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DENTAL ANXIETY AS AN INDEPENDENT PREDICTOR OF POSTOPERATIVE PAIN INTENSITY FOLLOWING ORAL AND MAXILLOFACIAL SURGICAL PROCEDURES: A PROSPECTIVE COHORT STUDY

Menahil Khan Swati[*1], Talha[2]

*[*1]BDS, Frontier Medical & Dental College Abbottabad*
[2]University of Makran

[*1]manokhuram2005@gmail.com, [2]talha@uomp.edu.pk

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Menahil Khan Swati

Abstract

Dental anxiety affects approximately 10-20% of the global population and represents a significant barrier to oral healthcare, with emerging evidence establishing it as a robust, independent predictor of postoperative pain intensity following oral and maxillofacial surgical procedures. This review synthesizes prospective cohort studies, clinical trials, and systematic reviews investigating the relationship between preoperative dental anxiety and postoperative pain outcomes, examining the underlying neurobiological mechanisms, psychometric assessment tools, and multimodal management strategies. Preoperative dental anxiety activates complex neuroendocrine cascades involving hypothalamic-pituitary-adrenal (HPA) axis stimulation and sympathetic-adrenal-medullary responses, leading to peripheral inflammatory amplification through increased prostaglandin E2 and serotonin release, alongside central sensitization via NMDA receptor-mediated wind-up phenomena. Validated psychometric instruments, particularly the Modified Dental Anxiety Scale (MDAS) with Cronbach's α=0.91, demonstrate strong predictive validity for identifying at-risk patients. Prospective cohort data consistently reveal that highly anxious patients experience significantly elevated postoperative pain trajectories, with up to 4.75-fold increased risk of severe symptoms (95% CI: 1.02-22.18), independent of surgical complexity, patient demographics, or intraoperative analgesia. Anxiety-induced autonomic dysregulation increases intraoperative anesthetic requirements, prolongs recovery times, and elevates risks of complications including alveolar osteitis, emergence delirium, and postoperative cognitive dysfunction. Comprehensive management incorporating pharmacological interventions (preemptive NSAIDs, NMDA antagonists, buffered local anesthetics, gabapentinoids) and non-pharmacological approaches (cognitive distraction, preoperative education, music therapy, physical desensitization through pre-cooling) effectively mitigates both anxiety and postoperative pain. However, significant implementation gaps persist between theoretical knowledge and clinical practice. In conclusion, dental anxiety serves as an independent predictor of postoperative pain intensity through well-characterized

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neurobiological pathways, supporting routine preoperative anxiety screening and implementation of targeted multimodal interventions to optimize patient outcomes, reduce postoperative morbidity, and transition from reactive pain management to prospective, risk-stratified perioperative care in oral and maxillofacial surgery.

1. Introduction

Dental anxiety is a highly prevalent, multifaceted psychophysiological response characterized by cognitive apprehension, hypervigilance, and physiological arousal in anticipation of or during dental interventions. This condition affects an estimated 10% to 20% of the global population, with severe cases meeting the diagnostic criteria for dental phobia, which represents a profound barrier to seeking and receiving necessary oral healthcare (Klingberg & Broberg, 2007). Within oral and maxillofacial surgery, invasive procedures such as the surgical extraction of impacted third molars serve as major stress triggers, eliciting intense perioperative anxiety and substantial postoperative morbidity, including acute pain, swelling, and trismus (Osunde et al., 2011).

Traditionally, postoperative pain management models have relied heavily on mechanical or procedural parameters, such as the complexity of the surgery, the experience of the operator, and the overall duration of the operation. However, clinical outcomes frequently deviate from these objective markers, suggesting that individual psychological variations play a dominant role in pain processing. Over the past several decades, a transitioning paradigm toward a biopsychosocial model has established that acute postoperative pain exists on a continuum modulated by the patient's baseline emotional and psychological state (Vlaeyen & Linton, 2000).

Prospective cohort data demonstrate that preoperative dental anxiety operates as a robust, independent predictor of postoperative pain intensity. This independent predictive capacity remains statistically significant even when adjusting for surgical difficulty, patient demographics, and the volume of intraoperative anesthetics or analgesics administered. Understanding these pathways is essential for transitioning from reactive postoperative pain management to prospective, risk-stratified clinical interventions (Ip et al., 2009).

