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REVIEW ARTICLE

Facial nerve monitoring during parotid gland surgery: a systematic review and meta-analysis

Carlos Miguel Chiesa-Estomba[1,8] · Ekhiñe Larruscain-Sarasola[1] · Jérome Rene Lechien[2,8] · Francois Mouawad[3] · Christian Calvo-Henriquez[4,8] · Evelyne Siga Diom[5] · Adonis Ramirez[6] · Tareck Ayad[7,8]

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Abstract

Introduction Facial nerve injury remains the most severe complication of parotid gland surgery. However, the use of intraoperative facial nerve monitoring (IFNM) during parotid gland surgery among Otolaryngologist—Head and Neck Surgeons continues to be a matter of debate.

Materials and methods A systematic review and meta-analysis of the literature was conducted including articles from 1970 to 2019 to try to determine the effectiveness of intraoperative facial nerve monitoring in preventing immediate and permanent postoperative facial nerve weakness in patients undergoing primary parotidectomy. Acceptable studies included controlled series that evaluated facial nerve function following primary parotidectomy with or without intraoperative facial nerve monitoring.

Results Ten articles met inclusion criteria, with a total of 1069 patients included in the final meta-analysis. The incidence of immediate and permanent postoperative weakness following parotidectomy was significantly lower in the IFNM group compared to the unmonitored group (23.4% vs. 38.4%; $p=0.001$) and (5.7% vs. 13.6%; $p=0.001$) when all studies were included. However, when we analyze just prospective data, we are not able to find any significant difference.

Conclusion Our study suggests that IFNM may decrease the risk of immediate post-operative and permanent facial nerve weakness in primary parotid gland surgery. However, due to the low evidence level, additional prospective-randomized trials are needed to determine if these results can be translated into improved surgical safety and improved patient satisfaction.

Keywords Parotidectomy · Parotid surgery · Facial nerve monitor · Facial nerve weakness · Intraoperative facial nerve monitoring

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✉ Carlos Miguel Chiesa-Estomba
chiesaestomba86@gmail.com

1 Otorhinolaryngology-Head and Neck Surgery Department, Hospital Universitario Donostia, Calle Doctor Begiristain, #1. CP. 20014 San Sebastian-Donostia, Guipuzkoa, Basque Country, Spain

2 Department of Human Anatomy and Experimental Oncology, University of Mons, Mons, Belgium

3 Department of Otorhinolaryngology-Head and Neck Surgery, CHRU de Lille, Lille, France

4 Department of Otolaryngology, Hospital Complex of Santiago de Compostela, Santiago de Compostela, Spain

5 ENT and Head and Neck Departement, CHU de La Paix, UFR Santé de l'Université Assane Seck, Ziguinchor, Sénégal

6 Head and Neck Surgery, Clinica Medilaser Neiva, Neiva, Colombia

7 Division of Otolaryngology-Head and Neck Surgery, Center Hospitalier de l'Université de Montréal, Montreal, Canada

8 Head and Neck Study Group of Young-Otolaryngologists of the International Federations of Oto-Rhino-Laryngological Societies (YO-IFOS), Paris, France

Introduction

Parotid gland tumors represent approximately 2% of all head and neck tumors and 70–80% of all salivary gland tumors, the majority of them being benign [1, 2]. Facial nerve injury remains the most severe complication of parotid gland surgery. Temporary facial nerve dysfunction occurs in 20–65% of patients undergoing parotidectomy, whereas permanent facial nerve dysfunction occurs in 0–7% of those patients [3–6]. These patients can suffer from a facial motor deficit, cosmetic and functional morbidity and ocular complications, which may significantly impair the patients' quality of life [7, 8]. Also, facial weakness may result in costly medical litigation [9].

Facial nerve preservation during parotidectomy was first described in 1907 by Carwardine, though it was not until 1940 that Janes described the routine identification of the facial nerve trunk early in the procedure [10, 11]. However, intraoperative facial nerve monitoring (IFNM) by direct visualization of facial muscle movement was first performed in 1898 [12, 13]. Since then, its application has been significantly refined, starting with the introduction of electromyography in 1970 [14, 15].

The routine use for facial nerve monitoring in neuro-otological procedures has demonstrated improved preservation of facial nerve function and to be cost-effective [16, 17]. Data regarding the use of IFNM during parotid gland surgery is about 75% of otolaryngologist-head and neck surgeons in Germany and over 67–80% in the United Kingdom [18, 19]. However, the use of IFNM during parotid gland surgery among Otolaryngologist—Head and Neck Surgeons in the USA seems to be a matter of debate. According to Lowry et al. 60% of practicing Head and Neck Surgeons in the United States use IFNM for parotid gland surgery, while the remaining 40% rely on anatomic landmarks or visual monitoring for facial muscle twitching [20]. Finally, comparing different surgical specialties, routine use of IFNM during parotid gland surgery is more common among Otolaryngologist—Head and Neck Surgeons than Oral and Maxillofacial Surgeons in the United Kingdom [21].

Another relevant factor is the type of surgery, with superficial parotidectomy and extracapsular dissection being the current procedures of choice. According to a recently published review performed by Martin et al., extracapsular dissection was related to a reduced recurrence rate, facial nerve paralysis, Frey syndrome, and operation time in spite of limitations within the review that may have affected their results, such as selection bias and being patients assigned to the different procedures depending on the tumor size and location [22].

