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Early-stage postoperative depression and anxiety following orthognathic surgery: a cross-sectional study

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Abstract

Background The objective of this study was to observe the incidence and potential risk factors of postoperative depression and anxiety in patients during the early period after undergoing orthognathic surgery.

Methods From March 7 to September 7, 2023, patients ≥ 18 years of age who were scheduled for elective orthognathic surgery under general anesthesia in Peking University School and Hospital of Stomatology were included in this study. We prospectively evaluated their degrees of pre- and postoperative depression and anxiety using the Patient Health Questionnaire-9 and the State Trait Anxiety Inventory. Associations between the perioperative factors and occurrences of postoperative anxiety and depression were evaluated using a multivariate logistic regression model.

Results A total of 371 patients were included in the analysis. Within five days after surgery, we observed the occurrence of depression in 32% (116) of the patients and anxiety in 72.8% (270) of them. Their preoperative depression score on the Pain Catastrophizing Scale and intraoperative urine output were significantly associated with a higher risk of postoperative depression. The presence of preoperative anxiety, postoperative moderate-to-severe pain, postoperative nausea and vomiting and postoperative insomnia were significantly associated with a higher risk of postoperative anxiety. Furthermore, a monthly income ≥ ¥10000 was found to be significantly associated with a lower risk of postoperative anxiety.

Conclusions Postoperative depression and anxiety are common among patients who undergo orthognathic surgery. Moreover, preoperative psychological status and incidence of postoperative adverse events were associated with an increased risk of depression and anxiety after surgery. The results of the present study suggest that careful psychological assessment and appropriate management are necessary to improve patients' recovery following orthognathic surgery.

Keywords Depression, Anxiety, Pain, Insomnia, Postoperative nausea and vomiting

Introduction

Orthognathic surgery affects the physical and mental health of patients. Mental health plays an important role in patient-reported outcomes and evaluating the psychological outcomes of patients undergoing orthognathic surgery requires an optimal recovery process. Postoperative complications are caused by multiple factors and mental status is one of them. Depression and anxiety are the most prevalent mood disorders during the

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postoperative period and can influence the quality of the surgical patient's recovery.

Patients undergoing orthognathic surgery are thought to be at high risk for depression and anxiety. However, studies investigating the postoperative psychosocial status of patients, from a few weeks to several years after they underwent orthognathic surgery [1] have found improved mood and reduced anxiety in patients. Among orthognathic surgical patients, long-term postoperative changes in mental health were mainly due to improvements in their appearance and living conditions. However, during hospital stays, the surgical related pathogenic factors of psychological changes may be different from those of the long-term psychological changes. Case series and small cohort studies have reported mental distress, such as depression and anxiety, as complications that occur during the postoperative period following orthognathic surgery [2–4]. A semi-structured interview of patients who underwent orthognathic surgery revealed that patients might be depressed for a few days during the immediate postoperative period [2]. Kiyak et al. investigated the emotional aspects of patients undergoing orthognathic surgery and reported an increase in patients' ratings of depression one day after the surgery [5]. Chen et al. also found that the depression and anxiety scores of the patients increased significantly following surgery during their hospital stay [6]. Thus, depressive and anxious episodes are complications of orthognathic surgery, which merit further attention. However, psychological distress in the form of anxiety and depression after orthognathic surgery has not undergone a comprehensive investigation. Therefore, we conducted the present study in order to provide insights into the psychological care for the management of patients' recovery from orthognathic surgery. We primarily investigated the incidences of depression and anxiety of patients within 5 days after undergoing orthognathic surgery and explored potential risk factors for postoperative depression and anxiety in this population.

Materials and methods

Participants

We included patients who were ≥ 18 years of age and scheduled to undergo elective orthognathic surgery under general anesthesia. Patients with a previous diagnosis of a neurological or psychiatric illness were excluded from the study. Written informed consent was obtained from each patient.

Measurements and questionnaires

The Patient Health Questionnaire-9 (PHQ-9) was used to assess depressive symptoms in participants at each testing session. The PHQ-9 consists of nine questions, based on the criteria of the Fourth Edition of the Diagnostic and Statistical Manual of Psychiatric Disorders (DSM-IV), with a total possible score ranging from 0 to 27. A cut-off score ≥ 10 points was selected to indicate the occurrence of depression [7].

Anxiety was assessed using the State Trait Anxiety Inventory (STAI), which contains two parts: the STAI-State (STAI-S) and STAI-Trait (STAI-T). Each inventory consists of 20 questions and the total score of each scale ranges from 20 to 80 points. A STAI-S score ≥ 40 points indicates the presence of post-operative anxiety [8].