2. Neurobiological and Psychophysiological Mechanisms of Pain Modulation

The pathological translation of emotional anxiety into heightened physical pain involves a complex network of neuroendocrine cascades, peripheral inflammatory amplification, and central nervous system sensitization. Preoperative anxiety begins within the central nervous system, where threat-related perceptions activate the amygdala. The amygdala initiates a rapid sympathetic-adrenal-medullary response alongside the activation of the hypothalamic-pituitary-adrenal (*HPA*) axis, culminating in the systemic release of key stress hormones, including cortisol and catecholamines such as adrenaline (McNeil & Randall, 2014).

In patients with high baseline dental anxiety, this stress response is compounded by autonomic dysregulation characterized by chronic sympathetic overactivity and a corresponding parasympathetic deficit. Under the acute physical stress of oral surgery, this autonomic profile reduces the patient's adaptive reserve, lowering the physiological activation threshold of nociceptive pathways and amplifying sensory vigilance (van Wijk & Hoogstraten, 2009).

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Figure 1. Schematic Overview of the Logical Analysis Model for Predicting Postoperative Pain from Intraoperative Predictions, Actual Events, and Baseline Pain Scores.

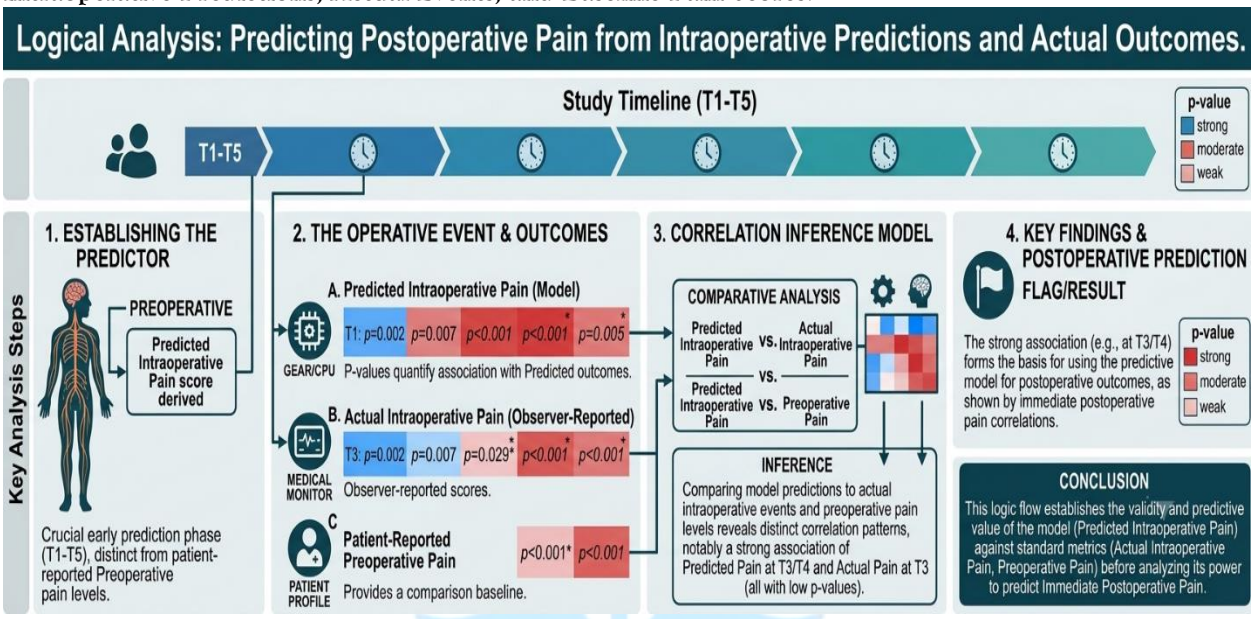


Table 1. Psychometric Comparison of Preoperative Dental and General Anxiety Scales

Instrument	Target Construct	Structural Design	Validated Cutoff	Clinical Strengths	Limitations
Corah's Dental Anxiety Scale (CDAS)	Anticipatory dental anxiety.	4 multiple-choice items with variable categorical answer options.	Score ≥ 15for extreme anxiety.	Historically validated, brief, and simple to score.	Lacks assessment of needle/injection phobia; inconsistent response categories complicate direct comparison.
Modified Dental Anxiety Scale (MDAS)	Multi-dimensional dental anxiety.	5 items on a uniform 5-point Likert scale (1 = not anxious, 5 = extremely anxious).	Score ≥ 19indicates clinical dental phobia.	Includes a dedicated local anesthetic injection question; high internal consistency ($\alpha = 0.91$).	Brief screening instrument that does not capture deep qualitative details of psychological coping.
Dental Anxiety Scale for Third Molar Surgery (DAS-TMS)	Procedure-specific anxiety for third molar odontectomies.	Multi-item scale scoring from 4 to 20 points.	Categories: No anxiety (4–5), Unease (6–10), Anxious (11–15), Very	Highly specific to surgical third molar extractions.	Limited generalizability to non-surgical or general dental procedures.

