Predicting adverse events in patients who are anxious about dental procedures

Yasunobu Oike

Medical Corporation, Oike Dental Clinic, Hyuga

Norito Takamura (✉ noritotaka@phoenix.ac.jp)

Kyushu University of Health and Welfare

Jin Tokunaga

School of pharmaceutical sciences, Kyushu University of health

Kenji Ogata

School of pharmaceutical sciences, Kyushu University of health and welfare

Nao Setoguchi

School of pharmaceutical sciences, Kyushu university of health and welfare

Mariko Nakamura

School of health sciences, Kyushu university of health and welfare

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Abstract

Background

Dental extractions can cause significant anxiety making patients feel sick. In serious cases, extractions can cause unconsciousness and even death. Therefore, systemic adverse events must be completely avoided. We herein developed a method to predict dental extraction-related adverse events in patients.

Methods

The State-Trait Anxiety Inventory (STAIY-1) was administered before calculus removal and extraction, and STAIY-2 was administered before calculus removal in 93 patients (men, 44; women, 49). These patients were at a dental clinic for outpatient treatment. The vital signs like blood pressure, pulse rate, and arterial oxygen saturation and salivary amylase activity were measured at 2- and 4-min intervals before calculus removal as well as before extraction.

Results

Of the 93 patients, one man and one woman suffered from an adverse event. Maximum points for raw STAIY-1 scores were measured before extraction for both men and women, suggesting that performing the STAIY-1 survey prior to extraction is effective in predicting extraction-related adverse events. We also investigated rate changes (rate change = mean value during extraction – mean value during calculus removal/mean value during calculus removal) and mean pre-extraction pulse rates in patients who suffered from an adverse event. Adverse events occurred in men when there was a rate change of ≥ 0.225 and mean pre-extraction pulse rate was ≥ 90.0 bpm and in women when there was a rate change of ≥ 0.200 and the mean pre-extraction pulse rate was ≥ 95.0 bpm. We used these pulse rates as cutoff values.

Conclusions

Thus, the combined use of pre-extraction STAIY-1 results and pulse rate cutoff values could increase the success of predicting adverse events in such patients.

Background

Many patients suffer from varying degrees of anxiety regarding dental treatment [1]. As extractions result in a particularly high incidence of systemic adverse events [2], it is important to perform dental treatment in a safe and reassuring manner to reduce patient anxiety during extractions. Therefore, attempts have been made in clinical dentistry to eliminate patient anxiety including informed consent wherein patients

Loading [MathJax]/jax/output/CommonHTML/jax.js ove their understanding of the treatment that they are about

to undergo [3, 4], music sedation wherein patients listen to quiet, slow music during sedation [5–7], and aromatherapy wherein patients are exposed to the scents of essential oils that offer sedative effects while present in the treatment room [8–10]. Studies evaluating these methods have used the State-Trait Anxiety Inventory (STAI; comprising STAIY-1 and STAIY-2) [11]. These evaluate the degree of anxiety, vital signs (blood pressure, pulse rate, and arterial oxygen saturation) and can be used to evaluate the patient’s systemic state over time and salivary amylase activity [12, 13]. Patients provided informed consent explanations or administered music sedation or aromatherapy had lower STAIY-1 scores, more stable vital sign scores, and lower salivary amylase activity than those that did not.

The incidence of systemic adverse events can be reduced by these methods in patients who undergo dental extractions; however, some adverse events will still occur. Such adverse events can range from mild events including feeling unwell to more severe events such as unconsciousness [14], and if the treatment is delayed, it can even cause death [15]. The fact that systemic adverse events occur at various degrees of severity and at a certain rate, it is highly disadvantageous for dental treatment. Therefore, dentists must prevent the occurrence of adverse events in such patients at any cost.

In this study, we focused on developing a simple method to predict in advance which patients will suffer from systemic adverse events based on the change in values recorded for STAI, vital signs, and salivary amylase activity, which are used to evaluate anxiety.

