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FACIAL NERVE INJURY IN MAXILLOFACIAL SURGERY: MECHANISMS, PREVENTION, AND MICROSURGICAL REPAIR OUTCOMES — A META-ANALYSIS OF CLINICAL TRIALS

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ABSTRACT
Background:
Facial nerve injury is one of the most distressing complications in oral and maxillofacial surgery, resulting in functional, aesthetic, and psychosocial consequences. Although intraoperative monitoring and microsurgical repair techniques have evolved, their comparative efficacy and long-term outcomes remain variably reported.
Objective:
To synthesize evidence from clinical trials evaluating the mechanisms, preventive strategies, and microsurgical repair outcomes of facial nerve injury in maxillofacial surgery.
Methods:
A systematic search of PubMed, Scopus, and Cochrane Central databases (January 2000 – October 2025) was performed. Eligible studies were randomized controlled trials (RCTs) or prospective clinical trials that assessed incidence, preventive measures, or outcomes of facial nerve injury during maxillofacial, parotid, or craniofacial surgery. Outcomes were pooled using a random-effects model (RevMan 5.4). Heterogeneity was quantified by I^2 statistics. Risk of bias was evaluated with the Cochrane RoB 2 tool.
Results:
*Thirty-one clinical trials (n = 4,872 participants) were included. Mechanisms of injury were iatrogenic trauma (61 %), tumor excision (23 %), and post-traumatic repair (16 %). Intraoperative nerve monitoring reduced the risk of permanent paralysis by **42 %** (RR 0.58, 95 % CI 0.46–0.73, $p < 0.001$). Early microsurgical repair (< 6 months) achieved **78 %** functional recovery (House–Brackmann grade ≤ II). Direct neurorrhaphy produced better motor outcomes than interposition //nerve grafting ($p = 0.03$). Delayed repair beyond 12 months lowered recovery to 46 %.*
Conclusion:
Meta-analytic synthesis demonstrates that intraoperative nerve monitoring and timely microsurgical

repair significantly enhance facial nerve recovery after maxillofacial surgery. Standardized outcome scoring and long-term follow-up are essential for future guideline development.
Keywords: *Facial nerve · Maxillofacial surgery · Microsurgical repair · Nerve monitoring · Meta-analysis · Functional outcomes*

INTRODUCTION

The facial nerve (cranial nerve VII) governs motor control of facial expression, eye protection, and oral competence. Injury to this nerve during maxillofacial or parotid surgery results in profound functional impairment, asymmetry, speech difficulty, and psychosocial distress. Its complex branching through the temporal, zygomatic, buccal, and marginal mandibular regions makes it particularly vulnerable during dissection for trauma, tumors, or orthognathic correction (Pereira 2022).

Modern oral and maxillofacial surgery increasingly relies on meticulous anatomical mapping, intraoperative nerve monitoring (IONM), and microsurgical repair to reduce iatrogenic damage. However, global outcome data remain inconsistent. Some reports highlight high recovery rates with immediate repair (Yetiser 2021), while others reveal incomplete functional restoration despite advanced techniques (Chen 2023). This variability underscores the need for quantitative synthesis.

This meta-analysis integrates evidence from two decades of clinical trials to determine:

1. Mechanisms of facial nerve injury in maxillofacial surgery.
2. Efficacy of preventive strategies such as IONM.
3. Functional outcomes of microsurgical nerve repair.

2. Methods

2.1 Design

A **systematic review and meta-analysis** was performed following **PRISMA 2020** guidelines. No new patient data were collected.

2.2 Data Sources and Search Strategy

Databases searched: **PubMed, Scopus, Cochrane CENTRAL, ClinicalTrials.gov** (2000–2025).

Search string:

(“facial nerve injury” OR “facial paralysis”) AND (“maxillofacial surgery” OR “parotidectomy” OR “trauma repair”) AND (“microsurgical repair” OR “nerve graft” OR “monitoring”) AND (randomized OR trial OR prospective).

Reference lists of relevant reviews were manually screened.

2.3 Eligibility Criteria

Inclusion	Exclusion
RCTs or prospective trials with ≥ 20 patients	Case reports < 10 patients
Procedures involving maxillofacial, parotid, or mandibular regions	Non-surgical or pharmacologic studies
Quantitative data on prevention or repair outcomes	Animal or cadaveric models
Follow-up ≥ 6 months	Non-English articles

2.4 Data Extraction

Two reviewers independently extracted: study design, sample size, mechanism of injury, preventive technique, repair type, follow-up, and functional outcomes (House–Brackmann scale, electromyography [EMG] findings, and recovery time). Disagreements were resolved by consensus.

2.5 Quality Assessment

The **Cochrane RoB 2** tool assessed bias across five domains. Most trials demonstrated moderate-to-low risk; older studies (pre-2010) lacked blinding details.

2.6 Statistical Analysis

Pooled estimates were computed using **random-effects (DerSimonian–Laird)** modeling in RevMan 5.4. Continuous

variables were expressed as mean difference (MD) ± 95 % CI; dichotomous outcomes as risk ratio (RR). Heterogeneity > 60 % was considered significant.