Preoperative insomnia was assessed using the Insomnia Severity Index (ISI) with scores ranging from 0 to 28; a score higher than 14 indicates the presence of insomnia within one month [9]. Postoperative sleep quality was assessed using the Richards-Campbell Sleep Questionnaire (RCSQ), which has a 0 to 100-point scale, with a score ≤ 65 indicating the presence of insomnia [10].

Scores on the Pain Catastrophizing Scale (PCS) range from 0 to 52, with a higher score indicating a more severe level of catastrophizing pain. It is a 13-item self-report measure of catastrophizing in the context of actual or anticipated pain and consists of three subscales: rumination, magnification and helplessness [11].

Scores on the Orthognathic Quality of Life Questionnaire (OQLQ) range from 0 to 88 points, with a higher score indicating a lower quality of life. The OQLQ consists of 22 statements rated on a four-point scale of the degree to which the issue addressed in the statement bothers the respondent [12].

All of the survey questionnaires used in this study were the Chinese versions, which have been found to be valid and reliable in Chinese studies [9, 11–15].

Pain severity was assessed using an 11-point numerical rating scale (NRS). A score of 0 indicated no pain, ≥ 4 indicated moderate to severe pain and a score of 10 indicated the worst possible pain.

We evaluated the postoperative nausea and vomiting (PONV) of patients using direct questioning. The level of severity of nausea was assessed using the 11-point NRS. Vomiting was diagnosed when patients retched or expelled intragastric contents; PONV was defined as the development of any nausea, retching or vomiting.

Data collection

On the day before the surgery, the research personnel who underwent specialized training on the details and steps involved in data collection, visited the patients. Data were collected using two sets of questionnaires. The first set contained demographic and morphometric information, education, marital status, comorbidities, occupation, income level, history of smoking and drinking, history of surgery, and physical status classifications

as measured by the American Society of Anesthesiologists (ASA) classification. The second set of questionnaires contained the PHQ-9, STAI, ISI, PCS and OQLQ.

On the day of surgery, patients were transferred to the operating room without any premedication. Anesthesia was provided in accordance with the routine practices of our medical center. Anesthesia was induced with propofol, opioids and muscle relaxants, and then followed by nasotracheal intubation. General anesthesia was maintained with intravenous infusion of propofol and remifentanil, with or without inhalational sevoflurane. Other medications were given at the discretion of the anesthesiologists. At the end of the surgery, the intravenous analgesia pump was attached and turned on for use for 48h. The intraoperative data recorded by research personnel included the duration of the anesthesia and surgery, types and doses of anesthetics and other medications, and fluid balance.

After surgery, patients were transferred to the post-anesthesia care unit (PACU) with nasal intubation. Patients were extubated when they regained consciousness, and had normal airway protective reflexes and stable circulatory status. The decision to transfer patients from the PACU to general wards was made by attending anesthesiologists. Usually, intermaxillary fixation with screw and wire was not applied. Intermaxillary elastics using rubber bands were employed to maintain correct occlusion. Facial compression with packs was used during the first two postoperative days. On postoperative day 1, the intraoral wound drainage tubes were removed and the patient was allowed to liberally consume liquid and soft food.

For postoperative follow-up, a set of questionnaires, including the PHQ-9 and STAI were administered to assess depression and anxiety on postoperative days 1, 3 and 5. Another set of scales, including the NRS and ISI, were administered to assess pain, nausea and vomiting, and sleep quality daily for five postoperative days. On the fifth day after surgery, patients completed the OQLQ questionnaire. Adverse events were monitored for up to five days after surgery. Potential adverse events included emergence agitation (Richmond Agitation-Sedation Scale $\geq +/2$), hypertension (systolic blood pressure > 180 mm Hg or an increase of > 30% from baseline and requiring therapy for all adverse events listed), hypotension (systolic blood pressure < 90 mm Hg or a decrease of > 30% from baseline), tachycardia (> 100 beats/min or an increase > 30% from the baseline) and bradycardia (< 50 beats/min or a decrease > 30% from the baseline).

Statistical analysis

No published studies have been conducted on in-hospital postoperative depression and anxiety among orthognathic patients; therefore, no accurate estimates of their prevalence have been reported. By using the following formula: $N = Z^2_{\alpha/2}\ P\ (1\text{-}P)\ /d^2$ (N: minimum sample size; $Z_{\alpha/2}$: standard normal variable value at 95% CI; P: population proportion; with d: a margin of error, 5%), the calculated sample size required to detect a prevalence of 50% was 384 patients.