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			anxious (16–20).		
State-Trait Anxiety Inventory (STAI)	State (situational) and Trait (baseline) anxiety.	40 items divided into two 20-item subscales with 4-point Likert choices.	Score ≥ 40indicates clinically significant state anxiety.	Distinguishes between acute stress and chronic personality traits.	Lengthy administration time; not specific to dental stimuli or local anesthetic injections.
Amsterdam Preoperative Anxiety and Information Scale (APAIS)	General surgical/anesthetic anxiety and information needs.	6 items scored on a 5-point Likert scale.	Score ≥ 11represents clinically significant anxiety.	Isolates situational fear of surgery and anesthesia from information-seeking behavior.	Lacks specific evaluation of local intraoral procedures or dental needle fears.

At the local surgical site, preoperative dental anxiety directly modulates biochemical inflammatory cascades. Heightened emotional distress alters the synthesis and release of prostaglandin E2 (PGE_2), which enhances local inflammatory processes by inducing vasodilation and increasing capillary blood flow. This elevated concentration of PGE_2sensitizes peripheral nociceptors, lowering their response threshold to subsequent mechanical or chemical stimuli (Bui et al., 2003).

Simultaneously, anxiety-induced stress alters the release of serotonin (5-hydroxytryptamine or 5-HT), presenting as an increased secretion of 5-HTby platelets, mast cells, and enterochromaffin cells. This extracellular 5-HTinteracts with specific receptors on the terminals of primary afferent fibers. The excitation of 5-HT_3receptors directly activate nociceptors, while the stimulation of 5-HT_{2A}receptors on primary afferent terminals further intensifies localized pain and tissue edema, magnifying the clinical inflammatory response (Lago-Méndez et al., 2007).

These peripheral events are subsequently translated into chronic or exaggerated pain states via central sensitization. Persistent nociceptive input from the surgical field, combined with sustained stress hormone release, triggers the activation of *N*-methyl-*D*-aspartate ($NMDA$) receptors within the dorsal horn of the spinal cord. This NMDA activation facilitates the "wind-up" phenomenon, characterized by progressive membrane depolarization and an enhanced synaptic response to normal afferent inputs, leading to hyperalgesia and allodynia (Gatchel et al., 2007).

Psychological distress and negative affect, along with cognitive distortions such as pain catastrophizing (characterized by rumination, magnification, and perceived helplessness), impair descending inhibitory pathways originating in the periaqueductal gray (PAG) and the nucleus raphe magnus (NRM). This impairment prevents the effective suppression of spinal nociceptive signals, allowing elevated pain impulses to reach the cerebral cortex, where they are perceived as highly intense pain (Turk & Okifuji, 2002).

3. Psychometric Validation and Comparison of Dental Anxiety Scales

Measuring preoperative dental anxiety requires validated psychometric tools capable of distinguishing dental-specific fears from general state anxiety. Corah's Dental Anxiety Scale ($CDAS$) has been widely used in clinical trials since the 1970s. However, psychometric evaluations have identified structural limitations in the $CDAS$. Specifically, the scale does not contain any

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questions regarding local anesthetic injections, which represents a primary focus of dental fear. Additionally, the multiple-choice response categories for several questions are not arranged in a consistent order of clinical severity, mixing physiological descriptions with emotional states and complicating direct comparison (Carter et al., 2014).

To address these limitations, the Modified Dental Anxiety Scale ($MDAS$) was designed to incorporate several structural improvements. The $MDAS$includes a fifth question specifically targeting fear of local anesthetic injections, and standardizes a uniform 5-point Likert scale (ranging from 1 = not anxious to 5 = extremely anxious) across all items. Methodological validation trials show a strong correlation between the two scales ($r = 0.89$), with the $MDAS$demonstrating higher internal consistency (Cronbach's alpha $\alpha = 0.91$) compared to the $CDAS(\alpha = 0.89)$ (Armfield & Heaton, 2013). Furthermore, the $MDAS$has been cross-culturally validated in numerous populations, establishing a highly reliable clinical cutoff score of 19 or greater to identify patients with extreme dental anxiety or dental phobia. For surgical procedures, specialized scales like the Dental Anxiety Scale for Third Molar Surgery ($DAS-TMS$) are utilized to evaluate patient apprehensions specifically related to surgical odontectomies (Kassem El Hajj et al., 2021).

