Facial Nerve Monitoring during Parotidectomy: A Systematic Review and Meta-analysis

Amit J. Sood, MD1, Jeffrey J. Houlton, MD1,2, Shaun A. Nguyen, MD, MA1, and M. Boyd Gillespie, MD1

Abstract

Objectives. To determine the effectiveness of intraoperative facial nerve monitoring (FNM) in preventing immediate and permanent postoperative facial nerve weakness in patients undergoing primary parotidectomy.


Review Methods. A systematic review and meta-analysis of the literature was conducted. Acceptable studies included controlled series that evaluated facial nerve function following primary parotidectomy with or without FNM (intraoperative nerve monitor vs control). Primary and secondary end points were defined as immediate postoperative and permanent facial nerve weakness (House-Brackmann score, \( \geq 2 \)), respectively.

Results. After a review of 1414 potential publications, 7 articles met inclusion criteria, with a total of 546 patients included in the final meta-analysis. The incidence of immediate postoperative weakness following parotidectomy was significantly lower in the FNM group compared to the unmonitored group (22.5% vs 34.9%; \( P = .001 \)). The incidence of permanent weakness was not statistically different in the long term (3.9% vs 7.1%; \( P = .18 \)). The number of monitored cases needed to prevent 1 incidence of immediate postoperative facial nerve weakness was 9, given an absolute risk reduction of 11.7%. This corresponded to a 47% decrease in the incidence of immediate facial nerve dysfunction (odds ratio, 0.53; 95% CI, 0.35 to 0.79; \( P = .002 \)).

Conclusion. In primary cases of parotidectomy, intraoperative FNM decreases the risk of immediate postoperative facial nerve weakness but does not appear to influence the final outcome of permanent facial nerve weakness.

Keywords

parotidectomy, parotid surgery, facial nerve monitor, intraoperative facial nerve monitoring, meta-analysis

Received June 24, 2014; revised October 9, 2014; accepted October 15, 2014.

Intraoperative facial nerve monitoring (FNM) by direct visualization of facial muscle movement was first performed in 1898.1,2 Since these early reports, its application has been significantly refined, starting with the introduction of electromyography in the 1970s.2,3 The benefit of electromyographic monitoring of the facial muscles for facial nerve preservation has been well established in acoustic neuroma surgery but has yet to be considered standard of care for many otolaryngologic procedures in which the facial nerve is at risk.4,5

Facial nerve injury is the most significant complication of parotidectomy. Despite preservation techniques, large institutional series report transient facial nerve dysfunction occurring in up to 65% of parotidectomy patients and permanent facial nerve weakness in approximately 4% to 7% of cases.4,6-10 This weakness can vary in severity from subtle marginal mandibular asymmetry to complete facial paralysis. Resultant facial weakness significantly impairs patients’ quality of life and may result in costly medical litigation.11-13

Several authors have suggested that FNM results in a decreased incidence of postoperative facial weakness.7,8,14 However, to date, no randomized controlled trials have assessed the efficacy of intraoperative FNM. The use of FNM among otolaryngologists in the United States appears to be a matter of debate. Currently, 60% of practicing head and neck surgeons in the United States employ intraoperative FNM for parotid surgery, while the remaining 40% rely on anatomic landmarks or visually monitoring for facial muscle twitching.13 The objective of this study was to systematically analyze the effectiveness of intraoperative FNM compared to no monitoring in the prevention of immediate and permanent postoperative facial nerve weakness in patients undergoing primary parotidectomy.

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This article was presented at the 2014 AAO-HNSF Annual Meeting & OTO EXPO; September 21-24, 2014; Orlando, Florida.

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Inclusion and Exclusion Criteria.

