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# Facial nerve injury following temporomandibular joint reconstruction, parotidectomy and mastoidectomy: a systematic review and meta-analysis

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**ABSTRACT**

Maxillofacial surgeries carry a risk of facial nerve injury (FNI) in the form of nerve paralysis. These injuries can be classified according to the onset of facial paralysis and the nature of the injury. The current literature shows several oral and maxillofacial surgeries associated with facial nerve injuries, such as parotid gland related procedures, temporomandibular joint (TMJ) replacement and mastoidectomy. Reporting of the incidence of facial injury following these procedures varied across studies. Therefore, our aim is to provide a review of the current literature reporting FNI following TMJ reconstruction and parotidectomy and report its distribution across different demographic characteristics. A systematic review and a meta-analysis were done following preferred reporting items for systematic review and meta-analysis (PRISMA) guidelines. Our findings indicate that females were more likely to develop FNI following the selected surgeries when compared to males. Out of 2013 patients who underwent parotidectomy procedures, 286 developed FNI with an incidence of 21.97% (95%CI: 10.39-36.41) and the most affected branch was the marginal mandibular branch. Among 154 patients who had TMJ-related procedures, 55 developed FNI with an incidence proportion of 29.99% (95%CI: 12.97-50.53) the temporal branch was the most affected.

**Keywords:** Facial nerve, Mastoidectomy, Parotidectomy, Temporomandibular joint.

**1. INTRODUCTION**

The facial nerve (FN), also referred to as the seventh cranial nerve (CN VII), is a vital structure in the head and neck as it regulates many functions of the face and mouth. Its branches have a unique anatomical and functional relationship

with the parotid gland, facial muscles and other structures in the area (May & Schaitkin, 2000). The nerve rises from the nuclei of the lower part of the pons in the brain, travels through the temporal bone and then exits the skull through the stylomastoid foramen (Kochhar et al., 2016). After leaving the skull, the main trunk of the nerve will terminate in the parotid gland, giving off its five main branches: The temporal branch, zygomatic branch, buccal branch, marginal mandibular branch and cervical branch. These branches are mainly responsible for innervating the muscles of facial expression (Waugh & Grant, 2014). The FN is considered a mixed nerve as it has both motor and sensory fibers; the main function of the sensory fibers is to convey the impulses from the taste buds in the anterior two-thirds of the tongue to the taste perception area in the cerebral cortex. While the motor fibers stimulate the movement of facial expression muscles, stylohyoid, stapedius and posterior belly of digastric (Dulak & Naqvi, 2021).

The close relationship between the FN and other anatomical structures carries a risk of damage to the nerve when performing head and neck surgeries (Mavrikakis, 2008). The damage can cause temporary weakness of the nerve or complete paralysis (Owusu et al., 2018). FN paralysis is evident through the loss of voluntary movement of the muscles on one side of the face. It is characterized by drooping of one side of the face, inability to wrinkle the forehead, loss of capability to whistle, inability to close an eye and deviation of the mouth toward the other side of the face (Mavrikakis, 2008; Owusu et al., 2018). FN paralysis can be congenital or caused by idiopathic, traumatic, neoplastic and inflammatory factors (Mavrikakis, 2008). Paralysis due to trauma includes post-surgical trauma (iatrogenic paralysis). It either appears immediately following surgery or is delayed up to 16 days from the surgical procedure (Mistry & Al-Sayed, 2021). The House-Brackman facial paralysis scale is widely used to assess the degree of facial paralysis, in which nerve dysfunction is considered at grade two when slight weakness on close inspection is observed with a slight asymmetry in the smile. However, this tool is used only to evaluate FN paralysis at the nerve trunk and is not a descriptive scale for a specific branch (Reitzen et al., 2009).