4. Empirical Clinical Evidence and Cohort Trajectories

Prospective clinical trials consistently demonstrate a significant association between preoperative dental anxiety and elevated postoperative pain trajectories across simple and complex oral surgical procedures (Gonçalves et al., 2025).

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Figure 2. CONSORT Flow Diagram Illustrating Patient Screening, Randomization, Allocation, Follow-Up, and Final Analysis across Study Groups.

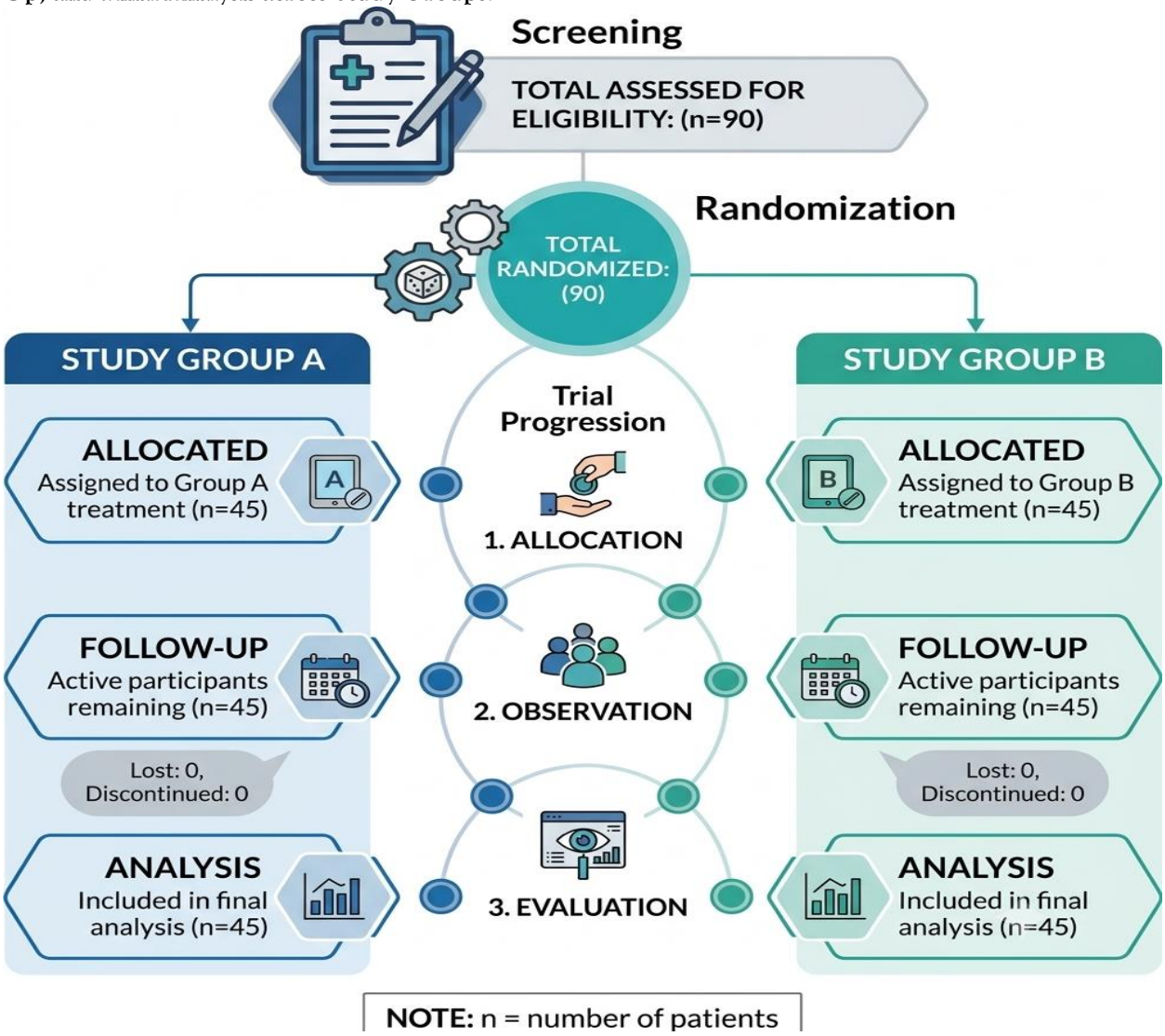


Table 2: Clinical Parameters and Findings of Highlighted Prospective Cohorts in Oral and Periodontal Surgery

