How Deleterious Is Facial Nerve Dissection for the Facial Nerve in Parotid Surgery: An Electrophysiological Evaluation

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Objective: This study was conducted to investigate subclinical electrophysiological deleterious effect due to microtrauma to the nerve in response to the dissection of a tumor and parotid tissue from the facial nerve and its branches and surgical traction experienced during the operation.

Methods: The study included 34 adult patients who underwent parotidectomy operations under intraoperative facial nerve monitoring. Three measurements were taken from each patient to evaluate facial nerve functions, with 3 stimuli of different intensities applied with different timing. An initial stimulus of 1 mA was applied to confirm the identification of the main trunk of the facial nerve (Group 1: Initial-Normal). Then, a threshold value was found by stimulating the main trunk until muscle fasciculations were observed on facial muscles (Group 2: Basal-Minimal). The same procedure was repeated after the tumor was resected (Group 3: Final-Minimal).

Results: There was no significant difference between the stimulus thresholds of Group 2 (0.31 mA) and Group 3 (0.30 mA). The highest amplitude in all 3 groups was observed at the mental branch, and the lowest at the frontal. The highest latency value was measured at the frontal branch and the lowest at the mental branch. Five (14.7%) of the patients developed postoperative pareses that was completely resolved by the seventh postoperative day visit in these patients.

Conclusion: This study demonstrated that the surgical trauma of a meticulously conducted dissection and surgical traction did not cause any deleterious electrophysiological alteration on the facial nerve.

Key Words: Emg, facial nerve, parotid, surgical trauma

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Facial nerve paralysis is one of the most feared complications of parotidectomy operations conducted for excision of parotid masses. Facial nerve paralysis may cause cosmetic and functional morbidity, ocular complications, a decrease in the quality of life, and medicolegal problems.[1] Transient paresis occurs in 20% to 40% of patients following parotidectomy, while permanent paralysis of the facial nerve is seen in up to 4% of the patients.[2] Today, facial nerve monitoring is widely used for facilitating intraoperative identification of the facial nerve, for preventing iatrogenic damage, and for predicting the postoperative status of the nerve, thus preventing postoperative neural complications.[3] Intraoperative electromyographic monitoring of the facial nerve has so far been associated with reduced complication rates (<1%) and with enhanced rates of preserving the integrity of the facial nerve (95–100%).[4]

The most important factors that may affect the facial nerve during parotidectomy surgery can be listed as the type, dimensions and the location of the tumor, the duration of surgery, the competency and experience of the surgeon, presence of postoperative inflammation, and revision surgery. Facial nerve injury due to electromonitoring has also been described. It is known that especially higher stimulation intensities can be traumatic for the nerve, to the extent of causing neurotmesis.[5]

Parameters of intraoperative measurements in facial nerve electromonitoring have already been the subject of various studies, especially in acoustic neuroma operations. Such studies have investigated the proximal-distal amplitude rates,[6] electromyographic changes of amplitude responses,[6] and the correlation of stimulus thresholds with amplitude responses.[6] All those studies were conducted with facial nerve monitoring at acoustic neuroma surgeries. However, there is yet no substantial in medical literature regarding any electrophysiological stimulus threshold changes that might have been brought about by the dissection and traction of the facial nerve during parotidectomy.

In this study, we aimed to investigate the electrophysiological traumatic effect brought about by surgical dissection and traction of the facial nerve during parotidectomy, and the correlation of stimulus thresholds of facial nerve branches with the length of the dissection site.

METHODS

Population

The study was conducted after obtaining the approval of the Local Clinical Research Ethics Committee. Thirty-four patients scheduled for surgery due to parotid masses were included in the study. All patients were informed about the procedure and about the measurement method, and their written consents were obtained. Exclusion criteria were set as: revision surgery, mentally retarded patients, patients who did not give their consents for the study protocol, patients who were carrying implants like cardiac pacemakers that could affect electrophysiological measurements, those with already impaired facial nerve functions, those with neurofibromatosis type 2, and those with tumors like acoustic neuroma or schwannoma which could affect facial nerve functions. All operations were performed by only 2 surgeons experienced in parotid surgery.