Several maxillofacial surgeries were frequently associated with damage to the FN (Imola & Liddell, 2016; Nogueira & Vasconcelos, 2007; Moin et al., 2018; Stewart et al., 2021; Chen et al., 2009). Iatrogenic facial nerve paralysis has been associated with temporomandibular joint (TMJ) reconstruction surgeries such as autogenous bone graft, alloplastic replacement and distraction osteogenesis (Imola & Liddell, 2016; Nogueira & Vasconcelos, 2007; Moin et al., 2018). Similarly, injury to the FN was found following surgical removal of the parotid gland (parotidectomy), whether it was a superficial (partial) or complete removal due to congenital malformations or tumors (Stewart et al., 2021; Lakkadsha et al., 2022). Furthermore, facial nerve paralysis was reported following surgeries related to the temporal bone, such as mastoidectomy, which involves the unfolding of the post auricular air cells by extracting the thin barrier between them. This surgery can be performed for the treatment of cholesteatoma and acute mastoiditis (Chen et al., 2009; Wormald, 1996).

A study conducted by Hohman in 2013 investigating causes of iatrogenic facial nerve injury (IFNI) using Facial Nerve Center patient records reported that injury was most observed with TMJ replacement followed by parotidectomy and mastoidectomy (Hohman et al., 2014). As these selected surgeries are frequently associated with IFNI, several studies reported the incidence proportion of IFNI following TMJ reconstruction, parotidectomy and mastoidectomy (Imola & Liddell, 2016; Nogueira & Vasconcelos, 2007; Moin et al., 2018; Stewart et al., 2021; Chen et al., 2009). We aim to provide a review of the current literature and conduct a meta-analysis to obtain a pooled estimate of the IFNI incidence proportion following each surgical procedure and to identify the affected FN branches.

## 2. MATERIALS AND METHODS

This systematic review and meta-analysis were done following preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) checklist. The included articles fulfilled the selected inclusion and exclusion criteria.

### Literature search strategy

The search strategy was performed to answer the specific question: "What is the incidence proportion of iatrogenic facial nerve injury following TMJ reconstruction, parotidectomy and mastoidectomy?". We searched PubMed and Embase using medical subject headings (Mesh and Emtree) and structured phrases with "AND" and "OR" Boolean operators. ("incidence" (MeSH Terms) AND "facial nerve injuries" (MeSH Terms) AND "temporomandibular joint" (MeSH Terms)) OR ("incidence" (MeSH Terms) AND "facial nerve injuries" (MeSH Terms) AND "mastoidectomy" (All Fields)) OR ("incidence" (MeSH Terms) AND "facial nerve injuries" (MeSH Terms) AND "parotidectomy" (All Fields)) ("facial nerve injuries" (MeSH Terms)) AND ("temporomandibular joint" (MeSH Terms) OR "temporomandibular joint" (All Fields) OR "tmj" (All Fields)) AND ("reconstruct" (All Fields) OR "reconstructability" (All Fields) OR "reconstructable" (All Fields) OR "reconstructed" (All Fields) OR "reconstructible" (All Fields) OR "reconstructing" (All Fields) OR "reconstructional" (All Fields) OR "reconstructive surgical procedures" (MeSH Terms) OR "reconstruction" (All Fields)

OR "reconstructive" (All Fields) OR "reconstructs" (All Fields)) ("facial nerve injuries" (MeSH Terms) AND ("parotidectomies" (All Fields) OR "parotidectomy" (All Fields)) ("facial nerve injuries" (MeSH Terms) AND ("mastoidectomy" (MeSH Terms) OR "mastoidectomy" (All Fields) OR "mastoidectomies" (All Fields))).

### Eligibility criteria

Inclusion criteria included studies with patients aged 18 years or older, published from 2000 to 2022, written in English, clinical human studies including prospective and retrospective cohort studies and those including patients who developed FN paralysis from the selected surgeries (TMJ reconstruction, parotidectomy and mastoidectomy), both types of delayed and immediate FNI. The exclusion criteria included studies with patients reporting preoperative facial paralysis; other factors and surgeries related to facial nerve paralysis such as infection to the nerve; animal studies; non-English-written articles; articles that were published before the year 2000; articles that were published multiple times with the same authors or patients; and infancy and childhood-focused papers.