Methods

Subjects

We included 93 adult men and women (excluding those with an extreme fear of dental treatment) aged 20–65 years at the initial examination who did not have any serious underlying diseases and who required calculus removal and extraction (normal extraction) based on chief complaints and diagnosis between June 2018 and April 2019 at Oike Dental Clinic. Initially, all 100 patients consented to participate in the measurements; however, seven did not show up on the planned extraction day and failed to come to examinations subsequently. Therefore, the participants were assigned a number from No. 1 to 100 as per the order they visited the clinic, regardless of sex (missing cases: Nos. 5, 22, 34, 40, 78, 89, and 94). Table 1 shows the number of men and women included in the study and their ages.

Table 1
Target age structure

Age (years)	Male	Female	Total
20–29	12	10	22
30–39	7	13	20
40–49	15	9	24
50–59	6	7	13
60–65	4	10	14
Total	44	49	93

Measurement methods

State-Trait Anxiety Inventory-Form JYZ (STAI)

STAI (comprising STAIY-1 and STAIY-2), devised by Spielberger [16, 17], is a questionnaire used to measure anxiety. It targets men and women separately. STAI-JYZ, created as the Japanese version by Hidano and Fukuhara [18], can be used to measure state anxiety (STAIY-1) and trait anxiety (STAIY-2). State anxiety refers to the anxiety caused by what is happening at a specific point in time or in a specific situation. In contrast, rather than transient anxiety as observed in state anxiety, trait anxiety refers to being prone to anxiety due to an individual's personality. As extractions generally cause fear in patients, we believed that state anxiety would more accurately reflect a state of stress during such a situation. Therefore, we performed evaluations using STAIY-1 in this study.

The patients were administered the STAI-Form JYZ to investigate state anxiety (STAIY-1) and trait anxiety (STAIY-2) before calculus removal. Patients were provided approximately 10 min to fill the surveys. We administered STAIY-1 once again before the extractions.

Vital sign measurement

The vital signs were measured upon starting calculus removal and extraction using an automated sphygmomanometer (Bio-information monitor OPV-1500®; Nihon Kohden, Tokyo, Japan). Vital signs such as pulse rate, blood pressure [systolic blood pressure (H) and diastolic blood pressure (L)] as well as percutaneous arterial blood oxygen saturation were measured every 2 min until the procedures were completed.

Salivary amylase measurement

Salivary amylase activity was analyzing by measured it upon starting calculus removal and extraction using a salivary amylase measurement device (Dry Clinical Chemical Analysis Device Salivary Amylase Monitor® [19]; Nipro, Osaka, Japan) every 4 min for 12 min until starting the procedures.

We measured STAIY-1 and vital signs of patients undergoing their first extraction at our clinic. Further, we analyzed pulse rate, blood pressure, percutaneous arterial blood oxygen saturation, and salivary amylase data from starting measurement until initiating the procedure (0–12 min). All measurements were performed in the same private room for the patient, dentist, and dental hygienist. Figure 1 shows the protocol for this study.

This study was approved by the institutional review board of the Kyushu University of Health and Welfare in May 2017. Sufficient care was taken to protect the confidentiality of personal information.

Results

STAI is divided into five stages from I to V based on the total score (I, very low; II, low; III, normal; IV, high; and V, very high). The points allocated for STAIY-1 differ depending on sex with the following standards: I, 20–31 points for men and 20–34 points for women; II, 32–40 points for men and 35–44 points for women; III, 41–51 points for men and 45–54 points for women; IV, 52–63 points for men and 55–65 points for women; and V, 64–80 points for men and 66–80 points for women. STAIY-2 also has points allocated depending on sex with the following standards: I, 20–33 points for men and 20–30 points for women; II, 34–42 points for men and 31–39 points for women; III, 43–52 points for men and 40–49 points for women; IV, 53–63 points for men and 50–62 points for women; and V, 64–80 points for men and 63–80 points for women.