We complied with the STROBE guidelines using its checklist to report this cross-sectional study. All statistical analyses were performed using the SPSS 21.0 software package (IBM SPSS Inc., Chicago, IL, USA). Normally distributed continuous variables are described as mean ± SD, non-normally distributed continuous variables are described as median interquartile range IQR and categorical variables are described as number (percentage). Missing data were not replaced. Univariate logistic analyses were performed first to analyze the association between the perioperative variables and postoperative depression and anxiety. The quantitative variables were not transformed to categorical variables. Independent variables with $P < 0.05$ in the univariate analyses were included in a multivariate regression model. We utilized the backward stepwise method to delete those variables that were not statistically significant. A $P < 0.05$ was considered statistically significant in the multivariate analyses.

Results

Preoperative and intraoperative variables

The 371 patients who underwent orthognathic surgery between March 7, 2023, and September 7, 2023, were included in the analysis (Fig. 1). The preoperative data are presented in Table 1. The study sample consisted of 98 men (26.4%) and 273 women (73.6%), and the median age was 25 (21, 29) years. The median BMI was 20.8 (19.0, 23.2 kg/m^2). Most of the patients' were of Han nationality (92.2%) and had no religious beliefs (93.3%). Forty-eight patients were married (12.9%) and 204 (55.0%) were employed. A large proportion of patients (89.5%) had high school or postgraduate experiences. Seventeen patients (4.6%) reported a smoking history and eight (2.2%) had a drinking history. Approximately 45% of patients reported a monthly income of less than ¥2500. The physical status of 84.6% of the patients was categorized as ASA class I. Twenty-one patients (5.7%) had obstructive sleep apnea and 70 (18.9%) had a surgical history.

Participants' data from the preoperative questionnaires are presented in Table 1. During the preoperative period, 34 (9.2%) patients had a PHQ-9 score ≥ 10. The median scores of the STAI-S and STAI-T were 39 (33, 46) and 40 (34, 46) respectively, and 177 (47.7%) patients had STAI-S scores equal to or higher than 40 points. The results of

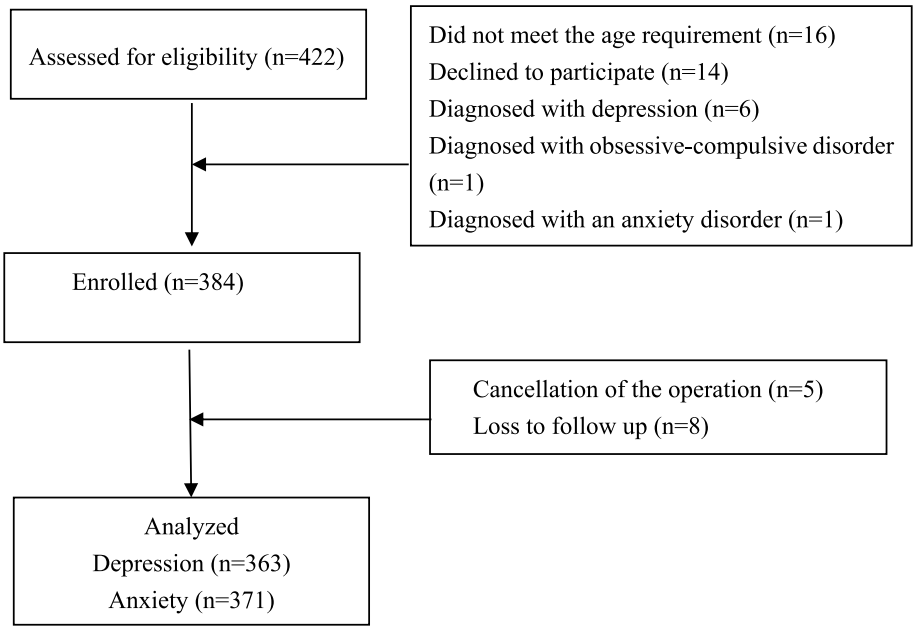

Fig. 1 Flowchart of the selection of patients for the study

the ISI assessment indicated that 20 (5.4%) patients experienced insomnia one month before surgery. The median IQRs of the OQLQ and PCS were 44 (28, 59) and 7 (2, 13), respectively.

As for the intraoperative data, 342 of the patients (92.2%) underwent bi-maxillary surgery. The median durations of the surgery and the anesthesia were 189 (152, 234) and 240 (200, 288) min, respectively. Information regarding the intraoperative medications and fluid balance are presented in Table 1.