Study Population & Design	Evaluated Surgical Procedure	Preoperative Anxiety Parameters	Postoperative Pain and Patient-Reported Outcomes	Key Statistical Findings & Parameters
Maxillofacial Odontectomy Cohort	Surgical extraction of mandibular third molars under local anesthesia ($N = 71$).	Modified Dental Anxiety Scale (MDAS).	Visual Analog Scale (VAS) pain scores tracked over 7 consecutive postoperative days.	Moderate anxiety in 50.0% of cases; severe anxiety in 13.6%. Females demonstrated significantly higher anxiety ($p = 0.03$) and

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				higher postoperative pain ($p = 0.002$).
Landmark King Khalid University Cohort	Surgical removal of impacted lower third molars under local block ($N = 55$).	Modified Dental Anxiety Scale (MDAS).	Pain tracked using a structured categorical rating scale and analgesic consumption logs.	Low anxiety in 54.5%, moderate in 34.5%, and severe in 11.0%. Severe anxiety was significantly linked to female gender ($\chi^2 = 13.449, p = 0.001$). No significant correlation with age or education.
Mandibular Third Molar Cohort	Mandibular third molar extraction under local anesthesia ($N = 34$).	Tooth Extraction Anxiety Scale (TEAS) and Corah's Dental Anxiety Scale (CDAS).	Visual Analog Scale (VAS) pain scores on postoperative days 1, 3, and 8.	Highly anxious patients experienced a significant increase in pain on postoperative day 1 ($p < 0.05$). Anticipated postoperative pain was significantly higher than actual pain ($p < 0.01$).
Periodontal Free Gingival Graft Cohort	Elective free gingival graft (FGG) periodontal surgery ($N = 36$).	State-Trait Anxiety Inventory (STAI-S/STAI-T) completed preoperatively.	100-mm VAS pain scores tracked daily on postoperative days 1 to 7; oral health-related quality of life via OHIP-14.	Preoperative STAI-S scores were significantly higher in females and strongly correlated with poorer OHIP-14 and pain-discomfort scores at baseline and days 3 to 7 ($p < 0.05$).
Periodontal Surgery Regression Model	Periodontal surgery (soft tissue grafts vs. scaling/root planing) ($N = 508$).	Multivariable 8-variable model: sex, surgery type, nervousness, anticipated pain, sedation, age, smoking, and pain pill use.	Actual pain experienced on postoperative day 1, daily pain scores, and subsequent analgesic consumption.	Greater preoperative nervousness predicted higher anticipated pain ($p < 0.01$). Sedation use was strongly associated with lower actual postoperative pain ($p < 0.01$).
Orthodontic Bracket Debonding Model	Bracket debonding removal procedures under mechanical traction.	State-Trait Anxiety Inventory (STAI) and Positive and Negative Affect Schedule (PANAS).	Visual Analog Scale (VAS) pain intensity immediately before (T0) and after (T1) bracket debonding.	Multivariable regression identified baseline pain, age, and negative affect (PANAS) as independent predictors of higher debonding pain ($p < 0.05$).

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In a prospective observational clinical trial of 573 patients undergoing dental extractions, researchers investigated the relationship between preoperative anxiety, intraoperative discomfort, and retrospective pain recalled on the seventh postoperative day. Preoperative anxiety levels were significantly higher in patients undergoing mandibular third molar extractions compared to simpler extraction procedures. While anxiety did not act as a direct predictor of seventh-day pain in most surgical subgroups, mediation analysis revealed a significant indirect pathway (Gonçalves et al., 2025).

Preoperative anxiety significantly increased intraoperative discomfort ($p < 0.001$), which in turn served as a primary driver of elevated postoperative pain intensity and persistent pain recall. This finding underscores how preoperative psychological distress can complicate intraoperative management, making surgical manipulation more challenging and prolonging the procedure (Zhang et al., 2025).

These findings are further supported by a prospective cohort study of 213 patients undergoing surgical extraction of lower third molars. Multivariable logistic regression analysis demonstrated that patients categorized as "Very anxious" on the DAS-TMS had a significantly higher risk of experiencing severe postoperative symptoms on the seventh day ($OR = 4.75$, 95% CI: 1.02–22.18) after controlling for clinical and radiographic covariates (Martínez-Martín et al., 2024).

A two-piecewise linear regression model revealed a non-linear relationship: the risk of serious postoperative symptoms increased significantly with each incremental anxiety point up to a threshold score of 7 (adjusted $OR = 1.94$, 95% CI: 1.12–3.74, $p = 0.012$). However, beyond 7 points, the association plateaued (adjusted $OR = 0.98$, 95% CI: 0.88–1.08, $p = 0.756$), indicating that even moderate levels of dental anxiety can maximize the physical risk of severe postoperative symptoms (Lima Neto et al., 2025).