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Facial Nerve Monitoring

The patient was placed on the surgical table. During general anesthesia, no neuromuscular blocking agents were used by the anesthesiologist other than induction anesthesia. The nerve intraoperative monitoring III Response nerve monitoring system (Medtronic, Minneapolis, MN) was utilized in this study. The needle electrodes were inserted in the frontal, zygomatic, buccal, and marginal mandibular muscles for optimal measurements[7] (Fig. 1). The ground electrode was placed on the sternum. The stimulus electrode probe, like all other electrodes, was plugged into the main console. The standard stimulation protocol was set as: stimulus intensity at 1 mA, stimulus duration at 100 microseconds, stimulus rate at 4 bursts per second, and stimulus threshold at 100 microvolts. Different stimulation intensities were applied for each study group.

Evaluation

Electromyographic Evaluation

Group 1 (Initial-Normal): At the beginning of the operation, after identifying the main nerve trunk surgically, the nerve was stimulated with a current intensity of 1 mA in all patients for a confirmatory response, and the amplitudes and latency values of the peripheral branches responding to that stimulus were recorded.

Group 2 (Initial-Minimal): After the main nerve trunk was identified at the beginning of the operation and the procedure of Group 1 was terminated, the main trunk was stimulated again, starting with a current intensity of 0.01 mA and gradually increasing the intensity until fasciculations were noticed on facial muscles, thus finding the minimum threshold value that would provoke a perceivable muscle contraction. Then, the main trunk was stimulated at the intensity of that stimulus threshold, and the amplitudes and latency values of facial nerve branches responding to that stimulus intensity were recorded.

Group 3 (Final-Minimal): At the end of the operation, when the tumor mass was removed completely and the nerve branches were exposed, repeating the procedure in Group 2, the main trunk was stimulated increasingly, beginning with a current intensity of 0.01 mA, until the minimum threshold value that could bring about muscular fasciculations on the face was reached. The amplitudes and latency values of the peripheral branches in response to that threshold stimulation were recorded.

Dimensions of the tumor: After the termination of the surgical procedure, the 2 dimensions of the excised tumor masses were measured and recorded.

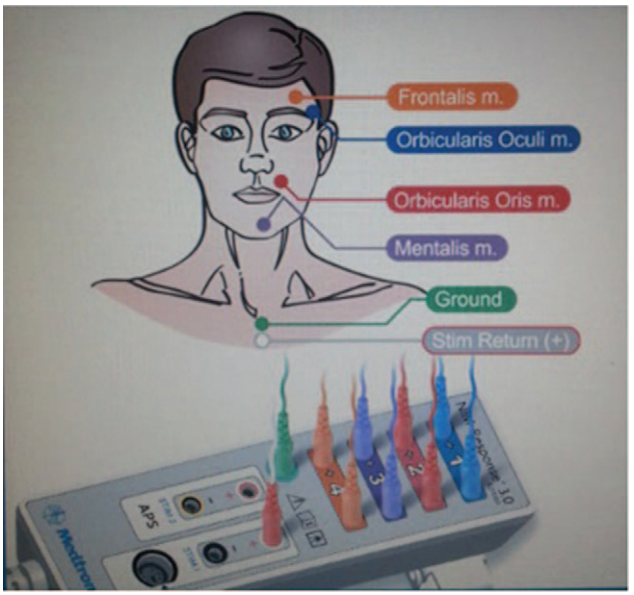

FIGURE 1. The placement of the electrodes for facial nerve monitoring.

Operation Time

The time period from the beginning to the termination of the surgical procedure was recorded in all patients.

The Dissection Lengths of the Frontal and Mental Branches

It is known that tumor masses in the parotid are usually located at the lower half of the gland; thus the mental nerve has the longest dissection length while the frontal nerve has the shortest distance. In this study, we have measured the distances of the dissected parts of the frontal and mental branches from the main nerve trunk with a ruler, and recorded the length in millimeters.