Inclusion
- Primary cases of parotidectomy
- Superficial and total parotidectomy
- Inflammatory, benign, and malignant parotid disease
- 2-arm studies (intraoperative facial nerve monitoring group vs control group)
- Retrospective and prospective studies (only studies with grading A–B according to Oxford Center for Evidence-Based Medicine)
- All languages (if data could be translated and extrapolated)

Exclusion
- Parotidectomy for recurrent cases
- Cases with preoperative facial weakness
- Cases with facial nerve sacrifice
- Single-arm studies (without unmonitored subjects)
- <20 patients treated in each group

### Methods

#### Literature Search

A comprehensive literature search was conducted through the PubMed-NCBI database from 1970 to 2014. Searches based on the following phrases were conducted: (1) “facial nerve monitoring during parotidectomy,” (2) “facial nerve monitoring” AND “parotidectomy,” (3) “facial nerve monitoring” AND “parotid surgery,” (4) “facial nerve monitoring,” and (5) “intraoperative facial nerve monitoring.” This resulted in a total of 1414 manuscripts that were subjected to our inclusion and exclusion criteria. The inclusion and exclusion criteria for the systematic review were determined a priori and are listed in Table 1. The search was conducted according to PRISMA guidelines.15

The primary outcome evaluated in this study was the rate of immediate postoperative facial nerve weakness. A secondary end point was the rate of permanent postoperative facial nerve weakness. Immediate postoperative facial nerve and permanent facial nerve weakness were defined as House-Brackmann grading scale score \( \geq 2 \).10 Normal facial nerve function was defined as a House-Brackmann score of 1, or “normal.” Maximum time to final assessment was 12 months after surgery. Minimum time to final assessment was 3 months, as previously defined in the literature.17

Because all studies but 1 were retrospective, the possibility of publication bias in each was evaluated with the Oxford Center for Evidence-Based Medicine.18 According to this assessment tool, the quality of a study is determined according to such criteria as randomization and presence of control group. The grading is as follows:

1a: Systematic reviews (with homogeneity) of randomized controlled trials
1b: Individual randomized controlled trials (with narrow confidence interval)
1c: All or none randomized controlled trials
2a: Systematic reviews (with homogeneity) of cohort studies
2b: Individual cohort study or low-quality randomized controlled trials (eg, <80% follow-up)
2c: “Outcomes” research or ecologic studies
3a: Systematic review (with homogeneity) of case-control studies
3b: Individual case-control study
4: Case series (and poor-quality cohort and case-control studies)
5: Expert opinion without explicit critical appraisal or based on physiology, bench research, or “first principles.”

Based on the level of evidence, a grading evaluation is obtained ranging from A to D.18

#### Data Extraction

Data from studies meeting inclusion and exclusion criteria were extracted and verified by 2 authors. Information extracted from each study included the following: author, year of publication, number of patients treated, extent of surgery, use of FNM, and proportion of patients with immediate and permanent facial nerve weakness.

#### Statistical Analysis

Meta-analysis of selected studies with an odds ratio (OR) comparing an intraoperative FNM (experimental) group and an unmonitored (control) group was performed with Cochrane Review Manager 5.2 (Nordic Cochrane Centre, Cochrane Collaboration, 2011, Copenhagen, Denmark). Both the fixed effects model and the random effects model were used in this study. Under the fixed effects model, it was assumed that all studies come from a common population and that the effect size (OR) was not significantly different among the trials. Under the random effects model, the true effects in the studies are assumed to vary among studies, and the summary effect is the weighted average of the effects reported in the different studies.19 This assumption was tested by the heterogeneity statistic, or \( I^2 \) statistic. If this test yielded a low \( P \) value (\( P < .05 \)), then the fixed effects model was invalid. In this case, the random effects model was more appropriate, in which both the random variation within the studies and the variation among the different studies are incorporated. Cochrane Review Manager uses the Mantel-Haenszel method for calculating the weighted summary OR under the fixed effects model. Next the heterogeneity statistic is incorporated to calculate the summary OR under the random effects model.20 For meta-analysis of OR, the null hypothesis stated that there was no difference between treatment and control with respect to postoperative paralysis in patients undergoing primary parotidectomy. The pooled OR with 95% CI is given for both the fixed effects model and the random effects model. If the value 1 is not within the 95% CI, then the OR is statistically significant at the 5% level (\( P < .05 \)). When overall results were significant, the number needed to treat for an additional beneficial outcome was calculated—that is, the number of participants...
who need to be treated with the intervention to prevent 1 incidence of facial nerve weakness.