Postoperative variables

Among the 371 participants, 85.2% received dexmedetomidine sedation in the post-anesthesia care unit. During the five days after the surgery, the incidence of moderate-to-severe pain and PONV were 51.6% and 66.8%, respectively, and 94.6% of the patients experienced insomnia. The incidence of moderate-to-severe pain, PONV and insomnia during the different periods are presented in Table 2. The median score of the OQLQ was 48 (32, 65).

Assessment of postoperative depression and anxiety

Within 5 days after the surgery, depression (a PHQ-9 score $\geq$ 10) occurred in 32% of patients (116/363), and anxiety occurred in 72.8% of patients (270/371) with an STAI-S score $\geq$ 40. The incidence of depression on postoperative days 1, 3 and 5 was 22.2%, 9.1% and 17.1%, respectively, and the incidence of anxiety on postoperative days 1, 3 and 5 were 56.8%, 44.2% and 57.7%, respectively (Table 3).

Multivariate logistic regression analysis of postoperative depression

The univariate analyses identified 12 factors that were potentially associated with the occurrence of depression within five days following the surgery ($P < 0.05$); therefore, these variables were included in the multivariate logistic regression model (backward method). After correcting for the confounding variables, three variables were identified as independent predictors of postoperative depression. The preoperative depression score on the PCS and intraoperative urine output were significantly associated with a higher risk of postoperative depression (preoperative depression: OR 4.582; 95% CI 1.911–10.984; $P = 0.001$; PCS: OR 1.032; 95% CI 1.000–1.065; $P = 0.048$; and intraoperative urine output: OR 1.001; 95% CI 1.000–1.002; $P = 0.008$ (Table 4).

Multivariate logistic regression analysis of postoperative anxiety

Twelve factors were identified in the univariate analyses that were potentially associated with the occurrence of postoperative anxiety ($P < 0.05$), and they were included in a multivariate logistic regression model (backward method). Seven factors were identified as being independent predictors of the occurrence of postoperative anxiety. Patients' preoperative anxiety (STAI-S $\geq$ 40), score on the STAI-T, moderate-to-severe postoperative pain, PONV, postoperative insomnia and OQLQ scores were significantly associated with a higher risk of postoperative anxiety (preoperative anxiety: OR 3.392; 95% CI

Table 1 Pre- and intraoperative data ($N=371$)

Variable	Total study sample n(% or IQR)
Preoperative data	
Age (years)	25(21, 29)
Body mass index (kg/m^2)	20.8(19.0, 23.2)
Male	98(26.4%)
Han nationality	342(92.2%)
Religious beliefs	25(6.7%)
Marital status, married	48(12.9%)
Occupation	
Current student	167(45.0%)
Full-time employment	204(55.0%)
Monthly income (RMB)	
< 2500	167(45.0%)
2500–5500	40(10.8%)
5500–10000	76(20.5%)
> 10,000	88(23.7%)
Education level	
Junior college or below	39(10.5%)
High school or postgraduate	332(89.5%)
Smoking	17(4.6%)
Drinking (alcohol)	8(2.2%)
Obstructive sleep apnea[a]	21(5.7%)
History of surgery	70(18.9%)
Preoperative comorbidities	17(4.6%)
Hypertension	5(1.3%)
Diabetes	1(0.3%)
Scoliosis	3(0.8%)
Hepatitis B	2(0.5%)
Anaphylactoid purpura	1(0.3%)
Phthisis	1(0.3%)
Chronic bronchitis	1(0.3%)
Asthma	1(0.3%)
Atrial myxoma	1(0.3%)
Sjogren's syndrome	1(0.3%)
Gout	1(0.3%)
Karman syndrome	1(0.3%)
ASA classification	
I	314(84.6%)
II	57(15.3%)
Preoperative insomnia[b]	20(5.4%)
Preoperative depression[c]	34(9.2%)
Preoperative anxiety[d]	177(47.7%)
Preoperative STAI-State score	39 (33, 46)
Preoperative STAI-Trait score	40 (34, 46)
Preoperative OQLQ score ($n=370$)	44(29, 59)
Preoperative PCS score	7(2, 13)

Table 1 (continued)