### Data Extraction

The data extracted consisted of the main author's name, year of publication, study design and sample size. Furthermore, we extracted our outcome variables including the incidence proportion of IFNI, the type of paralysis (immediately following the surgery in a few minutes to hours or permanent persisting after the surgery), dysfunction, or complete paralysis of the facial nerve injury according to House-Brackman (graded from 1 to 6). Our predictor variables included the surgical procedures, which are TMJ reconstruction, parotidectomy and mastoidectomy; the affected facial nerve branches (temporal, zygomatic, buccal, marginal mandibular and cervical branches); and patients' age and gender.

### Quality assessment

Our included studies were observational and we used Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines to assess the studies.

### Statistical analysis

A meta-analysis was performed using Statistical Analysis System (SAS) version 9.4. Heterogeneity was assessed using  $Q$  and  $I^2$  statistics. The included studies were limited to prospective and retrospective cohorts, those reporting the incident proportion of IFNI, the number of patients with IFNI, the total number of patients and the type of IFNI (transient or permanent). Weighted summaries of incident proportions were generated using fixed and random effects models for each surgical procedure.

## 3. RESULTS

Our search identified a total of 95 records. After removing the duplicates, 75 titles were screened. Fifty-three articles were eligible for full-text review, of which 14 articles met our eligibility criteria and were included in the review. Out of the 14 articles, 10 were included in the quantitative analysis and four did not provide enough for the analysis. The findings of the four articles were reported narratively. The included and excluded studies, along with reasons for exclusion, are shown in figure (1).

All the included maxillofacial surgeries showed some degree of FNI. Females were more likely to develop FNI following the selected surgeries when compared to males. Seven of the included articles were focused on parotidectomy. Significant heterogeneity was observed across these studies using the test for assumption of homogeneity ( $P$ -value  $< 0.0001$ ) and high inconsistency ( $I^2 = 97.9$ ). Therefore, a mixed effects model was used to report the incidence proportion. The total number of patients who underwent parotidectomy was 2103 patients, of whom 286 developed FNI (table1) with an incidence of 21.97% (95% CI: 10.39-36.41) (figure 2). The most affected branch was the marginal mandibular branch, with a temporary injury extending up to 43 months to completely resolve. When exploring TMJ-related procedures, three articles were included. A mixed effects model was used due to significant heterogeneity observed across studies with the test for assumption of homogeneity ( $P$ -value  $< 0.0015$ ) and high inconsistency ( $I^2 = 84.67\%$ ). Out of the total 154 patients who had TMJ surgeries, 55 patients developed FNI (table1). The reported incidence proportion was 29.99% (95% CI: 12.97-50.53) (figure 3). Temporal branch was the most affected, with a temporary injury taking up to 24 months to completely heal.

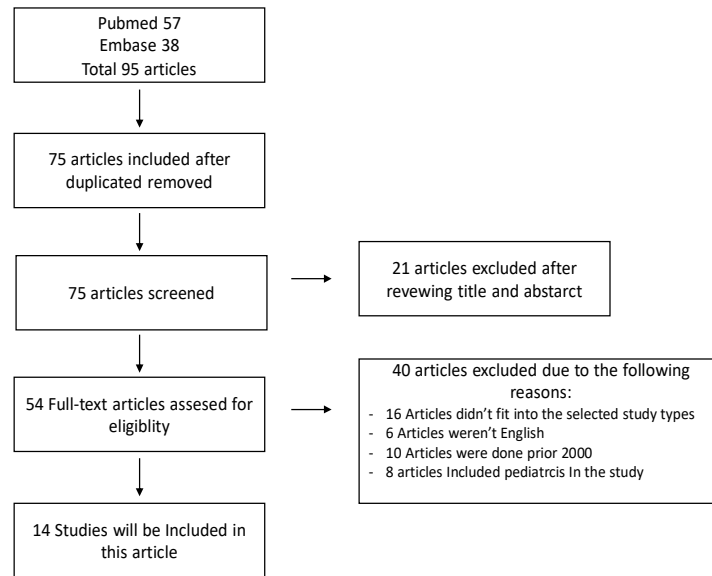


Figure 1 Study flow diagram.

Table 1 Characteristics of included studies.