In addition, a chi-square test with Yates correction for continuity was applied with 2-sided (or 2-tailed) $P$ values for the comparison of 2 proportions from independent samples (these proportions being sex, histology, and procedures) expressed as a percentage, as calculated from the aforementioned aggregations. A $P$ value < .05 was considered indicative of statistical significance.

**Results**

The literature search resulted in a total of 1414 manuscripts. After the removal of duplicates studies, incomplete/unobtainable manuscripts, and those based on tumors for other primary sites based on abstract review, 46 studies underwent full manuscript review. Of these, reasons for exclusion were the following: lacking FNM (n = 22), recurrent parotid surgery (n = 2), and single-armed studies (n = 15). In total, 7 studies were included in our statistical analysis (Figure 1). According to the Oxford Center for Evidence-Based Medicine grading system, 1 study received a grading of A, and the remaining received evaluations of B. Demographic data of included studies are summarized in Table 2.

The intraoperative FNM group consisted of 288 patients, while the control group consisted of 258. A comparison of age at surgery, sex, histology, procedure, and maximum time to follow-up between the FNM and unmonitored groups is depicted in Table 3. Demographic data between the FNM monitoring group and unmonitored group are similar. When compared to unmonitored patients, FNM-monitored patients had a mean age of 49.9 versus 49.3, with an even sex distribution of 52% versus 49% male patients. A majority of tumors in both groups were benign (88% vs 91%), a finding consistent with reported literature. Each group underwent a comparable amount of superficial and total parotidectomies (83% vs 79%; 17% vs 21%). Thus, the 2 cohorts were considered adequately homogenous for comparison.

The incidence of immediate postoperative facial nerve weakness in the FNM group was 22.5% (95% CI, 12.2% to 34.9%), in comparison to 34.2% (95% CI, 19.3% to 50.9%) in the control group (P = .001). Therefore, intraoperative FNM resulted in a 47% decrease in incidence of immediate facial nerve weakness (OR, 0.53; 95% CI, 0.35 to 0.79; $P = .002$). Absolute risk reduction in immediate weakness was 11.7%, translating into 9 patients requiring intraoperative monitoring to prevent 1 incidence of immediate postoperative facial nerve weakness.

The incidence of permanent facial nerve weakness in the FNM group was 3.9% (95% CI, 1.2% to 8.4%), in comparison to 7.1% (95% CI, 2.7% to 13.4%) in the control group (P = .18). This discrepancy was not statistically significant with permanent facial nerve dysfunction (OR, 0.59; 95% CI, 0.28 to 1.22; $P = .15$). The incidence of immediate and permanent facial nerve weakness in the FNM and unmonitored groups is summarized in Table 4 and illustrated in Figures 2 and 3.

**Subanalysis**

When stratifying for patients undergoing superficial parotidectomy, the incidence of immediate facial nerve weakness was 25.2% (95% CI, 17.6% to 34.0%) in the FNM group versus 33.2% (95% CI, 16.8% to 52.0%) in the unmonitored group (P = .12). The incidence of permanent weakness was 6.9% (95% CI, 3.0% to 13.0%) in the FNM group versus 9.1% (95% CI, 4.1% to 16.8%) in unmonitored patients (P = .78). These differences were not statistically significant for either immediate facial nerve dysfunction (OR, 0.62; 95% CI, 0.33 to 1.17; $P = .14$) or permanent (OR, 0.80; 95% CI, 0.28 to 2.32; $P = .69$).