Even though several authors have suggested that IFNM results in a decreased incidence of post-operative facial weakness [4], just two prospective, randomized, controlled trials have been performed to evaluate the efficacy of IFNM [6, 23]. The objective of this study was to analyze the effectiveness of IFNM compared to non-monitoring in the prevention of post-operative facial nerve palsy during primary parotidectomy.

Methods

This meta-analysis involved a systematic review using the Population Intervention Comparison and Outcome (PICO) modeling and following the guidelines proposed by the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement. A formal PROSPERO protocol was published according to the NHS International Prospective Register of Systematic Review (Nº 149254).

Population and inclusion/exclusion criteria

The Inclusion criteria considered for this meta-analysis were primary cases of parotidectomy, superficial and total parotidectomy, inflammatory, benign, and malignant parotid disease, 2-arm studies (IFNM vs. WIFNM) and prospective or retrospective studies. While, the exclusion criteria were parotidectomy for recurrent cases, cases with preoperative facial weakness, cases with facial nerve sacrifice, single-arm studies (without unmonitored subjects) and studies with less than 20 patients treated in each group.

Intervention and comparison

In the intervention group were included patients operated using IFNM; while the comparison group was established with patients operated without IFNM (WIFNM).

Outcomes

The primary outcome evaluated was the rate of immediate post-operative facial nerve weakness and a secondary outcome was the rate of permanent post-operative facial nerve palsy. Immediate post-operative facial nerve and permanent facial nerve weakness were defined in all the studies included according to House–Brackmann grading scale score above or equal to 2 [24]. Normal facial nerve function was defined as a House–Brackmann score of 1, or "normal." Minimum follow-up to final assessment was three months, and maximum follow-up time was 12 months after surgery.

Search strategy

This review involved a systematic search of the electronic databases MEDLINE/PUBMED, Google Scholar, Ovid

Medline, Embase, Scopus, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, and the Database of Abstracts of Reviews of Effects. Papers from January 1970 to July 2019 were included. Search was based on the following phrases: (1) "parotidectomy" (2) "facial nerve monitoring during parotidectomy", (3) "facial nerve monitoring" and "parotid surgery", (4) "facial nerve monitoring", and (5) "intraoperative facial nerve monitoring" (Supplement Table 1). This resulted in a total of 1981 manuscripts that were subjected to our inclusion and exclusion criteria. Titles and abstracts were screened by two investigators (CMCE and ELS) to discard irrelevant publications. Information extracted from each study includes the following: author, year of publication, number of patients treated, the extent of surgery, use of IFNM, and proportion of patients with immediate and permanent facial nerve weakness.

Assessment of quality

Methodological quality of identified studies was appraised using the Oxford Center for Evidence-Based Medicine (OCEBM) Levels of Evidence [25]. According to this, prospective or retrospective studies (Grading 2–3) were included. Concerning the assessment of risk of bias in individual cohort studies, the risk of bias in nonrandomized studies of interventions tool (ROBIN-I) was used [26].

Statistical analysis

A meta-analysis of selected studies with an odds ratio (OR) comparing an IFNM (experimental) group and patients WIFNM (control) group was performed with Cochrane Review Manager 5.3 (Nordic Cochrane Centre, Cochrane Collaboration, 2014, Copenhagen, Denmark). A fixed effects model was used in this study. The heterogeneity assumption was checked using the Q test and I^2 test.

Cochrane Review Manager uses the Mantel–Haenszel method for calculating the weighted summary OR under the fixed effects model, and the heterogeneity statistic is incorporated to calculate the summary OR under the random-effects model. The pooled OR with 95% CI is given for both fixed effects model and random-effects model. When overall results were significant, the number needed to treat for an additional beneficial outcome was calculated.

Besides, a Chi-square test with Yates correction for continuity was applied with a 2-tailed p value for the comparison according to sex, histology and type of procedures from independent samples. A p value (<0.05) was considered statistically significant.

Results

A total of 1981 manuscripts were revised, and 70 studies met our inclusion criteria. From those, 60 were excluded for the following reasons: absence of IFNM ($N=22$), recurrent parotid surgery ($N=15$), and single-armed studies ($N=23$). In total, ten studies were included in our final statistical analysis (Fig. 1) [6, 23, 27–34]. According to the Oxford Center for Evidence-Based Medicine grading system, two studies received a grading 2, and the remaining received evaluations of 3. Demographic data of included studies are summarized in Table 1. Risk of bias according to ROBIN-I can be check in Supplement Table 2.

Five hundred and Fifty-four patients were included in the IFNM group, while the control group consisted of 515 patients. Variables like age, sex, histology, type of surgery and maximum time to follow-up were compared between both groups (Table 2). Demographic data between the IFNM monitoring group and WIFNM group were similar. Each group underwent a comparable amount of superficial and total parotidectomies (85% vs. 82.6%; 15% vs. 17.4%, respectively). Also, histology between both groups was comparable, the majority of them being benign. This makes both cohorts adequately homogenous for comparison.

The incidence of immediate postoperative facial nerve weakness in the IFNM group was 23.4% (95% CI 15.7–30.2%) with a mean absolute deviation of 7.5, while in the control group WIFNM was 38.4% (95% CI 31.2–44.7%) ($p=0.001$), (Table 3). Therefore, intraoperative IFNM resulted in a 42.7% decrease in incidence of immediate facial nerve weakness (OR 0.48; 95% CI: 0.37 – 0.64 with a $p\leq0.001$). The absolute risk reduction of immediate facial nerve weakness was 14.98% (95% CI 13.5–16.3%), resulting into seven patients requiring intraoperative monitoring to prevent one incidence of immediate post-operative facial nerve weakness (Fig. 2).