Postoperative Facial Nerve Functions

All patients were seen on postoperative first, seventh, and fifteenth days, and were evaluated by the House–Brackmann facial paralysis grading scale.[8]

STATISTICS

Statistical analysis was carried out using the Statistical Package for the Social Sciences version 13.0 software for Windows (SPSS Inc, Chicago, IL). All quantitative variables were estimated using measures of central location (ie, mean and median) and measures of dispersion (ie, standard deviation). Data normality was checked using the Kolmogorov–Smirnov tests of normality. Repeated ANOVA was used for comparing quantitative data between groups. (The difference among groups was considered to be $P<0.05$). To determine the days among which there were differences, the Tukey honest significant difference test was administered as a post hoc test. Since this was a multiple comparison, the Bonferroni correction was applied and $P<0.016$ was accepted as the value of significance. Pearson correlation analysis was used for comparison of data.

RESULTS

Twenty-nine patients of our study group underwent superficial parotidectomy, and 5 patients had total parotidectomy. Histopathological evaluation revealed 23 pleomorphic adenomas, 4 Warthin tumors, and 4 mucoepidermoid carcinomas. The mean age of the patients was 37.5 ± 3.8. Twenty-one of the patients were female and 13 were male.

There was no significant difference between the stimulus thresholds of the main trunk of Groups 2 and 3 ($P=0.923$) (Fig. 2). Likewise, no significant difference was observed between the amplitude values of Groups 2 and 3 (Table 1). The intensities of stimulus thresholds were higher in all facial nerve branches of Group 1, and amplitude values of Group 1 were also higher than the other 2 groups (Table 1).

The mental branch of the facial nerve had significantly higher amplitude values than other branches in all 3 groups (Table 1). The frontal branch presented the lowest amplitude values (Table 1). Amplitude values of orbicularis oris and orbicularis oculi were significantly lower than those of the mental branch but higher than the frontal branch (Table 1).

A comparison of the latency values of facial nerve branches showed that the latency values of the frontal branch were higher than those of the mental branch in all 3 groups; however, the difference was not statistically significant (Fig. 3).

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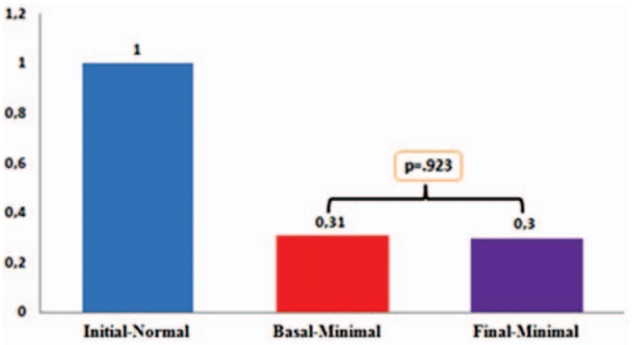

FIGURE 2. Stimulus thresholds of the main trunk of the facial nerve in the groups.

Analysis based on the data presented by all patients did not reveal any correlation between the size of the tumor and the dissection distances of frontal and mental branches. Likewise, there was no significant correlation between tumor size and operation time ($P > 0.05$). No significant correlations were found between dissection distances of the frontal and mental branches and operation time (Table 2). A significant correlation was observed between the dissection distance of the frontal branch and postoperative stimulus thresholds ($r = 0.588$, $P = 0.001$). There was no significant correlation between the dissection distance of the mental branch and postoperative stimulus threshold ($r = 0.257$, $P = 0.186$). Thirty-four patients were also evaluated in 2 separate groups according to their tumor sizes (16 patients with tumor <2 cm and 18 patients with tumor >2 cm). As the tumor size increased, dissection distances of the frontal and mental branches also increased; however that increment was not statistically significant ($P > 0.05$). Operation time also increased as the tumor size increased, but no statistically significant difference was observed between the 2 groups ($P > 0.05$).

Five (14.7%) of the patients developed postoperative pareses (House–Brackmann Grade 2) that was completely resolved by the seventh postoperative day visit in these patients. There was no significant difference between the Group 2 and 3 stimulus threshold and latency measurements in the paretic 5 patients.