In patients undergoing total parotidectomy, the incidence of immediate facial nerve weakness was 39.1% (95% CI, 11.1% to 71.8%) in the FNM group, in comparison to 48.7% (95% CI, 17.8% to 80.1%) in the unmonitored group (P = .38). The incidence of permanent facial nerve weakness was 4.0% (95% CI, 0.4% to 14.9%) in patients with FNM monitoring versus 12.4% (95% CI, 0.3% to 38.0%) in unmonitored patients. These differences, too, were not statistically significant for either immediate facial nerve dysfunction (OR, 0.69; 95% CI, 0.25 to 1.85; $P = .46$) or permanent (OR, 0.20; 95% CI, 0.03 to 1.36; $P = .10$). A summary of subanalysis results is represented in the appendix (available online at http://www.otojournal.org).

**Discussion**

The importance of intraoperative FNM for parotidectomy remains controversial among practicing physicians. A
recent nationwide survey demonstrated that 60% of otolaryngologists utilize nerve monitoring, while the remaining 40% avoid utilizing intraoperative FNM in their surgical practice. The report found that FNM use was more common among surgeons who had trained using the device during residency. Undoubtedly, this discrepancy has

Table 2. Demographics of Studies Included for Analysis.

<table>
<thead>
<tr>
<th>Author</th>
<th>No. of Parotidectomies</th>
<th>Mean Age, y</th>
<th>Sex, %</th>
<th>Histology, %</th>
<th>Procedures</th>
<th>Max Time to Final Follow-up, mo</th>
<th>Grade (Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deneuve21</td>
<td>87</td>
<td>46</td>
<td>46.54</td>
<td>77.23</td>
<td>SP, TP</td>
<td>6</td>
<td>B (2c)</td>
</tr>
<tr>
<td>Yuan22</td>
<td>109</td>
<td>47</td>
<td>63.37</td>
<td>95.5</td>
<td>SP, TP</td>
<td>6</td>
<td>B (2c)</td>
</tr>
<tr>
<td>Pons23</td>
<td>65</td>
<td>56</td>
<td>47.53</td>
<td>79.21</td>
<td>SP, TP</td>
<td>6</td>
<td>B (2c)</td>
</tr>
<tr>
<td>Grosheva6</td>
<td>100</td>
<td>52</td>
<td>52.48</td>
<td>100.0</td>
<td>SP, TP</td>
<td>7.9</td>
<td>A (1c)</td>
</tr>
<tr>
<td>López24</td>
<td>52</td>
<td>50</td>
<td>67.33</td>
<td>87.13</td>
<td>SP, TP</td>
<td>12</td>
<td>B (2c)</td>
</tr>
<tr>
<td>Witt25</td>
<td>53</td>
<td>51</td>
<td>53.47</td>
<td>98.2</td>
<td>SP</td>
<td>3</td>
<td>B (2c)</td>
</tr>
<tr>
<td>Terrell26</td>
<td>80</td>
<td>48</td>
<td>26.74</td>
<td>83.27</td>
<td>SP, TP</td>
<td>5.9</td>
<td>B (2c)</td>
</tr>
<tr>
<td>Weighted total</td>
<td>546</td>
<td>50 (10-89)</td>
<td>51.49</td>
<td>88.12</td>
<td>SP, TP</td>
<td>6.7 (3-12)</td>
<td></td>
</tr>
</tbody>
</table>

aMen, women.
bBenign, malignant.
cSuperficial parotidectomy, total parotidectomy.
dGrading recommendation (level of evidence) based on Oxford Center for Evidence-based Medicine.18
eRange in parentheses.

Table 3. Comparison of Demographics in FNM vs Unmonitored Patients.