Variable	Total study sample n(% or IQR)
Intraoperative data	
Surgical procedures	
Single-jaw surgery	29(7.8%)
Bimaxillary surgery	342(92.2%)
Duration of surgery (min)	189(152, 234)
Duration of anesthesia (min)	240(200, 288)
Intraoperative medications	
Dexamethasone	272(73.3%)
Tropisetron	67(18.1%)
Dose of sufentanil (ug)	30(25, 40)
Dose of remifentanil (mg)	2(1.6, 2.8)
Dezocine	168(45.3%)
Flurbiprofen axetil	250(67.4%)
Esketamine	63(17.0%)
Dexmedetomidine	197(53.1%)
Intravenous fluids (ml)	1600(1600, 1600)
Infusion of hydroxyethyl starch	81(21.7%)
Blood loss (ml)	200(200,3 00)
Urine output (ml)	300(150, 500)

IQR Interquartile Range, *ASA* American Society of Anesthesiologists, *ISI* Insomnia Severity Index, *OQLQ* Orthognathic Quality of Life Questionnaire, *PCS* Pain Catastrophizing Scale, *PHQ-9* Patient Health Questionnaire-9, *STAI* State Trait Anxiety Inventory, *RMB* Renminbi

[a] Obstructive sleep apnea was diagnosed by otolaryngologists using polysomnography

[b] Insomnia Severity Index score > 14 on the day before surgery

[c] Patient Health Questionnaire-9 score ≥ 10 on the day before surgery

[d] STAI-State score ≥ 40 on the day before surgery

1.531–7.514; $P=0.003$; score on the STAI-T: OR 1.138; 95% CI 1.077–1.202; $P<0.001$; postoperative moderate-to-severe pain: OR 2.966; 95% CI 1.608–5.470; $P<0.001$; PONV: OR 2.114; 95% CI 1.148–3.892; $P=0.016$; postoperative insomnia: OR 4.597; 95% CI 1.420–14.882; $P=0.011$; and score on the Quality-of-Life questionnaire: OR 1.025; 95% CI 1.010–1.041; $P<0.001$). A monthly income ≥ ¥10000 was significantly associated with a lower risk of postoperative anxiety (OR 0.367; 95% CI 0.178–0.760; $P=0.007$) (Table 5).

Discussion

This study investigated the prevalence and predictors of postoperative depression and anxiety following orthognathic surgery during the early postoperative stage. To the best of our knowledge, this study is the most extensive evaluation of this issue. An analysis of a large population from a national database that underwent major surgery showed that the incidence of new onset postoperative depression ranged from 6.8% to 18.8% and that

Table 2 Postoperative data ($N=371$)

Variable	Total study sample n(%)
Dexmedetomidine used in the post-anesthesia care unit	316(85.2%)
Moderate to severe pain within 5 days after surgery[a] ($n=366$)	189(51.6%)
Nausea and vomiting within 5 days after surgery ($n=371$)	248(66.8%)
Insomnia within 5 days after surgery[b] ($n=369$)	349(94.6%)
OQLQ score 5 days after surgery(score) ($n=356$)	48(32, 65)
In-hospital complications	66(17.8%)
Agitation[c]	46(12.4%)
Hypotension[d]	12(3.2%)
Bradycardia[e]	8(2.2%)
Hypertension[f]	3(0.8%)

OQLQ Orthognathic Quality of Life Questionnaire

[a] Score ≥ 4 on the Numerical Rating Scale at any time during the 5 days after surgery

[b] Insomnia Severity Index score > 14 during the 5 days after surgery

[c] Defined as the Richmond Agitation-Sedation Scale ≥ + 2

[d] Defined as a systolic blood pressure < 90 mm Hg or a decrease > 30% from the baseline measurement and requiring therapeutic intervention

[e] Defined as a heart rate < 50 beats min^{-1} or a decrease of > 30% from baseline and requiring therapeutic interventions

[f] Defined as a systolic blood pressure > 180 mm Hg or an increase of > 30% from baseline and requiring therapeutic interventions

Table 3 Trial outcomes

Outcomes	
Postoperative depression within 5 days after surgery[a] ($n=363$)	116(32.0%)
Depression 1 day after surgery ($n=370$)	82 (22.2%)
Depression 3 days after surgery ($n=363$)	33 (9.1%)
Depression 5 days after surgery($n=357$)	61(17.1%)
Postoperative anxiety within 5 days after surgery[b] ($n=371$)	270 (72.8%)
Anxiety 1 day after surgery ($n=368$)	209(56.8%)
Anxiety 3 days after surgery ($n=364$)	161(44.2%)
Anxiety 5 days after surgery ($n=359$)	207(57.7%)

[a] Patient Health Questionnaire-9 score ≥ 10 points on the day before the surgery

[b] STAI-State score ≥ 40 points on the day before the surgery

the risk of postoperative depression differed by surgical type [16]. However, no patients who underwent orthognathic surgery were included in that study. In our study, depression occurred in 32% of patients following orthognathic surgery, suggesting that patients undergoing orthognathic surgery are more susceptible to depression and require more attention because of this.