3. Results

3.1 Study Selection and Characteristics

From 756 identified records, 31 trials met inclusion criteria . Total =

4,872 participants; mean age = 43.8 ± 11.5 years; male = 58 %. Follow-up ranged 6–60 months. **Common indications:** trauma (37 %), parotid tumor (28 %), orthognathic surgery (21 %), reconstructive or oncologic resections (14 %).

3.2 Mechanisms of Injury

Aggregate data revealed three dominant mechanisms:
Iatrogenic trauma during dissection – 61 % (esp. parotidectomy, sagittal split osteotomy).
Tumor excision requiring nerve sacrifice – 23 %.
Post-traumatic nerve transection – 16 %.
Temporary neuropraxia occurred in 39 %, **complete transection** in 12 %.

3.3 Prevention: Intraoperative Nerve Monitoring (IONM)

Twelve RCTs compared **IONM vs visual identification alone** (n = 1,940). Pooled RR = **0.58 (95 % CI 0.46–0.73)**, $p < 0.001$ — demonstrating a 42 % risk reduction for permanent facial paralysis. IONM also shortened dissection time by 15 min on average (MD −14.7, 95 % CI −20.3 to −9.1).

3.4 Microsurgical Repair Outcomes

Nineteen trials (n = 2,932) analyzed repair outcomes:

Technique	Pooled Functional Recovery (HB ≤ II)	Notes
End-to-end neurorrhaphy	82 % (95 % CI 75–88)	Ideal when tension-free ends
Interposition nerve graft (sural/greater auricular)	67 % (95 % CI 60–74)	Moderate fibrosis risk
Nerve transfer (hypoglossal, masseteric)	71 % (95 % CI 64–78)	Early dynamic motion but synkinesis 11 %
Delayed (> 12 mo)	46 % (95 % CI 38–53)	Denervation atrophy major factor

Heterogeneity (I^2 = 68 %) arose mainly from variable assessment intervals.

3.5 Complications and Re-operations

Common sequelae included synkinesis (9 %), neuropathic pain (7 %), and donor-site hypoesthesia (4 %). Re-exploration rate = 5 %.

3.6 Subgroup Analyses

Early vs Delayed Repair: RR 1.71 (95 % CI 1.23–2.38) favoring early < 6 months.
IONM + Microsurgical Team vs Single-discipline: combined approach improved HB ≤ II outcomes by 19 %.
Nerve Graft Type: autologous sural graft slightly superior to synthetic conduits (p = 0.04).

3.7 Publication Bias

Funnel plots were symmetrical; Egger's test p = 0.27, indicating minimal bias.

4. Discussion

4.1 Principal Findings

This meta-analysis provides pooled quantitative evidence from two decades of clinical trials.

Key outcomes:

1.IONM significantly lowers the risk of iatrogenic facial paralysis.
2.Early microsurgical repair yields the best motor recovery.
3.Direct neurorrhaphy remains the gold standard when feasible.

4.Graft and transfer techniques provide viable alternatives when tension-free coaptation is impossible.

4.2 Mechanistic Insights

Facial nerve vulnerability arises from its superficial course through the parotid gland and mandibular ramus. Traction, compression, or thermal injury disrupts axonal conduction and Schwann-cell regeneration (Yetiser 2021). Timely microsurgical approximation maintains perineural continuity and prevents Wallerian degeneration (Farber 2023).

4.3 Preventive Strategies

Intraoperative nerve monitoring assists in mapping branch positions during osteotomy, condylar exposure, and parotidectomy. Its use is especially crucial in revision cases, scarring, and oncologic resections. Although it increases operative cost, the functional gains justify routine implementation (Chang 2022).

4.4 Microsurgical Techniques

Current literature supports **direct epineurial repair** where feasible. Grafting using the sural or great auricular nerve provides tension-free continuity but at the expense of donor morbidity. **Masseteric–facial transfers** offer rapid movement but limited spontaneity. Emerging biomaterials and conduit scaffolds show promise but need long-term validation (Singh 2024).

4.5 Rehabilitation and Quality of Life

Post-repair rehabilitation — facial physiotherapy, neuromuscular retraining, and botulinum toxin modulation — accelerates symmetry and prevents synkinesis. Inclusion of standardized QOL instruments such as **FaCE Scale** and **Sunnybrook Score** is still limited in trials.

4.6 Research and Clinical Gaps

Lack of age-stratified or comorbidity-adjusted survival models.
Under-representation of female and geriatric cohorts.
Limited use of electrophysiological outcome metrics.
Need for standardized reporting intervals (6, 12, 24 months).
Few trials assess cost-effectiveness of IONM in low-resource settings.

4.7 Strengths and Limitations

Strengths: rigorous PRISMA adherence, exclusive inclusion of prospective trials, and statistical pooling across diverse techniques.

Limitations: moderate heterogeneity, incomplete blinding, and inconsistent follow-up durations.

5. Conclusions

Facial nerve injury remains a major challenge in maxillofacial surgery.
Meta-analytic evidence confirms that:
Intraoperative nerve monitoring substantially decreases iatrogenic injury.
Early microsurgical repair (< 6 months) optimizes recovery.
Direct neurorrhaphy offers superior functional outcomes compared to grafting or delayed repair.
Adoption of standardized outcome metrics, multicenter collaboration, and long-term QOL assessment will refine future reconstructive protocols.

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