These findings are consistent with data from other surgical specialties. In patients undergoing amputation surgery, preoperative anxiety was significantly associated with phantom limb pain (PLP) scores on all five postoperative days ($r = 0.30$ to 0.62, $p < 0.05$), remaining a significant predictor even after controlling for baseline preoperative pain and daily postoperative opioid equivalent doses (López-Jornet et al., 2014).

In major general surgery, a prospective study of 400 patients found that preoperative state anxiety (STAI-S ≥ 40) was significantly associated with increased postoperative morbidity ($OR = 2.12$, 95% CI: 1.14–3.96, $p = 0.018$) in patients undergoing high-risk complex procedures, with a significantly higher prevalence of anxiety observed in female patients (53.5% vs 46.5%, $p = 0.003$) (Abdulhameed et al., 2024).

5. Systemic and Neurocognitive Complications of Preoperative Anxiety

The clinical impact of preoperative dental anxiety extends beyond local pain perception, influencing systemic drug requirements, anesthetic recovery, and postoperative cognitive function. High levels of preoperative anxiety are associated with increased requirements for anesthetics and analgesics, including propofol and opioids, during surgical procedures (Kain et al., 2006).

Meta-analytic data show a significant positive correlation between preoperative state anxiety (STAI-S) and intraoperative propofol consumption (pooled correlation r = 0.35, 95% CI: 0.15–0.55), as well as between preoperative trait anxiety (STAI-T) and propofol requirements (r = 0.43, 95% CI: 0.18–0.68). This increased anesthetic requirement can elevate the risk of dose-dependent adverse effects, including respiratory depression, prolonged extubation times, systemic hypotension, and delayed discharge. Highly anxious patients show a statistically significant delay in reaching a post-anesthetic Modified Aldrete Score of 9 (mean difference = 1.83 minutes, 95% CI: 1.21–2.46) (Lin et al., 2023).

Preoperative anxiety also contributes to the development of postoperative delirium (POD) in adults and emergence delirium (ED) in pediatric patients. From a pathophysiological perspective, emergence delirium is characterized by

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disorientation, agitation, and restlessness during the early awakening phase. This condition is increasingly understood as a clinical manifestation of neuroendocrine dysregulation under surgical stress, driven by baseline autonomic imbalances (Kain et al., 2004).

In a prospective study of 56 children undergoing elective surgery, high preoperative anxiety (measured via m-YPAS) was associated with elevated postoperative pain (measured via the FLACC scale, which evaluates five core behavioral indicators: breathing, negative vocalization, facial expression, body language, and consolability) and a higher incidence of emergence delirium (Davidson et al., 2006).

In geriatric populations, preoperative anxiety and acute postoperative pain interact to increase the risk of postoperative delirium. In a prospective cohort study of 120 patients aged 65 years or older undergoing major surgery, preoperative anxiety (measured via the Beck Anxiety Inventory) was identified as a significant independent risk factor for both high postoperative pain ($P < 0.001$) and first-day postoperative delirium ($P = 0.010$) (Leung et al., 2005).

These findings suggest that preoperative psychological distress contributes to delirium through systemic neuroinflammatory responses, blood-brain barrier disruption, and postoperative pain amplification, emphasizing the clinical value of routine anxiety screening and targeted perioperative interventions (Evered et al., 2018).

In addition to acute cognitive disturbances, traumatic or highly stressful extractions can lead to localized complications such as alveolar osteitis (AO), commonly known as dry socket. Alveolar osteitis occurs in up to 59.3% of traumatic tooth extraction cases, presenting with severe localized pain (100%), difficulty eating (61.78%), and malodor or bad taste (55.28%). These localized complications can further elevate postoperative pain trajectories, delay functional recovery, and impair patient satisfaction (Kolokythas et al., 2010).

6. Comprehensive Multimodal Management and Preventive Protocols

Given the clear relationship between preoperative dental anxiety and elevated postoperative pain, clinical protocols must incorporate structured pharmacological and non-pharmacological interventions to optimize patient recovery (Blum, 2002).

Table 3: Pharmacological and Physical Preemptive Analgesic Regimens

Intervention Category	Tested Agent / Protocol	Primary Mechanism of Action	Evaluated Efficacy Metrics	Key Clinical Findings & Parameters
Systemic Preemptive NMDA Antagonism	Dextromethorphan (DM) syrup (dose administered 90 min preoperatively).	Non-competitive NMDA receptor antagonist; blocks spinal cord hyperexcitability and prevents central sensitization.	Time elapsed to first rescue analgesic demand; total count of analgesic tablets consumed.	Extended time to first rescue analgesic to 3.92 hours, significantly longer than ibuprofen (2.79 hours) and placebo (1.88 hours) ($p = 0.023$).