The incidence of permanent facial nerve weakness in the IFNM group was 5.7% (95% CI 2.5–12.5%), in comparison to 13.6% (95% CI 5.1–20.8%) in the control group ($p=0.001$) with a mean absolute deviation of 3.1 (Table 3), being statistically significant (OR 0.31; 95% CI 0.20–0.49 with a $p\leq0.001$.). The absolute risk reduction of permanent facial nerve weakness was 7.82% (95% CI 4.5–11%), resulting into 13 patients requiring intraoperative monitoring to prevent 1 incidence of permanent post-operative facial nerve weakness (Fig. 2).

Sub-analysis groups

Prospective data

We performed a sub-analysis, including patients from prospective studies. IFNM group consisted of 102 patients,

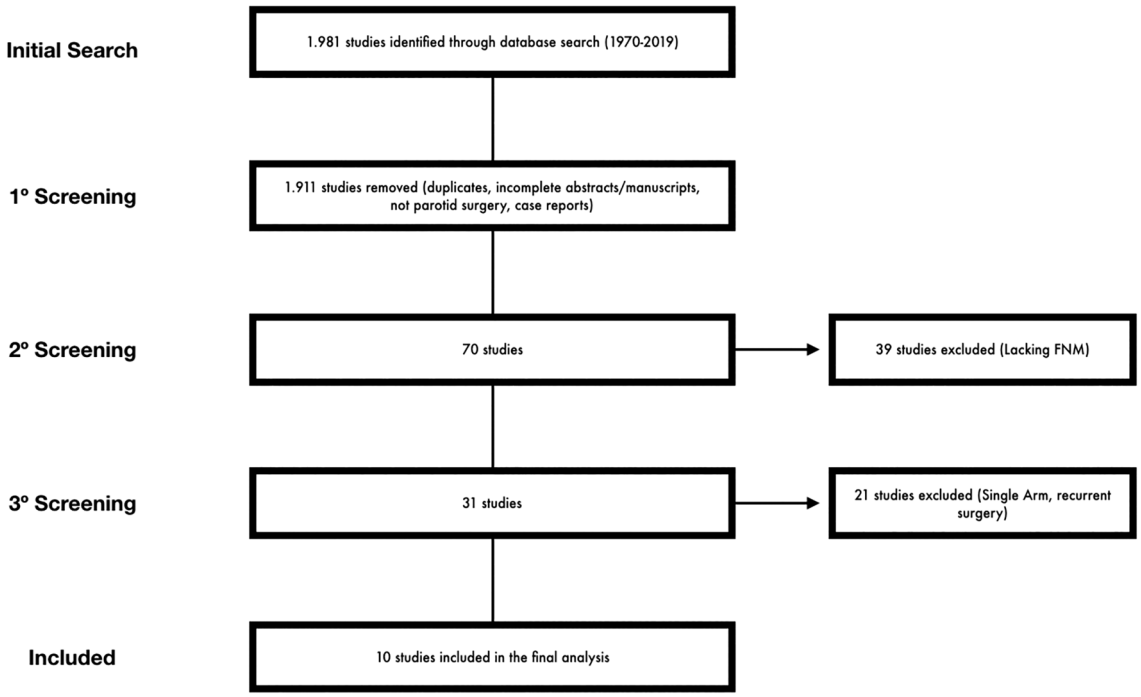


Fig. 1 Algorithm of study selection

while the control group consisted of 104 patients. Demographic data between the IFNM monitoring group and WIFNM group are similar. In one group all the patients underwent a superficial parotidectomy while in the other group 79% patients underwent superficial parotidectomy, and 21% underwent total parotidectomy making not possible to perform comparisons according to the type of surgery. Comparable histology in both groups, with all the tumors being benign, makes cohorts adequately homogenous for comparison (Table 4).

The rate of immediate postoperative facial nerve weakness in the IFNM group was 38.2% (95% CI 28.5–47.4%), while in the control group WIFNM was 48% (95% CI 38.4–57.6%) ($p=0.198$), being not statistically significant (OR 0.67; 95% CI 0.38–1.17; $p=0.60$). Moreover, the incidence of permanent facial nerve weakness in the IFNM group was 2.9% (95% CI 0.31–6.31%), in comparison to 4.8% (95% CI 0.81–9.2%) in the control group ($p=0.739$), being not significant the difference about permanent facial nerve dysfunction (OR 0.60; 95% CI 0.14–2.59; $p=0.83$) (Table 4 and Fig. 3).

Type of surgery

According to each type of surgery, those patients undergoing superficial parotidectomy, the incidence of immediate facial nerve weakness in the IFNM group was 22.9% (95% CI 12–31.9%) versus 46.6% (95% CI 36.4–55.5%) in the control group WIFNM ($p=0.0005$). The incidence of permanent weakness in the IFNM group was 6.9% (95% CI − 4.1–18.1%) versus 19% (95% CI 7.6–30.3%) in the control group WIFNM ($p=0.0004$). These differences were statistically significant for either immediate facial nerve dysfunction (OR 0.39; 95% CI 0.27–0.58; $p=0.0001$) or permanent (OR 0.31; 95% CI 0.18–0.53; $p=0.0001$) (Table 2 and Fig. 4).