Our study evaluated depression using the PHQ-9, which is a frequently used tool in research and practice. A score of 10 or higher has a high sensitivity and specificity; therefore, a score of 10 is recommended as the cut-off value for diagnosing depression. This tool is widely used in perioperative assessments of depression in surgical patients, including those undergoing orthognathic surgery [7, 13]. Preoperative depression has been found to be significantly associated with a higher risk of postoperative depression in other surgical populations [17].

Pain catastrophizing is defined as a fear appraisal of an actual or anticipated pain experience, which is associated with a host of adverse clinical outcomes, independent of pain intensity [18]. Moreover, catastrophizing is considered a determinant of symptoms of a wide range of mental problems [19]. Several studies have found an association between a higher score on the PCS and depression in non-surgical patients. For example, high levels of pain catastrophizing predicts more severe and prolonged depressive symptoms in patients with whiplash injury disorders [20, 21]. Our study showed that preoperative depression and pain catastrophizing were independent risk factors for postoperative depression in patients who underwent orthognathic surgery. Surprisingly, a significant association was found between intraoperative urine output and postoperative depression, which warrants investigation to explain this association.

Patients who undergo orthognathic surgery show higher levels of anxiety than people in the general population do [22]. In our study, the total incidence of postoperative anxiety was 72.8%. Given the large number of orthognathic surgeries in China, attention should be given to the care of anxious patients during their postoperative management after orthognathic surgery.

The level of trait anxiety influences the level of state anxiety to a certain extent. Under stressful conditions, patients with high levels of trait anxiety are more likely to experience high levels of state anxiety. Our data show that the STAI-T score was significantly associated with a higher risk of postoperative anxiety. Carr et al. also found that preoperative anxiety predicted early postoperative anxiety [23]. We also found that patients with a high monthly income were less likely to experience anxiety after surgery. The association between income and postoperative anxiety has been reported in previous studies [24]. Expenditures for anesthesia, surgery and other types of perioperative care are an economic burden for most patients, unlike those with higher incomes.

Pain is common after orthognathic surgery and the incidence of moderate-to-severe pain was high (51.6%) in our sample. A cohort study reported that anxiety scores were significantly higher in patients with anxiety about postoperative pain than they were in patients without pain-related anxiety [25]. Another study found a positive association of anxiety with acute postoperative pain

Table 4 Multivariate logistic regression of postoperative depression

	Bivariate analyses[a]				Multivariate analyses[b]			
	OR	**Upper limit of 95%CI**	**Lower limit of 95%CI**	***P*-value**	**OR**	**Upper limit of 95%CI**	**Lower limit of 95%CI**	***P*-value**
Monthly income (RMB)								
< 2500	Reference							
2500–5500	0.112	0.542	2.284	0.772	-	-	-	-
5500–10000	0.531	0.283	0.995	0.048	-	-	-	-
> 10,000	0.729	0.415	1.282	0.273	-	-	-	-
Obstructive sleep apnea	0.211	0.048	0.920	0.038	0.242	0.052	1.121	0.070
Preoperative insomnia	3.956	1.515	10.333	0.005	-	-	-	-
Preoperative depression	7.265	3.267	16.157	< 0.001	4.582	1.911	10.984	0.001
Preoperative anxiety	2.326	1.479	3.658	< 0.001	1.635	0.965	2.771	0.068
Preoperative STAI-Trait score	1.065	1.036	1.094	< 0.001	-	-	-	-
Preoperative OQLQ score	1.016	1.005	1.028	0.006	-	-	-	-
Preoperative PCS score	1.061	1.033	1.090	< 0.001	1.032	1.000	1.065	0.048
Intraoperative urine output (ml)	1.001	1.000	1.002	0.002	1.001	1.000	1.002	0.008
Postoperative moderate to severe pain	2.000	1.268	3.154	0.003	1.566	0.941	2.606	0.085
PONV	1.781	1.087	2.916	0.022	-	-	-	-
Postoperative OQLQ score	1.020	1.009	1.032	< 0.001	1.012	0.999	1.024	0.068