<table>
<thead>
<tr>
<th></th>
<th>FNM</th>
<th>Unmonitored</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parotidectomies, No.</td>
<td>288</td>
<td>258</td>
<td>n/a</td>
</tr>
<tr>
<td>Mean age, y</td>
<td>49.8</td>
<td>49.3</td>
<td>n/a</td>
</tr>
<tr>
<td>Sex, No. (%)</td>
<td></td>
<td></td>
<td>.50</td>
</tr>
<tr>
<td>Men</td>
<td>150 (52)</td>
<td>126 (49)</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>126 (48)</td>
<td>132 (51)</td>
<td></td>
</tr>
<tr>
<td>Histology, No. (%)</td>
<td></td>
<td></td>
<td>.27</td>
</tr>
<tr>
<td>Benign</td>
<td>253 (88)</td>
<td>235 (91)</td>
<td></td>
</tr>
<tr>
<td>Malignant</td>
<td>35 (12)</td>
<td>23 (9)</td>
<td></td>
</tr>
<tr>
<td>Procedures, No. (%)</td>
<td></td>
<td></td>
<td>.29</td>
</tr>
<tr>
<td>Superficial parotidectomy</td>
<td>239 (83)</td>
<td>204 (79)</td>
<td></td>
</tr>
<tr>
<td>Total parotidectomy</td>
<td>49 (17)</td>
<td>54 (21)</td>
<td></td>
</tr>
<tr>
<td>Max time to final follow-up, mo</td>
<td>6.5 (3-12)</td>
<td>6.3 (3-12)</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Abbreviation: FNM, facial nerve monitoring; n/a, not applicable.

Table 4. Incidence of Facial Nerve Weakness in FNM vs Unmonitored Patients, No. (%).

<table>
<thead>
<tr>
<th>Author</th>
<th>PAROT</th>
<th>IMMED</th>
<th>PERM</th>
<th>PAROT</th>
<th>IMMED</th>
<th>PERM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deneuve21</td>
<td>41</td>
<td>5 (12.1)</td>
<td>1 (2.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yuan22</td>
<td>44</td>
<td>9 (20.4)</td>
<td>2 (4.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pons23</td>
<td>23</td>
<td>6 (26.1)</td>
<td>2 (8.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grosheva6</td>
<td>50</td>
<td>22 (44.0)</td>
<td>2 (4.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>López24</td>
<td>27</td>
<td>19 (70.4)</td>
<td>8 (29.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Witt25</td>
<td>33</td>
<td>5 (15.2)</td>
<td>0 (0.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrell26</td>
<td>40</td>
<td>23 (57.5)</td>
<td>3 (7.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighted total</td>
<td>258</td>
<td>34.2%</td>
<td>7.1%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: FNM, facial nerve monitoring; IMMED, immediate postoperative weakness; PAR, parotidectomies; PERM, permanent outcome weakness.
contributed to the controversy of whether intraoperative FNM should be considered standard of care.13

Advocates suggest that monitoring may be a beneficial adjunct in patients with bulky tumors and revision surgery, where dissection and direct visualization alone may prove insufficient.8,29-32 Moreover, others have demonstrated decreased operation time6,33 and increased patient satisfaction with the use of intraoperative monitoring.34 According to Lowry et al, the most common reasons to use intraoperative monitoring were as follows: to help identify the nerve (20%), medicolegal concerns (14%), increased safety (11%), and the belief that FNM was standard of care (11%).13

Opponents of FNM have suggested that overreliance of nerve monitoring provides a false sense of security that may result in less meticulous surgical dissection.13,25 Multiple factors have been reported to result in false positive and false negatives when using the monitor: incorrect monitor settings, inexperience with FNM, anesthetic effects, malignant involvement of the nerve, and chronic parotitis/infection.4,7,35-37

In the present meta-analysis, the incidence of immediate postoperative weakness in patients undergoing parotidectomy with intraoperative FNM was significantly lower versus control subjects (22.5% vs 34.2%). However, permanent facial nerve weakness in both groups was not significantly different (3.9% vs 7.1%), which is consistent with previously reported series.4,6,10 Further scrutiny of results revealed a broad range of immediate postoperative weakness among studies in both the FNM (6.1% to 38%) and unmonitored groups (12.4% to 70.4%). These differences are likely attributed to surgeon variation and/or parotidectomy procedure performed (superficial vs total).

Subgroup analysis revealed similar trends in favor of intraoperative nerve monitoring. Patients undergoing either superficial or total parotidectomy with FNM experienced a decreased incidence of immediate postoperative facial nerve weakness compared to unmonitored patients (25.2% vs 33.2%; 39.1% vs 48.7%). These findings were consistent with final postoperative function, which favored monitoring but was not significant (6.9% vs 9.1%; 4.0% vs 12.4%).