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Systemic Preemptive NSAID Therapy	Diclofenac Sodium (50 mg oral tablet administered 1 hour preoperatively).	Reversible cyclooxygenase (COX) inhibition; suppresses peripheral prostaglandin synthesis and inflammatory hyperalgesia.	Visual Analog Scale (VAS) scores for pain, trismus, and facial swelling.	Significant reduction in postoperative tenderness scores ($p = 0.00$); minimal differences in objective facial swelling.
Systemic Preemptive Gabapentinoid	Pregabalin (single oral dose administered preoperatively).	Binds to $\alpha_2\delta$subunit of voltage-gated calcium channels; reduces excitatory neurotransmitter release.	Postoperative pain scores and cumulative opioid consumption.	Significantly decreased acute postoperative pain intensity in patients undergoing orthognathic surgery.
Pediatric Preemptive Analgesia	Intravenous Acetaminophen (10 mg/kg administered 30 min before incision).	Central cyclooxygenase inhibition and indirect activation of descending serotonergic pathways.	Wong-Baker Faces Pain Scale (WBFPS); Pediatric Anesthesia Emergence Delirium (PAED) scale.	Preemptive group demonstrated significantly shorter extubation times ($p < 0.001$) and reduced duration of emergence delirium.
Chemical Local Anesthetic Buffering	2% Lidocaine with 1:80,000 Epinephrine buffered with Sodium Bicarbonate (pH raised to 7.35–7.4).	Raises local pH, increasing the uncharged lipid-soluble free base form of lidocaine to accelerate nerve membrane penetration.	Pain during needle infiltration (buccal/palatal); onset time of sensory anesthesia; patient satisfaction.	Significantly faster onset of buccal/palatal anesthesia ($p = 0.02$ and $p = 0.01$, respectively) and higher patient satisfaction ($p < 0.0001$).
Physical Site Desensitization	Pre-cooling the local mucosal injection site with ice for 1 minute.	Decreases nerve conduction velocity and local metabolic rate; activates thermal receptors to close the pain gate.	Wong-Baker FACES pain scale scores during subsequent local anesthetic needle infiltration.	Achieved the lowest mean pain score (2.4) compared to vibration (2.6), buffered local anesthesia (5.6), and topical anesthetic gel (6.2) ($p < 0.001$).

A clinical survey of 93 oral and maxillofacial surgeons in Nigeria (82.8% male, 62.4% consultants, 93.5% working in public tertiary hospitals) revealed a clear gap between clinicians'

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theoretical knowledge and their actual practice of preemptive analgesia. While 75.3% of the surveyed surgeons demonstrated a good theoretical understanding of the clinical benefits of preemptive analgesia, only 43.0% reported implementing optimal preemptive practices in their routine surgical care (Klingberg & Broberg, 2007).. The most common preemptive agents used were non-steroidal anti-inflammatory drugs ($NSAIDs$). The primary barriers to implementing preemptive analgesia in clinical practice included inadequate training, a lack of standardized institutional guidelines, poor administrative prioritization, and limited drug availability (Osunde et al., 2011).

In pediatric patients undergoing adenotonsillectomy, a prospective observational study of 64 patients compared the clinical efficacy of preemptive analgesia (intravenous acetaminophen 10 mg/kg administered 30 minutes before surgical incision; Group 1) with late administration (acetaminophen administered 15 minutes before the end of surgery; Group 2). Patients in the preemptive group (Group 1) demonstrated significantly shorter extubation times ($p < 0.001$) (Vlaeyen & Linton, 2000). Furthermore, elevated emergence delirium scores (PAED score ≥ 10) persisted for only 10 minutes postoperatively in Group 1, compared to 15 minutes in Group 2, with PAED and pain scores showing a strong positive correlation and declining over time ($p < 0.05$). This suggests that preemptive analgesia can reduce early postoperative pain and emergence delirium, though multimodal strategies addressing both pain and anxiety are required for optimal recovery (Ip et al., 2009).

However, the clinical use of systemic analgesics requires careful patient-specific customization, particularly in frail older adults. In geriatric patients, age-related pharmacokinetic alterations, driven primarily by impaired glucuronidation with preserved sulfation, can result in elevated serum concentrations and a higher risk of hepatotoxicity at standard doses (McNeil & Randall, 2014).