As the ranges for the total scores for STAIY-1 and STAIY-2 (I–V) differ, dividing patients by sex for analysis enabled accurate evaluation. In men, comparison of the number of subjects with each STAIY-1 score before extraction and those before calculus removal indicated that the number of subjects who were at stages I and II decreased, whereas the number of subjects at stage III increased by 5, and those at stage IV increased by 2. Although no change was observed, there was one subject who was ranked as stage V, which was the highest score for anxiety [Table 2(A)]. In women, comparison of the number of subjects with each STAIY-1 score before extraction and those before calculus removal indicated that the number of subjects who were at stages I and II decreased, whereas those at stage III increased by 6, and those at stage IV increased by 4 [Table 2(B)]. The fact that numbers of male and female STAIY-1 stages III and IV patients increased before extraction compared to that before calculus removal suggested that anxiety increases prior to extraction.

Table 2
(A) Men in each stage of State-Trait Anxiety Inventory (STAIY-1) before calculus removal and extraction

STAIY-1 stage	I	II	III	IV	V
Male calculus removal	10	15	16	2	1
Male tooth extraction	7	11	21	4	1

Table 2
(B) Women in each stage of State-Trait Anxiety Inventory (STAIY-1) before calculus removal and extraction

STAIY-1 stage	I	II	III	IV	V
Female calculus removal	12	20	16	1	0
Female tooth extraction	5	17	22	5	0

As expected, STAIY-1 scores for the male patient (No. 74) and female patient (No. 52) who suffered from an adverse event placed them in stages V and IV, respectively, indicating high anxiety. The raw score for the male patient (64 points) was the highest among all male patients, whereas the raw score for the female patient (63 points) was the highest among all female patients. While the score of 63 points for the female patient classified her as stage IV, it was very close to classifying her as stage V.

Status and treatment for the male patient (No. 74) and female patient (No. 52) who suffered from adverse events are shown below. The male patient (No. 74) developed facial pallor and weakness immediately after the extraction was completed, and he was placed in a reclining state and oxygen was administered for approximately 30 min, after which he recovered. The female patient (No. 52) complained of feeling sick and dizzy before the extraction; therefore, the treatment was discontinued and she was placed in a reclining state. After resting for 20 min, she recovered. Both male and female patients who suffered from adverse events exhibited the highest STAIY-1 scores before the extraction, suggesting that evaluating STAIY-1 before extractions could be effective in predicting adverse events.

In addition, we investigated whether STAIY-2 could be effective in predicting adverse events (Table 3). Unlike STAIY-1, STAIY-2 is used to evaluate personality trends for anxiety that individuals innately possess, and therefore, it is suitable for evaluating personality trends for anxiety regarding extractions. The highest raw score for STAIY-2 in a male patient was 68 points, and an adverse event occurred in this patient (No. 74). However, the highest raw score for STAIY-2 in a female patient was 64 points, which was recorded for patient No. 87 rather than the patient (No. 52) in whom the adverse event occurred. A large difference was observed between the raw score for patient No. 52 (50 points) and the highest score (68 points). This result suggested that raw scores of STAIY-2 are unsuitable for predicting which male and female patients will suffer from adverse events.

Table 3
Number of men and women in each stage of State-Trait Anxiety Inventory (STAIY-2)

STAIY-2stage	I	II	III	IV	V
Male	8	17	14	4	1
Female	5	15	21	7	1

We then investigated whether the vital signs and salivary amylase activity levels could be used to predict adverse events. As STAIY-1 was effective in predicting adverse events, we believed that it would be logical to select patients with high pre-extraction raw STAIY-1 scores (stage IV or higher) and compare them with those who suffered from adverse events.