Collectively, these findings suggest that intraoperative FNM may not influence final outcomes but may have a role in decreasing the incidence of immediate postoperative facial nerve dysfunction. This finding may become increasingly important in an era where patient experiences are included in pay-for-performance formulas.

One explanation for these results is that monitoring provides real-time feedback to reduce blunt trauma to the facial nerve and its branches that may occur as a result of nerve manipulation, dissection, electrocautery, and surgical

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**Figure 2.** Odds ratio: immediate postoperative incidence of facial nerve weakness in intraoperative facial nerve monitoring (experimental) versus unmonitored (control) groups. M-H, Mantel-Haenszel.

**Figure 3.** Odds ratio: final outcome postoperative incidence of facial nerve weakness in intraoperative facial nerve monitoring (experimental) vs. unmonitored (control) groups. M-H, Mantel-Haenszel.
instrumentation. However, monitoring may not increase the already high yield in identifying the trunk of the nerve and its major branches and thus would not necessary prevent complete transection of the nerve. These suggestions are further supported through our analysis, as patients undergoing parotidectomy with intraoperative FNM had a 47% decrease in the risk of facial nerve dysfunction in the immediate postoperative period but failed to demonstrate a difference in permanent weakness.

In addition, the percentage of risk reduction of facial nerve weakness with nerve monitoring patients over control subjects was 11.7%, translating into 9 patients required to undergo intraoperative FNM to prevent 1 incidence of immediate postoperative facial nerve weakness. The current cost of FNM equipment (electrodes and probe stimulator) is approximately $172.00, steadily decreasing since its advent nearly 2 decades ago. Therefore, FNM appears to not only be immediately effective in the postoperative period but possibly cost-effective as well.

According to Lowry et al, approximately 93% of otolaryngologists in the United States perform parotid gland surgery, with fellowship-trained surgeons 4 times more likely to perform >10 parotidectomies annually. The data suggest that although experienced surgeons intuitively may avoid intraoperative FNM, use of adjunctive nerve monitoring may in fact be valuable during the postoperative recovery period. This may result in not only more satisfied patients postoperatively but also decreased parotid surgery-related medical litigation.

The main limitation of this study is that no facial nerve grading analysis could be performed, as reports of specific House-Brackmann scoring were not consistently reported in the literature. Our definition of “facial weakness” denotes a varied group of patients with slight to complete facial nerve paralysis (House-Brackmann ≥ 2). Therefore, it is unknown whether intraoperative FNM reduces incidence of total paralysis (House-Brackmann = 6) or whether it only decreases marginal mandibular nerve weakness. In addition, attempts were made to reduce bias and increase study validity by utilization of the Oxford Center for Evidence-Based Medicine grading system. Our analysis included only studies with grading A-B and studies with 2 arms where monitored and unmonitored patients were drawn from a relatively homogeneous population. Although this greatly minimized the potential for bias, we cannot exclude the potential for bias on the part of surgeons in the absence of randomized controlled trials. However, it is expected that if bias were present, surgeons would be more likely to use FNM in cases that they determine to be at higher risk preoperatively.

Conclusion

This study suggests that in primary cases of parotidectomy, intraoperative FNM decreases the risk of immediate postoperative facial nerve dysfunction but does not appear to influence final outcome of facial nerve weakness. Additional studies are needed to determine if this reduction in short-term paresis translates into improved patient quality of life and satisfaction.

Author Contributions

Amit J. Sood, study concept/design, manuscript writing, manuscript edits/revision, statistical analysis; Jeffrey J. Houlton, study concept/design, manuscript writing, manuscript edits/revision; Shaun A. Nguyen, study concept/design, manuscript writing, manuscript edits/revision; M. Boyd Gillespie, study concept/design, manuscript writing, manuscript edits/revision.

Disclosures

Competing interests: None.
Sponsorships: None.
Funding source: None.

Supplemental Material

Additional supporting information may be found at http://otojournal.org/supplemental.

References