In those patients undergoing total parotidectomy, the incidence of immediate facial nerve weakness in the IFNM group was 34.9% (95% CI 22.3–45.7%), in comparison to 49.2% (95% CI 37–60.1%) in the control group WIFNM ($p=0.686$). The incidence of permanent facial nerve weakness was 12.6% (95% CI 3.9–20%) in patients with IFNM monitoring versus 25.3% (95% CI 14.6–35.3%) in the control group WIFNM ($p=0.195$). Differences were not statistically significant for immediate facial nerve dysfunction (OR 0.71; 95% CI 0.33–1.52; $p=0.38$), but were statistically significant for permanent facial nerve dysfunction (OR 0.31; 95% CI 0.11–0.85; $p=0.02$) (Table 2 and Fig. 4).

Discussion

Injury to the facial nerve is one of the most undesirable complications of parotid gland surgery. This can be secondary to dissection, transection, laceration, clamp compression, retraction, electrocautery injury, ligature entrapment, suction

Table 1 Demographic data of studies included in the final analysis

Author	Number of patients included	Mean age	Sex	Type of surgery (N)	Histology	Follow-up (months)	Grade (Oxford Level)
Deneuve [31]	87	46	F: 47 (54%)/M: 40 (46%)	TP. SP	Benign: 67 (77%)/ malignant: 20 (23%)	6	3
Yuan [32]	109	47	F: 40 (37%)/M: 69 (63%)	TP, SP	Benign: 103 (94.5%)/malig-nant: 6 (5.5%)	6	3
Pons [33]	65	56	F: 35 (53.8%)/M:30 (46.2%)	TP, SP	Benign: 51 (78.5%)/ malignant: 14 (21.5%)	6	3
Grosheva [9]	100	52	F: 48 (48%)/M: 52 (52%)	TP, SP	Benign: 100 (100%)/malignant: 0 (0%)	7.9	2
López [34]	52	50	F: 17 (33%)/M: 35 (67%)	TP, SP	Benign: 45 (87%)/ malignant: 7 (13%)	12	3
Witt [35]	53	51	F: 25 (47%)/M: 28 (53%)	SP (53)	Benign: 52 (98%)/ malignant: 1 (2%)	3	3
Terrell [36]	80	48	F: 52 (65%)/M: 28 (35%)	TP, SP	Benign: 58 (72.5%)/ malignant: 22 (27.5%)	5.9	3
Sethi [37]	150	53	F: 78 (52%)/M: 72 (48%)	TP, SP	Benign: 150 (100%)/malignant: 0 (0%)	12	3
Savvas [38]	267	51.3	F: 140 (52.4%)/M: 127 (47.6%)	TP, SP	Benign: 250 (93.6%)/malignant 17 (6.4%)	N/E	3
Graciano [10]	106	48.5	F: 65 (61.4%) /M: 41 (38.6%)	SP	Benign: 106 (100%)/malignant: 0 (0%)	N/E	2
Total	1.069	50.28 (min 10–max 89)	F: 547 (51%)/M: 522 (49%)	N/A	Benign: 982 (91.8%)/malig-nant: 87 (8.2%)	7.35 (Min: 3/Max: 12)	N/A

TP total parotidectomy, *SP* superficial parotidectomy

Table 2 Demographics data comparison between patients with IFNM vs. WIFNM

Variable	IFNM *N* (%)	WIFNM *N* (%)	*p*
Mean age	50.6	50.4	n/a
Sex[a]	161	162	0.507
Women	167	150	0.162
Men			
Number of parotidectomies	554	514	n/a
Histology[b]	372 (91.4)	372 (94.2)	0.490
Benign	35 (8.6)	23 (5.8)	0.052
Malignant			
Type of surgery[c]	414 (85)	357 (82.6)	0.020
Superficial parotidectomy	73 (15)	75 (17.4)	0.543
Total Parotidectomy			
Follow-up[d]	7.3 (min: 3/max: 12)	7.1 (min: 3/max: 12)	n/a

[a]Studies performed by Sethi and Savvas do not differentiate patients according to sex and facial nerve monitoring

[b]The study performed by Savvas do not differentiate patients according to histology

[c]The study performed by Sethi do not differentiate patients according to type of surgery and facial nerve monitoring

[d]Studies performed by Savvas and Graciano do not specify follow-up time

Table 3 Incidence of facial nerve weakness in IFNM (intra operative facial nerve monitoring) vs. unmonitored patients (WIFNM), no. (%)

Author	Type of study	Type of surgery	Patients with IFNM	Inmediate facial nerve weakness	Permanent facial nerve weakness	Patients without IFNM	Inmediate facial nerve weakness	Permanent facial nerve weakness
Deneuve [31]	R	TP. SP	46	3 (6.5%)	0 (0%)	41	5 (12.1%)	1 (2.4%)
Yuan [32]	R	TP, SP	65	4 (6.1%)	0 (0%)	44	9 (20.4%)	2 (4.5%)
Pons [33]	R	TP, SP	42	11 (26.1%)	3 (7.1%)	23	6 (26.1%)	2 (8.7%)
Grosheva [9]	P	TP, SP	50	19 (38%)	1 (4%)	50	22 (44%)	2 (4%)
López [34]	R	TP, SP	25	9 (36%)	1 (4%)	27	19 (70.4%)	8 (29.6%)
Witt [35]	R	SP	20	4 (20%)	0 (0%)	33	5 (15.2%)	0 (0%)
Terrell [36]	R	TP, SP	40	13 (33%)	4 (10%)	40	23 (57.5%)	3 (7.5%)
Sethi [37]	R	TP, SP	67	17 (25.3%)	3 (4.4%)	83	23 (27.7%)	1 (1.2%)
Savvas [38]	R	TP, SP	147	30 (20.4%)	18 (12.2%)	120	58 (48.3%)	48 (40%)
Graciano [10]	P	SP	52	20 (38.46%)	2 (3.8%)	54	28 (51.8%)	3 (5.5%)
Total	n/a	n/a	554	130 (23.4%)	32 (5.7%)	515	198 (38.4%)	70 (13.6%)
Meta-analyzed summary rate of facial paralysis	Immediate facial palsy in patients with IFNM vs. WIFNM: $p=0.001$—OR 0.39 (0.27–0.58)				Permanent facial palsy in patients with IFNM vs. WIFNM: $p=0.001$—OR 0.31 (0.18–0.53)			