OQLQ Orthognathic Quality of Life Questionnaire, *PCS* Pain Catastrophizing Scale, *PHQ-9* Patient Health Questionnaire-9, *PONV* Postoperative nausea and vomiting, *STAI* State Trait Anxiety Inventory, *RMB* Renminbi

[a] Variables with $P < 0.05$ in the bivariate analyses that were included in the multivariate model

[b] Backward logistic regression

Table 5 Multivariate logistic regression of postoperative anxiety

	Bivariate analysis[a]				Multivariate analysis[b]			
	OR	**Upper limit of 95%CI**	**Lower limit of 95%CI**	***P*-value**	**OR**	**Upper limit of 95%CI**	**Lower limit of 95%CI**	***P*-value**
Marital status(unmarried)	0.519	0.276	0.976	0.042	-	-	-	-
Monthly income (RMB)								
< 2500	Reference							
2500–5500	2.278	0.837	6.199	0.107	2.142	0.599	7.660	0.241
5500–10000	0.976	0.521	1.828	0.940	0.826	0.372	1.832	0.637
> 10,000	0.470	0.271	0.816	0.007	0.367	0.178	0.760	0.007
Preoperative insomnia	7.570	1.000	57.303	0.050	-	-	-	-
Preoperative depression	6.655	1.565	28.307	0.010	-	-	-	-
Preoperative anxiety	9.467	5.119	17.507	< 0.001	3.392	1.531	7.514	0.003
Preoperative STAI-Trait score	1.176	1.128	1.225	< 0.001	1.138	1.077	1.202	< 0.001
Preoperative OQLQ score	1.028	1.016	1.041	< 0.001	-	-	-	-
Preoperative PCS score	1.068	1.031	1.106	< 0.001	-	-	-	-
Postoperative moderate to severe pain	2.879	1.776	4.667	< 0.001	2.966	1.608	5.470	< 0.001
Postoperative nausea and vomiting	1.866	1.163	2.994	0.010	2.114	1.148	3.892	0.016
Postoperative insomnia	5.593	2.162	14.466	< 0.001	4.597	1.420	14.882	0.011
Postoperative OQLQ score	1.032	1.020	1.044	< 0.001	1.025	1.010	1.041	0.001

OQLQ Orthognathic Quality of Life Questionnaire, *PCS* Pain Catastrophizing Scale, *PHQ-9* Patient Health Questionnaire-9, *PONV* postoperative nausea and vomiting, *STAI* State Trait Anxiety Inventory, *RMB* Renminbi

[a] Variables with $P < 0.05$ in the bivariate analysis were included in the multivariate model

[b] Backward logistic regression

in patients who underwent major gynecological surgery [23]. We also identified postoperative moderate-to-severe pain following orthognathic surgery as an independent risk factor for anxiety. More importantly, a link between mood disorders and acute pain has been found to be significant and bi-directional, with both of them acting as risk factors for one another [26]. Perioperative anxiety is associated with the severity of augmented pain [27, 28]; therefore, an effective analgesic strategy is crucial for both pain control and the psychological management of patients undergoing orthognathic surgery.

The most frequent complication after orthognathic surgery is PONV, with an incidence of up to 78% [29]. Consistent with these results, 66.8% of patients in our study experienced PONV. A survey of patients following general anesthesia and surgery reported that, compared to their pain and decreased mental alertness, PONV was the most undesirable complication during postoperative recovery [30]. Among the patients who reported anxiety in a study by Bello et al., fear of developing PONV was the most reported cause of anxiety [31]. Our study found a positive association between PONV and postoperative anxiety. Although PONV is regarded as a short-lived and nonfatal complication, it may be life threatening to patients after orthognathic surgery, because of maxillomandibular elastic tractions, facial swelling and pain may affect mouth opening, which increases the risk of aspiration and leads to asphyxia. A patient who underwent a LeFort I osteotomy in one study vomited during the first postoperative night and suffocated because of the mandibulomaxillary fixation, which finally led to cerebral hypoxia [32]. Thus, the patients' anxiety was derived from the uneasiness and apprehension of nausea and vomiting.

We found a high prevalence of insomnia among patients following orthognathic surgery. Sleep is essential for regulating the metabolism of the brain and mood [33]. Preclinical studies have reported findings that sleep deprivation causes anxiety-like behaviors in animals [34, 35]. A study on the postoperative sleep quality of patients who underwent a flap transfer for head and neck surgery revealed that anxiety was significantly associated with postoperative insomnia [36]. Our study showed that postoperative insomnia was associated with a 4.6-fold increased risk of anxiety following orthognathic surgery. These relationships between anxiety and insomnia following surgery suggest that attention should be paid to the quality of sleep postoperatively, not only to ameliorate insomnia, but also to improve the patient's mental and emotional recovery.