Author	Region	Type of Surgery	Total/FNI
**Jeong et al., 2020	Germany	Parotidectomy	577/5
**Hokyung et al., 2019	Republic of Korea	Parotidectomy	794/114
**Elizabeth Mamelle et al., 2013	France	Parotidectomy	50/27
**Jason et al., 2013	United states of America	Parotidectomy	44/24
**Suzuki et al., 2017	Japan	Parotidectomy	106/20
**Paola Bonavolonta et al., 2019	Italy	Parotidectomy	297/30
**Mohammed Ayub Musani et al., 2014	Pakistan	Parotidectomy	65/5
**Saeed et al., 2021	Germany	TMJ	82/38
**Belmiro et al., 2020	Brazil	TMJ	27/3
**Valdimir et al., 2019	Czech Republic	TMJ	45/14
*Choi, Hyo Geun et al., 2017	Republic of Korea	Mastoidectomy	
*Waheed Saleem et al., 2020	Pakistan	Mastoidectomy	
*Yeoh Thiam Long et al., 2004	Malaysia	Mastoidectomy	
*Eleftherios Savvas et al., 2006	Germany	Parotidectomy	

\*\*Included in systematic review and meta-analysis

\*Included only in the systematic review

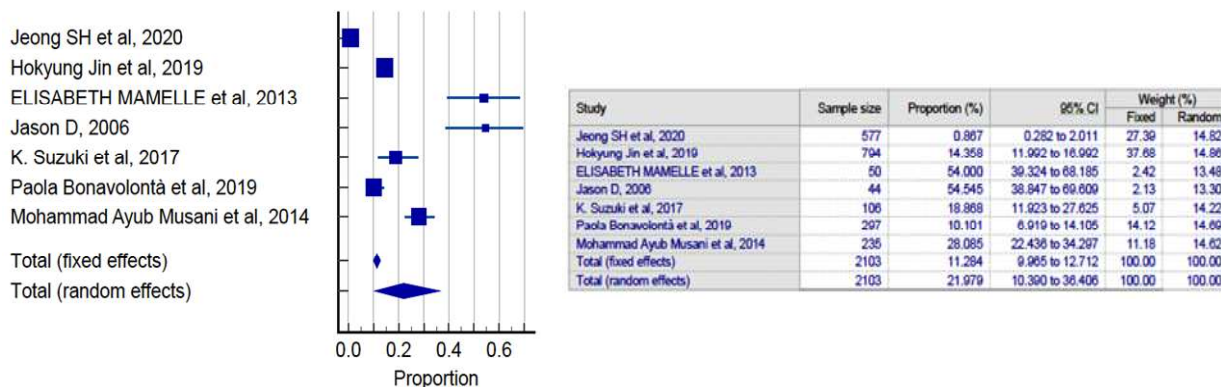


Figure 2 Forest plot of incidence proportion of facial nerve injury following Parotidectomy.

All the included articles went through STROBE (Strengthening the Reporting of Observational Studies in Epidemiology), to assess the quality of the included articles, the average score of the articles was 15.7 out of 22 based on STROBE criteria (Table 2).

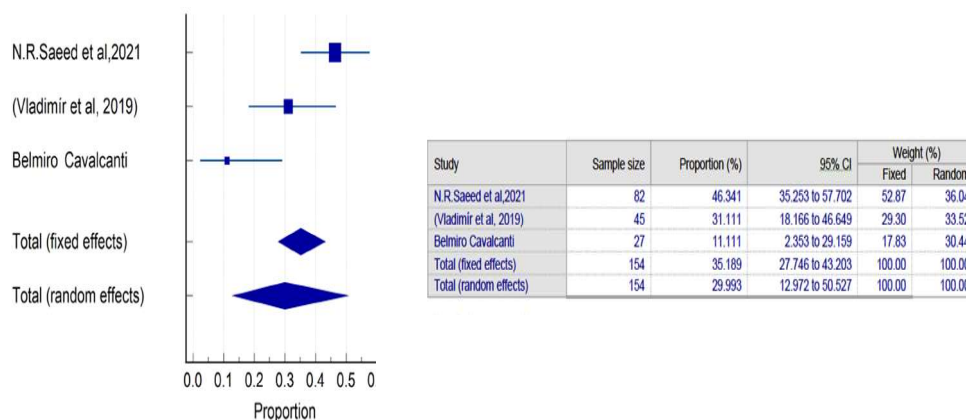


Figure 3 Forest plot of incidence proportion of facial nerve injury following TMJ- related surgeries.