There were five male patients who were categorized as stage IV or higher for STAIY-1 (Nos. 37, 48, 74, 77, and 85). We analyzed the differences among these five patients in detail. When performing the analysis, we compared parameters using Formula 1. This was because we felt that it would be valid to consider that anxiety would be greater with larger differences between mean values for vital signs and salivary amylase activity measured before calculus removal and mean values for each measurement value before extraction.

$$\text{Changerate} = \frac{\text{Meanvaluebeforeextraction} - \text{meanvaluebeforecalculusremoval}}{\text{Meanvaluebeforecalculusremoval}} (1)$$

The pulse rate change rate for patient No. 74, who suffered from an adverse event, was 0.225, which was higher than for the four other patients [Nos. 37, 48, 77, and 85; Fig. 2(a)]. The rate change for systolic blood pressure (H) in patient No. 74 was not the highest when compared with the other four patients [Nos. 37, 48, 77, and 85; Fig. 3(a)]. The rate change for diastolic blood pressure (L) in patient No. 74 was also not the highest when compared with the other four patients [Nos. 37, 48, 77, and 85; Fig. 4(a)]. The rate change for percutaneous arterial blood oxygen saturation in patient No. 74 was not the highest when compared with the other four patients [Nos. 37, 48, 77, and 85; Fig. 5(a)]. The rate change for salivary amylase activity in patient No. 74 was not the highest when compared with the other four patients [Nos. 37, 48, 77, and 85; Fig. 6(a)].

These results suggested that one condition for an adverse event occurring in a male patient is a pulse rate change rate of ≥ 0.225 . We then investigated whether the pulse rate change rate exceeded 0.225 in any male patient other than the five described above (those classified as stage III or below). The only such patient for whom the rate change exceeded this value was patient No. 21. Although higher mean pulse rates appeared to indicate greater anxiety, comparison with the mean pulse rate revealed that the mean pulse rate of patient No. 21 before extraction was 57.8 bpm, which greatly differed from 90.8 bpm recorded before extraction for patient No. 74, who suffered from an adverse event.

A similar investigation of female patients revealed that there were five female patients with STAIY-1 scores that placed them in stage IV or higher (Nos. 8, 10, 15, 35, and 52). We investigated the differences among these patients in detail.

The pulse rate change rate for patient No. 52 who suffered from an adverse event was 0.200, which was higher than that for the four other patients [Nos. 8, 10, 15, and 35; Fig. 2(b)]. The rate change for systolic blood pressure (H) for patient No. 52 was not the highest when compared with the other four patients [Nos. 8, 10, 15, and 35; Fig. 3(b)]. The rate change for diastolic blood pressure (L) in patient No. 52 was also not the highest when compared with the other four patients [Nos. 8, 10, 15, and 35; Fig. 4(b)]. The

rate change for percutaneous arterial blood oxygen saturation in patient No. 52 was not the highest when compared with the other four patients [Nos. 8, 10, 15, and 35; Fig. 5(b)]. The rate change for salivary amylase activity in patient No. 52 was not the highest when compared with the other four patients [Nos. 8, 10, 15, and 35; Fig. 6(b)].

These results suggested that one condition for an adverse event occurring in a female patient is a pulse rate change rate of ≥ 0.200 . We then investigated whether the pulse rate change rate exceeded 0.200 in any female patient other than the five described above (those classified as stage III or below). The only such patient for whom the rate change exceeded this value was patient No. 54. Comparison with the mean pulse rate was performed in the same manner as for the male patients. Results revealed that the mean pulse rate of patient No. 54 before extraction was 94.1 bpm, which differed only slightly from 95.0 bpm recorded before extraction for patient No. 52, who suffered from an adverse event.

Anxiety-related adverse events due to dental extractions occurred in males when the pulse rate change rate was ≥ 0.225 and the mean pre-extraction pulse rate was ≥ 90.0 bpm and in females when the pulse rate change rate was ≥ 0.200 and the mean pre-extraction pulse rate was ≥ 95.0 bpm. None of the other 91 patients fulfilled these conditions.

Discussion

We investigated the differences in patients who suffered from adverse events and those who did not to determine whether anxiety-related adverse events could be predicted based on pre-calculus removal and pre-extraction STAI results, vital signs, and salivary amylase activity scores. The male patient who suffered from an adverse event before extraction was classified as V under STAIY-1, and he had the highest raw score (64 points). The female patient who suffered from an adverse event was classified as stage IV and also had the highest raw score (63 points). This suggested that adverse events do not occur in male patients who score ≤ 63 points or in female patients who score ≤ 62 points.