trauma and ischemia [35]. Some authors suggest that monitoring may be beneficial in patients with bulky tumors or in revision surgery [22, 36–38], leading to a decreased operation time [6, 39, 40] and an increased patient satisfaction [3]. However, opponents of IFNM have suggested the false sense of security that may result in less meticulous surgical nerve dissection [18].

The intraoperative facial nerve monitoring provides electrophysiological monitoring of facial muscle activity via electromyography (EMG) [41]. This is the reason why neuromuscular blockade should be avoided for facial nerve monitoring [42]. During the surgery, the EMG can be monitored and interpreted subjectively by an electrophysiologist or by the surgical team, with auditory and visual alert signals.

Data about pre- and post-operative facial nerve stimulation thresholds did not show a correlation with facial nerve dysfunction related to parotidectomy. Also, there is no correlation of intraoperative nerve responses with post-operative facial nerve function [43, 44]. However, Brennan et al. reported that an elevated nerve response [0.5 milliamperes (mA)] was predictive of post-operative facial nerve paresis at the end of procedure [45].

According to Lowry et al., the most common reasons to use intraoperative monitoring in USA were helping to identify the nerve (20%), medicolegal concerns (14%), increased safety (11%), and the belief that IFNM was the standard of care (11%) [18]. Conceptually, facial nerve monitoring during parotid surgery would allow surgeons early nerve identification, warn the surgeon of unexpected facial nerve stimulation during gland dissection, mapping the course of the nerve, reduce mechanical nerve trauma, and perform an evaluation and prognostication of function at the end of the procedure. However, multiple factors have been reported to result in false positive and false negatives when using the monitOR incorrect monitor settings, inexperience with IFNM, anesthetic effects, malignant involvement of the nerve, and chronic parotitis/infection [3, 22, 46, 47].

Nerve monitoring systems commercially available typically have 2–8 channels. The most common systems used in parotid gland surgery have two channels, and most data are published for 2-channel systems [48]. All systems perform continuous passive monitoring, tracking facial muscle activity during surgery and have a built-in pulse generator for active monitoring through electrical evoked EMG responses. No data has shown that systems with greater than two channels are more effective than 2-channel systems. Furthermore, it has not been demonstrated that a combination of passive and active monitoring is superior to passive monitoring alone in protecting the facial nerve [49].

In the current meta-analysis, when we consider all the studies (prospective and retrospective data) the incidence of immediate and permanent post-operative facial nerve weakness in patients with IFNM versus the group of patients operated WIFNM was significantly different in both cases in favor of IFNM. Data related to the incidence of immediate post-operative weakness in patients with IFNM is consistent with the previous meta-analysis published by Sood et al. [48]. However, in contrast to the meta-analysis published by Sood et al. [48], we also found a statistical difference between both groups (IFNM vs. WIFNM) related to the rate of permanent facial nerve weakness in favor of the IFNM. Despite this, results revealed a broad range of immediate post-operative facial nerve weakness among studies included