Table 2 Quality assessment using STROBE criteria.

Author	STROBE score
Jeong et al., 2020	14/21
Saeed et al., 2021	16/21
Savvas et al., 2006	18/21
Hokyung et al., 2019	21/21
Mamelle et al., 2013	17/21
Choi et al., 2017	19/21
Belmiro et al., 2020	15/21
Valdimir et al., 2019	14/21
Jason et al., 2013	17/21
Saleem et al., 2020	13/21
Suzuki et al., 2017	10/21
Long et al., 2004	13/21
Bonavolonta et al., 2019	18/21
Musani et al., 2014	16/21

Average score of the included articles is 15.7 out of 21

## 4. DISCUSSION

In our study, we are focusing on facial nerve injury (FNI) following selected surgical procedures such as: Parotidectomy, TMJ reconstruction and mastoidectomy. We identified 95 articles that are related to our subject and after careful evaluation, we reached a total of 14 articles using PRISMA. Eight of them were related to parotidectomy, three were TMJ-related surgeries and three were for mastoidectomy, which are included in the systematic review. However, only 10 were selected to be included in the meta-analysis. All the articles were subjected to STROBE evaluation. Through the exploration of the studies on PubMed and Embase, it was clear that a great number of the published papers on facial nerve injury were focused on parotid-related procedures, while those exploring the post-operative complications following mastoidectomy were limited, thus, limiting our ability to produce a summary of the incidence proportion of FNI following mastoidectomy procedures. Our results revealed that females were more vulnerable to facial nerve injuries than men.

Following parotidectomy, the marginal mandibular branch was the most affected and most of the injuries were temporary, almost 25% of the cases were permanent. The follow-up time ranged from 2 to 43 months. The pooled sample of the seven studies was 2103 (286 positive cases) with an incidence proportion of 21.97%. Injury to the nerve after TMJ reconstruction surgery had a similar distribution across the patients' gender, with females having a higher incidence when compared to males, but it seems to be more reported to occur in the temporal branch of the nerve. Moreover, the results showed that the temporary nerve injury was more dominant by more than 10 folds in comparison with the permanent. The follow-up period ranged from 12 to 24 months, which varied between the included studies. The total sample size was 154 patients (55 positive cases), with an incidence proportion of 29.99%. Lastly, in studies focused on mastoidectomy, females were more affected than males, but unfortunately neither the affected branches nor the type of injury (temporary or permanent) were mentioned. In addition, the follow up period wasn't addressed.

Overall, injury to the facial nerve following maxillofacial surgeries showed to occur more among females when compared to males with the marginal mandibular branch being the most affected nerve. In addition, injuries that occur temporarily were noticeably higher than the permanent type. When comparing our results to the retrospective cohort study published by them, which included 1810 patients with 102 positive cases, they similarly had a higher percentage of facial nerve injury among females when compared to males. This difference was attributed to a higher number of females receiving TMJ-related surgeries (Hohman et al., 2014).

## 5. CONCLUSION

FNI is a serious complication that needs careful perioperative planning to be avoided. FNI seems to occur more frequently following TMJ-related procedures than the other selected maxillofacial surgeries.

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The authors would like to declare that there is no acknowledgment to be made.

### Author contributions

All authors have participated in collecting and analyzing the data. Writing the article and revising it critically for publication. All authors have read the final version of the manuscript and approved it for publication. Fahad Maki have participated in data collection, data analysis and writing this manuscript.

### Ethical Approval

Institutional review board (IRB) committee approval was obtained from King Abdullah International Medical Research Center (KAIMRC) SP21R/359/06.

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This study has not received any external funding.

### Conflict of interest

The authors declare that there is no conflict of interests.

**Data and materials availability**

All data sets collected during this study are available upon reasonable request from the corresponding author.

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