Furthermore, the rapid intravenous administration of acetaminophen can cause transient hemodynamic instability, with 10% to 60% of critically ill patients developing significant hypotension. This hypotensive response is mediated by the metabolite N-acetyl-p-benzoquinone imine ($NAPQI$), which triggers a $K_v7.4/7.5$potassium channel-mediated vasodilatory cascade amplified by calcitonin gene-related peptide ($CGRP$) release. While paracetamol/codeine combinations can improve early acute pain control compared to ibuprofen or placebo, large-scale clinical analyses suggest that a multimodal combination of $NSAIDs$, dexamethasone, and regional anesthesia provides the most effective opioid-sparing benefits in adult surgical patients (Bui et al., 2003).

At the local level, chemical buffering of local anesthetics with sodium bicarbonate represents a highly effective pharmacological strategy for managing injection-related anxiety and pain. Commercially prepared local anesthetics with epinephrine are formulated at an acidic pH (3.0 to 4.0) to prevent epinephrine oxidation and extend shelf life. Infiltration of this acidic solution causes a localized burning sensation and delays the onset of anesthesia.

Alkalinizing the anesthetic solution to a physiologic pH of 7.35 to 7.4 immediately before injection increases the fraction of uncharged, lipid-soluble molecules. This active free base form can rapidly cross nerve membranes, accelerating the onset of sensory blockade from six minutes to under two minutes and reducing injection-related pain (Rosenbaum et al., 2021).

Additionally, physical desensitization techniques can significantly reduce the discomfort of local anesthetic administration. In a randomized clinical trial comparing different injection-site desensitization techniques in pediatric patients, pre-cooling the local mucosa with ice for 1 minute achieved the lowest mean pain score (2.4 on the Wong-Baker FACES scale). This was significantly more effective than vibratory stimulus (mean score 2.6), sodium bicarbonate-buffered local anesthesia (mean score 5.6), and topical anesthetic gel (mean score 6.2) ($p < 0.001$), establishing localized pre-cooling as a highly reliable, safe, and cost-effective clinical strategy (Shi et al., 2020).

Finally, non-pharmacological interventions are highly effective in mitigating preoperative anxiety

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and subsequent postoperative pain. Preoperative anticipated pain education helps patients form accurate expectations, reducing the central hyperactivation of pain pathways associated with anxiety $(R^2 = 0.88, p < 0.0001)$ (Maldonado, 2018).

Simultaneously, cognitive distraction techniques, such as music therapy, modulate emotional processing in the brain by decreasing amygdala hyperactivation and strengthening prefrontal cortex-mediated emotional regulation. This reduction in sympathetic nervous system activation lowers perioperative physiological stress, improves patient compliance, and reduces overall postoperative pain intensity (Mulugeta et al., 2018).

7. Conclusions

This comprehensive review establishes that preoperative dental anxiety functions as a robust, independent predictor of postoperative pain intensity following oral and maxillofacial surgical procedures. The evidence demonstrates that high baseline dental anxiety activates complex neuroendocrine cascades including HPA axis stimulation and sympathetic-adrenal-medullary responses which amplify peripheral inflammatory processes and central sensitization through mechanisms involving prostaglandin E2, serotonin, and NMDA receptor activation. These biological pathways translate emotional distress into clinically significant elevated pain trajectories, independent of surgical complexity or intraoperative analgesia. Validated psychometric instruments, particularly the Modified Dental Anxiety Scale (MDAS), provide reliable tools for identifying at-risk patients. Prospective cohort studies consistently demonstrate that highly anxious patients experience substantially higher postoperative pain scores, increased analgesic requirements, prolonged recovery times, and elevated risks of complications including alveolar osteitis and emergence delirium. Notably, even moderate anxiety levels maximize the physical risk of severe postoperative symptoms, emphasizing the clinical necessity of routine screening.

The clinical implications are substantial: implementing structured multimodal protocols combining pharmacological preemptive analgesia (NSAIDs, NMDA antagonists, buffered local anesthetics) with non-pharmacological interventions (cognitive distraction, preoperative education, physical desensitization) can effectively mitigate both anxiety and postoperative pain. However, significant gaps persist between theoretical knowledge and clinical practice implementation. Future research should focus on developing standardized perioperative anxiety management protocols, investigating optimal timing and combinations of interventions, and addressing barriers to implementation in routine surgical care. Ultimately, transitioning from reactive pain management to prospective, risk-stratified care incorporating psychological assessment represents the optimal pathway for improving surgical outcomes and patient satisfaction.

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