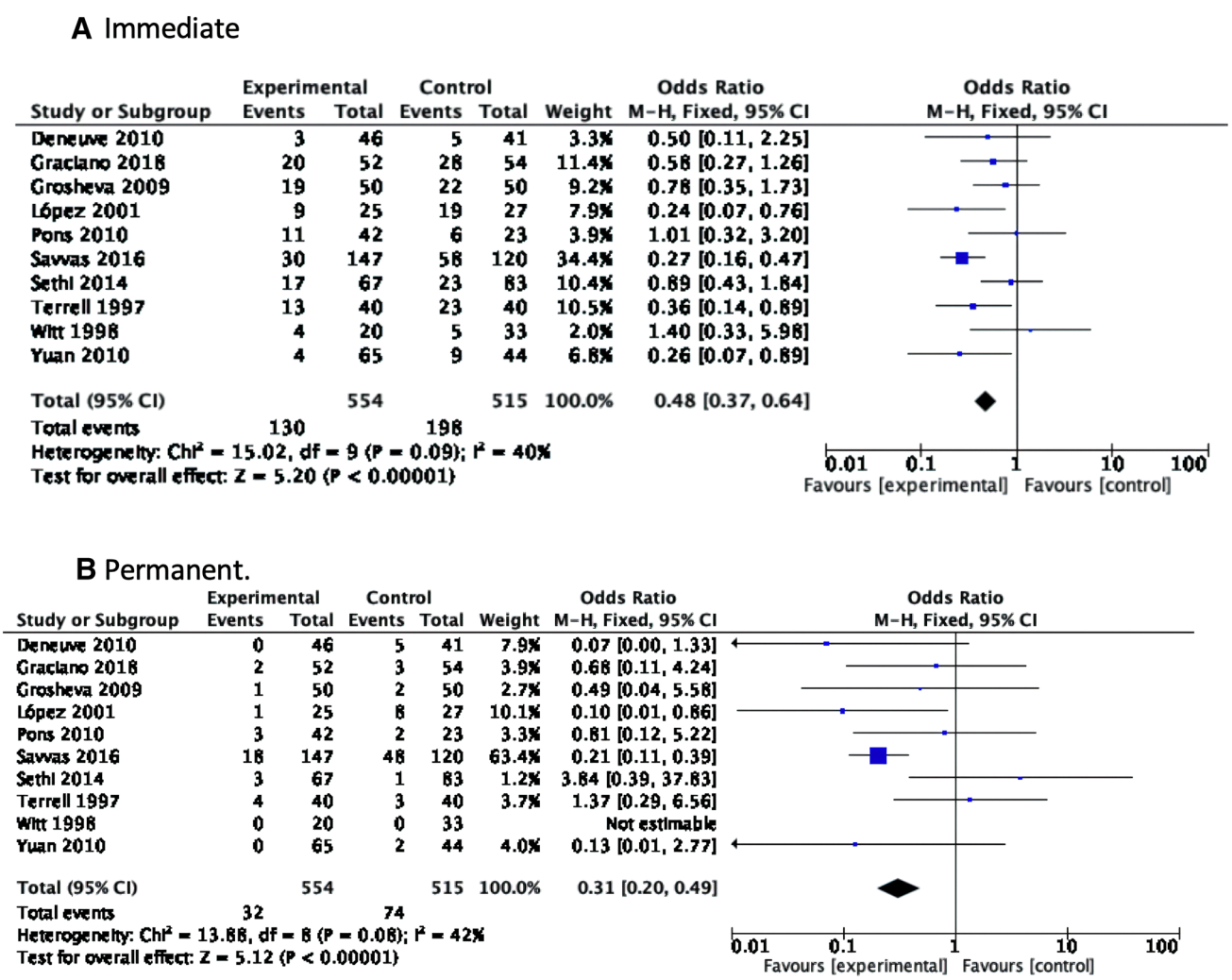


Fig. 2 Forest plot showing the rate of **a** immediate vs. **b** permanent facial nerve palsy. The experimental cohort (IFNM) vs. The control cohort (WIFNM) including all the studies

Table 4 Incidence of facial nerve weakness in IFNM vs. unmonitored patients, no. (%) including only prospective data

Author	Type of surgery	Patients with IFNM	Inmediate facial nerve weakness	Permanent facial nerve weakness	Patients without IFNM	Inmediate facial nerve weakness	Permanent facial nerve weakness
Grosheva [9]	TP, SP	50	19 (38%)	1 (4%)	50	22 (44%)	2 (4%)
Graciano [10]	SP	52	20 (38.46%)	2 (3.8%)	54	28 (51.8%)	3 (5.5%)
Total	n/a	102	39 (38.2%)	3 (2.9%)	104	50 (48%)	5 (4.8%)
Meta-analyzed summary rate of facial paralysis	Immediate facial palsy in patients with IFNM vs. WIFNM: $p=0.198$—OR 0.67 (0.38–1.17)				Permanent facial palsy in patients with IFNM vs. WIFNM: $p=0.739$—OR 0.60 (0.14–2.59)		

in both the IFNM (6.1–38.4%) and the group of patients operated WIFNM (12.4–70.4%). These differences are likely attributed to the retrospective nature of the studies, surgeon variation, and experience or type of parotidectomy performed (superficial vs. total); nevertheless, the heterogeneity assumption was never ≥ 50% in both subgroup analysis.

Since our analysis included only two prospective studies with grading A, we considered performing a subgroup analysis just including this data. After the analysis, we were not able to find any statistical difference in the rate of immediate ($p=0.198$) or permanent ($p=0.739$) facial nerve weakness between those patients operated with IFNM or WIFNM.

