ACKNOWLEDGEMENTS: This research was supported by

a grant from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: HI16C0822).

CONFLICT OF INTEREST: The authors have no conflicts of interest to declare.

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