The OQLQ is a well-established instrument for evaluating the quality of life of patients with dento-facial deformities, and it is one of the most frequently used questionnaires for evaluating the quality of life of patients undergoing orthognathic surgery. Although patients usually report a higher level of quality of life than the level they had before the surgery [37], facial swelling, pain, restricted mouth opening and diet restrictions during the early postoperative stage can lead to a decrease in quality of life. A lower quality of life has been reported to be associated with psychological distress (including anxiety) in other populations [38, 39]. Similarly, our study found a positive association between a lower quality of life and risk of anxiety in patients following orthognathic surgery.

The results of the present study showed that the presence of preoperative psychological symptoms could increase the incidence of postoperative psychological symptoms among patients undergoing orthognathic surgery. Furthermore, a high incidence of postoperative psychological symptoms, which was observed in patients who underwent orthognathic surgery was associated with an increased risk of several postoperative adverse events. These findings demonstrated that psychological symptoms were not only related to patient satisfaction, but also to clinical outcomes. Based on our findings, we advocate a thorough preoperative interview that includes enquiring about patients' financial situations and conducting assessments of their emotional status, which can be useful for identifying patients at high risk for postoperative depression and anxiety. During the postoperative period, multiple strategies, such as the use of multimodal analgesia (e.g., the combined use of opioids and non-steroidal anti-inflammatory drugs or use of a nerve block or other medication), the administration of antiemetics to prevent PONV and improve sleep quality through nonpharmacological and pharmacological interventions could be used to benefit patients by improving psychological outcomes. Due to the high incidences of postoperative depression and anxiety, perioperative care involving clinical psychologists or psychiatrists should be included as an ancillary treatment with maxillofacial surgeons.

This study has some limitations. First, due to the nature of cross-sectional studies, it is impossible to determine causal relationships between perioperative factors and depression and anxiety and their underlying mechanisms. Second, we excluded patients with a self-reported history or a clinical diagnosis of a neurological or psychiatric illness. Not every patient who is screened undergoes psychiatric and neurological examinations in cross-sectional studies. This information might be overlooked or hidden without a prior diagnosis by a specialist, and thus cause bias. Third, the reliance on self-report instruments, albeit validated, might lead to self-report biases. Fourth, the exclusion of patients diagnosed with neuropsychiatric disorders from the study might result in an underestimation of the prevalence of depression and anxiety in

the general population. Last, this study was conducted at a single institution, which might limit the generalizability of our findings.

Conclusion

In this prospective cross-sectional study, we found that postoperative depression and anxiety were common among patients who underwent orthognathic surgery. Moreover, the preoperative psychological status and incidence of postoperative adverse events was associated with an increased risk of depression and anxiety after the surgery. Therefore, the results of the present study suggest that careful psychological assessments and appropriate management (e.g., multiple strategies during both pre- and postoperative periods) are necessary to improve patients' recovery following orthognathic surgery.

Abbreviations

PHQ-9	Patient Health Questionnaire-9
DSM-IV	Diagnostic and Statistical Manual of Psychiatric Disorders
STAI	State Trait Anxiety Inventory
STAI-S	State Trait Anxiety Inventory-State
STAI-T	State Trait Anxiety Inventory-Trait
ISI	Insomnia Severity Index
RCSQ	Richards-Campbell Sleep Questionnaire
PCS	Pain Catastrophizing Scale
OQLQ	Orthognathic Quality of Life Questionnaire
NRS	Numerical rating scale
PONV	Postoperative nausea and vomiting
ASA	American Society of Anesthesiologists
IQR	Interquartile Range

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions

DZ contributed to conceive and design the study, data acquisition and interpretation, drafted the manuscript. LKW contributed to conceive and design the study, data acquisition and interpretation, drafted the manuscript. HYW contributed to conceive and design the study, data acquisition. LG contributed to conceive and design the study, data acquisition. XDY contributed to conceive and design the study, interpretation and critically revised the manuscript. All authors gave their final approval and agree to be accountable for all aspects of the work.

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Availability of data and materials

The datasets generated and/or analyzed during the current study will be available from the corresponding author on a reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Biomedical Ethics Committee of Peking University Hospital of Stomatology (Number: PKUSSIRB-202281155) on November 15, 2022. Written informed consent was obtained from all participants prior to their involvement in the study.

Consent for publications

Not applicable.

Competing interests

The authors declare no competing interests.

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