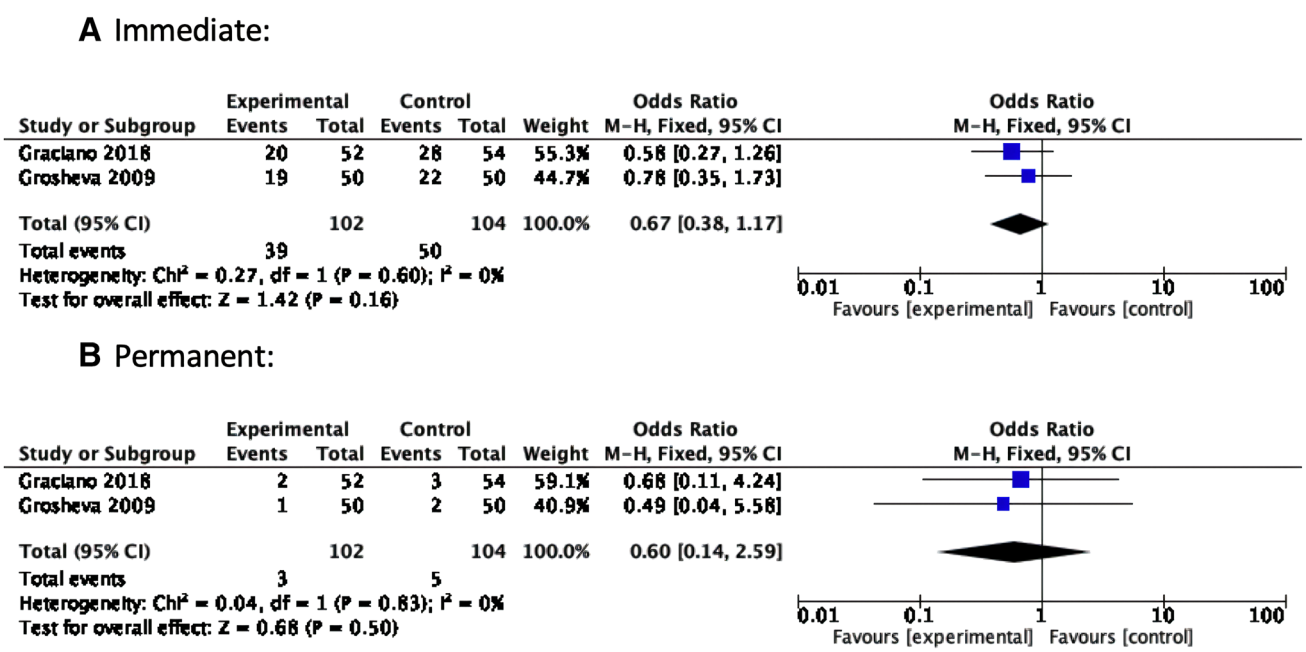


Fig. 3 Forest plot showing the rate of **a** immediate vs. **b** permanent facial nerve palsy. The experimental cohort (IFNM) vs. The control cohort (WIFNM) including just prospective data

However, the small sample size limits the statistical significance of this subgroup analysis.

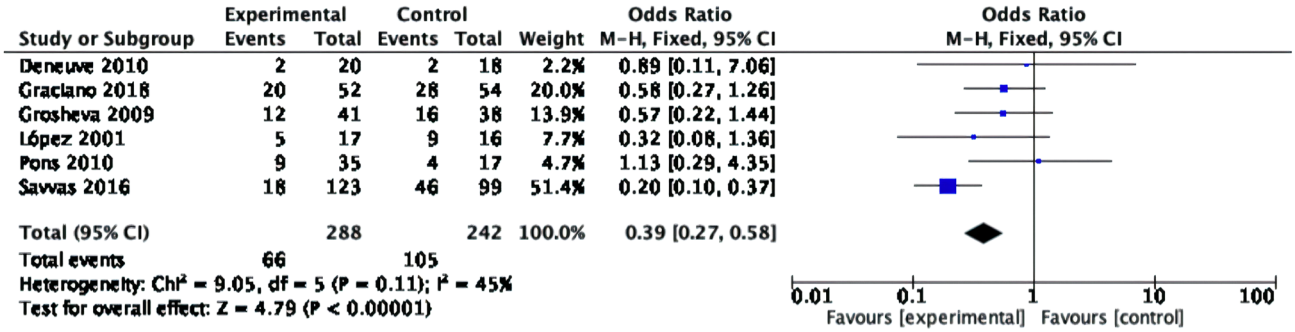
After analyzing our data, we can hypothesize as Sood et al. did [48] that IFNM may provide real-time feedback to reduce blunt trauma over the facial nerve or its branches that may occur during nerve manipulation, dissection, electrocautery, and surgical instrumentation. Also, we can suggest that monitoring may increase the surgeon's caution during the identification of nerve's trunk and its major branches, resulting in less risk of facial nerve weakness. These suggestions are supported in our analysis, as patients undergoing parotidectomy with IFNM had a 42.7% decrease in incidence of immediate facial nerve weakness in the immediate post-operative period and 7.8% decrease in the incidence of permanent facial nerve weakness. Besides, the percentage of risk reduction of facial nerve weakness in patients operated using IFNM over control subjects WIFNM was 14.98%, translating into 7 patients required to undergo IFNM to prevent 1 incidence of immediate post-operative facial nerve weakness. However, these results do not necessarily mean than IFNM use translates into an absence of risk of injury or transection of the nerve or its branches during dissection. Also, a proper anatomical knowledge cannot be substituted by the facial nerve monitor.

Results from our meta-analysis do not allow us to give strong recommendations against or in favor of the use IFNM. When including all types of studies (prospective and retrospective), we found data in favor of the use of IFNM. However, when we just analyze prospective data, we are not able to found any significant difference. Despite a heterogeneity assumption under 50%, we consider the difference between both subgroups a product of bias from retrospective cohorts due to the potential for bias on the part of surgeons in the absence of randomized controlled trials. This is the reason why we consider it necessary to conduct comparative prospective-randomized studies to establish a proper surgical recommendation. Also, it is important to emphasize that tumor histology, size (< 3 cm vs. > 3 cm), morphology, and location of the tumor (Superficial, deep or in the lower pole of the gland) may influence facial nerve weakness, despite the use of nerve monitoring [50].