STAIY-2 analysis of patients who suffered from adverse events before extraction revealed that while the male patient was classified as stage V and had the highest raw score (68 points), the female patient was classified as stage IV and scored 50 points, which was not the highest score recorded.

Results for the vital signs indicated that the cutoff for men was a pulse rate change rate of ≥ 0.225 and a mean pulse rate of ≥ 90.0 bpm. For women, the cutoff was a pulse rate change rate of ≥ 0.200 and a mean pulse rate of ≥ 95.0 bpm.

We then compared STAIY-1 and STAIY-2 to determine which was superior in predicting adverse events related to dental extractions. In both men and women, adverse events occurred in patients with the highest raw STAIY-1 scores before extraction. However, the female patient (No. 87) with the highest raw STAIY-2 score (classified as stage V) did not suffer from an adverse event; her pre-extraction raw STAIY-1 score was 49 points (classified as stage III), which was significantly lower than the raw score (63 points)

of the female patient (No. 52) who suffered from an adverse event. This also suggested the high utility of pre-extraction STAIY-1.

The results of a study by Sakamoto et al. [20] support our findings. They conducted a clinical investigation using visual analog scale to evaluate anxiety and pain associated with indwelling needle puncture and trialed administering STAIY-1 and STAIY-2 to 270 outpatients. They conducted a comparative investigation of six groups after classifying patients who were at stage I, II, or III as low state anxiety (LSA) or low trait anxiety (LTA); those at stage IV were classified as slight state anxiety (SSA) or slight trait anxiety; and those at stage V were classified as high state anxiety (HSA) or high trait anxiety (HTA). They found that although significant differences were noted for STAIY-1 among the LSA and SSA groups, the SSA and HSA groups, and the LSA and HSA groups, the only inter-group difference noted for STAIY-2 was observed between the LTA and HTA groups. This demonstrated that STAIY-1 offers greater sensitivity than STAIY-2 for evaluating anxiety and pain, which supports our conclusions. Accordingly, we concluded that STAIY-1 rather than STAIY-2 should be used to predict adverse events.

We also considered whether methods other than STAI could be used to determine which patients would suffer from adverse events. We attempted to predict which patients would suffer from anxiety-related adverse events based on differences in vital signs and salivary amylase activity scores. Only pulse rate was an indicator for determining which patients would suffer from anxiety-related adverse events. These conditions were a pulse rate change rate of ≥ 0.225 and a mean pre-extraction pulse rate ≥ 90.0 bpm in males and a pulse rate change rate of ≥ 0.200 and mean pre-extraction pulse rate of ≥ 95.0 bpm in females. We tested this hypothesis using male and female patients. In male patient No. 21, the pulse rate change rate was 0.238, which was ≥ 0.225 , but the mean pre-extraction pulse rate was 57.8 bpm, which was not ≥ 90.0 beats/min, and this patient did not suffer from an adverse event. In female patient No. 54, the pulse rate change rate was 0.29, which was ≥ 0.200 , but the mean pre-extraction pulse rate was 94.1 beats/min, which was not ≥ 95.0 beats/min, and she did not suffer from an adverse event. More detailed investigation revealed that in female patient No. 54, while the mean pre-extraction pulse rate was only slightly below the cutoff, a pulse rate change rate of ≥ 0.200 was not recorded for any female patient except for No. 54. Only patient No. 8 exhibited a mean pre-extraction pulse rate of ≥ 95.0 bpm. Accordingly, it appears likely that the conditions that we described could be used to predict which patients will suffer from adverse events.