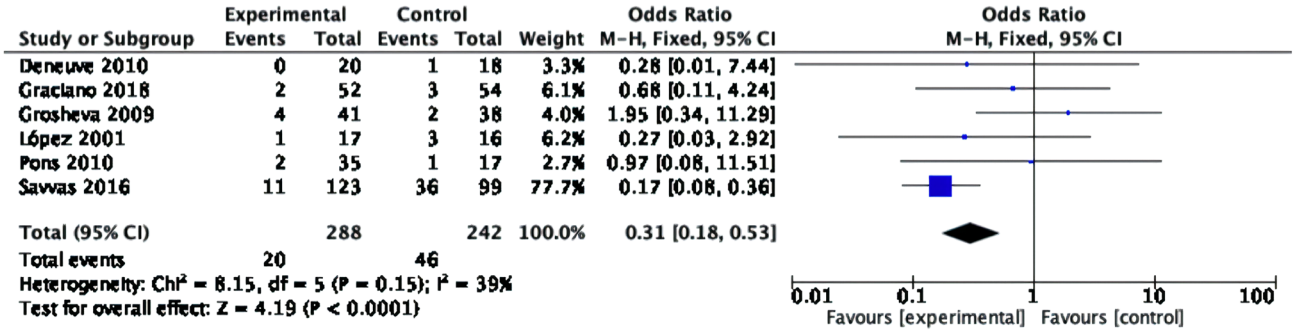
Finally, we summarize the limitations of this study. The absence of uniformity across studies about the grading of facial nerve weakness makes impossible to perform a proper analysis. Moreover, a correlation between the use of facial nerve monitoring and the rate of facial nerve weakness according to histology (Benign vs. Malignant) was not possible, due to the absence of information in the studies included. A specific House–Brackmann scoring was not consistently reported in the revised literature, with the definition of "facial weakness" encompassing a varied group of patients (House–Brackmann = 2–6). A trend in favor of more limited resection in parotid gland surgery makes it necessary to perform more specific studies about the need of IFNM and its influence reducing the incidence of transient or permanent paralysis or single branch nerve weakness in partial superficial parotidectomy. Our analysis included ten studies with grading A-B, with all of them having two arms (IFNM

Superficial parotidectomy

A Immediate:

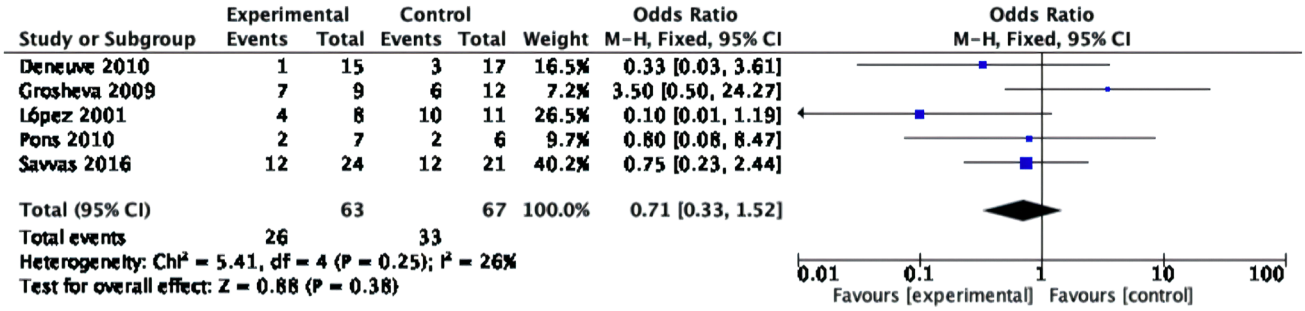


B Permanent:



Total parotidectomy

A Immediate:



B Permanent:

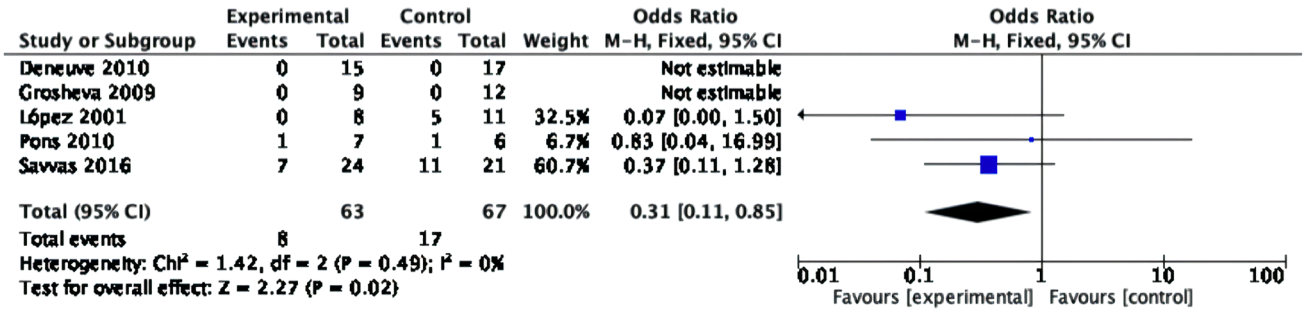


Fig. 4 Forest plot showing the rate of **a** immediate vs. **b** permanent Facial nerve palsy in patients underwent superficial and total parotidectomy. The experimental cohort (IFNM) Vs. The control cohort (WIFNM)

and WIFNM), drawn from a relatively homogeneous population. Although this significantly minimized the potential for bias, we cannot exclude it all. Attempts were made to reduce bias and increase the study validity by utilization of the Oxford Center for Evidence-Based Medicine grading system and the ROBIN-I. The risk of bias analysis showed that the overall bias evaluation was considered to be at low to moderate risk in most studies, where the main reason for lowering the quality was the risk of bias due to missing data (Due to short follow-up) and measurement of outcomes (Absence of uniformity across studies). Therefore, the main weakness of the studies included is possible risk of bias in selection of the reported results (Supplement Table 2).

Conclusion

In summary, this study suggests that IFNM may decrease the risk of immediate post-operative and permanent facial nerve weakness in primary parotid gland surgery. However, due to the low evidence level, additional prospective-randomized trials are needed to determine if these results can be translated into improved surgical safety and improved patient satisfaction.

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Compliance with ethical standards

Conflict of interest Authors declare that they do not have any conflict of interest.

Ethical approval No ethical approval was required.

Informed consent Consent for the use of medical images was obtained from patients included.

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