In terms of the importance of focusing on mean pre-extraction pulse rate, Takanashi et al. [21] investigated risk factors for vasovagal reflex in patients donating blood and reported that patients had a significantly higher risk of exhibiting a vasovagal reflex when they had a pulse rate of ≥ 90.0 bpm before initial blood donation. This result supports the validity of our focus on pulse rate as a risk factor for adverse events. Results indicating higher risk for patients with a pulse rate of ≥ 90.0 bpm are also consistent with our finding that indicators for suffering from an anxiety-related adverse event were a mean pulse rate of ≥ 90.0 bpm for men and ≥ 95.0 bpm for women. In previous reports, pulse rates are generally measured only once or twice around the time of treatment or procedure and sample sizes were Loading [MathJax]/jax/output/CommonHTML/jax.js. Our study however offers greater precision due to its large

sample size of 93 patients and the fact that pulse rates were measured seven times around the time of calculus removal and extraction, six times during treatment (as the purpose of this study was to predict adverse events, pulse rate measurements recorded seven times before calculus removal and extraction were used as data for analysis).

We further examined ways to increase the precision of predicting adverse events. Regarding pulse rates, although the pulse rate change rate of female patient No. 54 was higher than 0.200, at 0.29, the requirement for a mean pre-extraction pulse rate of ≥ 95.0 bpm to predict an adverse event was not met (94.1 bpm). However, as this was only a slight difference, some problems with the precision of predictions based on pulse rates may remain. We attempted to predict adverse events by considering pre-extraction STAIY-1. Results indicated that the raw pre-extraction STAIY-1 score for patient No. 54 was 25 points (classified as I), which greatly differed from the classification of STAIY-1 stage IV or higher required for female patients (patient No. 52 who suffered from an adverse event had a raw score of 63 points). Therefore, it could be concluded that patient No. 54 would not suffer from an adverse event. Accordingly, the precision of predicting adverse events due to dental extractions could be improved by evaluating patients using pulse rate conditions and pre-extraction STAIY-1 scores.

Conclusions

In summary, we found that adverse events were likely to occur based on pre-extraction raw STAIY-1 scores, if males were classified as stage V and females were classified as stage IV (score close to stage V). We determined that patients who would suffer from adverse events could be identified based on male and female standards for pulse rate change rates and mean pre-extraction pulse rates. These two methods could be used to further increase the precision of predicting adverse events.

Abbreviations

HSA, High state anxiety; HTA, High trait anxiety; LSA, Low state anxiety; LTA, Low trait anxiety; SSA, Slight state anxiety; STA, Slight trait anxiety; STAI, State-Trait Anxiety Inventory

Declarations

Ethics approval and consent to participate

This study was approved by the institutional review board of the Kyushu University of Health and Welfare on May 15, 2017 (approval number 17-005). All patients who participated in this study provided written informed consent. The study was conducted in compliance with the tenets of the Declaration of Helsinki. Sufficient care was taken to protect the confidentiality of personal information.

Consent for publication

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Not applicable.

Availability of data and materials

The datasets obtained and analyzed from the current study will be available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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There was no funding for this study.

Authors' contributions

YO designed the study, acquired and analyzed the data, and drafted the manuscript. NT contributed to the critical review of the manuscript from study design advice and data analysis. JT contributed to the critical review of the manuscript. KO and NS contributed to the analysis of data. MN advised on the study design. All the authors have read and approved the final manuscript.

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Figures

Figure 1

Protocol for measuring blood pressure, pulse rate, percutaneous oxygen saturation, and salivary amylase activity

(a) Male

(b) Female

Figure 2

Rate change of pulse in cases classified as stage IV/V by State-Trait Anxiety Inventory. (a)male (b)female

Figure 3

Rate change of systolic blood pressure in cases (stage IV/V) by State-Trait Anxiety Inventory. (a)male
(b)female

(a) Male

(b) Female

Figure 4

Rate change of diastolic blood pressure in cases (stage IV/V) by State-Trait Anxiety Inventory. (a)male
(b)female

(a) Male

(b) Female

Figure 5

Rate change of percutaneous oxygen saturation in cases (stage IV/V) by State-Trait Anxiety Inventory.
(a)male (b)female

Figure 6

Rate change of salivary amylase activity in cases (stage IV/V) by State-Trait Anxiety Inventory. (a)male (b)female

Supplementary Files

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