DISCUSSION

Facial nerve dissection is a surgical procedure widely employed especially in parotidectomy operations. All branches of the facial nerve are carefully dissected both from the tumor and also from the neighboring parotid tissue. During the procedure the facial nerve can be affected due to various reasons. Even when the sheath of the nerve looks intact, it does not mean that nerve function has not been impaired.[9] Traction and manipulations can make some nerve fibers break and loss of nerve function may follow.[9] Facial nerve monitoring is being used for many years, aimed at reducing the risk of facial nerve injuries.[10]

Most studies in the medical literature investigating facial nerve monitoring have focused on its predictive value for nerve injuries manifest in early or late postoperative periods, and on the advantages of that predictive value as compared with the classical method. Today, the routine use of facial nerve monitoring in parotidectomies is yet a controversial issue.[11] Various studies have been conducted for clarifying the causes of nerve injury, aimed at enhancing patient and physician satisfaction,[6] but still there is not sufficient information about the effect of microtraumas induced by the dissection itself.

In the postoperative period of parotidectomy operations, the rates of transient paralysis were reported as 9.1% to 64.0%, and those for permanent paralysis as 0% to 3.9%.[12] Various factors may affect the development of postoperative facial nerve paralyses following parotidectomies, such as the type, size, and location of the tumor, the duration of the surgical procedure, the experience of the surgeon, the development of postoperative inflammation, and revision surgery; however, this study demonstrated that the surgical trauma due to facial nerve dissection conducted with great care did not have any significant effect by itself on facial nerve functions. Previous studies showed that an appropriate surgical technique and an adequate knowledge of anatomy were highly important for the preservation of the facial nerve.[13] Our results also support those studies.

Today, facial nerve monitoring is employed both for preventing postoperative complications and also for overcoming medicolegal issues. Facial nerve monitoring is routinely employed in acoustic neuroma surgeries. For the identification of the facial nerve, the nerve is stimulated by currents of stimulus threshold intensities and the responses to those stimuli are observed. The intensity of stimulus thresholds used in acoustic neuroma patients is usually 0.05 to 0.1 mA, while in parotid tumors the intensity is usually 0.5 to 1.0 mA.[9,10] It was reported that increased stimulus intensities during surgery could cause impairment in the facial nerve, even to the extent of causing neurotmesis.[5] A study about the threshold stimuli in acoustic neuroma patients has demonstrated that a stimulus intensity of <0.05 mA would both better preserve facial nerve functions and also would better predict postoperative nerve functions.[9]

A second important result of our study was the finding that stimulus thresholds with intensities as low as 0.3 mA could identify the location of the facial nerve and provoke muscle twitching. Since it is known that frequent use of high stimulus thresholds during surgery may fatigue the nerve cells and may lead to postoperative paresis or paralysis, our results can be informative in preventing such complications with the use of lower intensity stimulus thresholds than the generally applied higher intensities. In our

TABLE 1. Amplitude Values of Facial Nerve Branches in the Groups*

Facial Branch	Group 1 (Initial-Normal) μV	Group 2 (Basal-Minimal) μV	Group 3 (Final-Minimal) μV
Frontal†,‡,§	471.68 ± 149.75	221.64 ± 78.60	228.89 ± 64.00
Orbicularis Oculi†,‡,§	564.18 ± 139.3	234.86 ± 59.6	259.29 ± 101.83
Orbicularis Oris†,‡,§	621.96 ± 126,63	256.86 ± 70.56	283.25 ± 156.67
Mental†,‡,§	961.50 ± 87.50	316.32 ± 99.80	382.50 ± 71.11

*Repeat ANOVA ($P < 0.05$), Tukey HSD, Bonferoni düzeltmesi ($P < 0.016$).
†Group 1 versus Group 2: ($P < 0.016$).
‡Group 1 versus Group 3: ($P < 0.016$).
§Group 2 versus Group 3: ($P > 0.016$).

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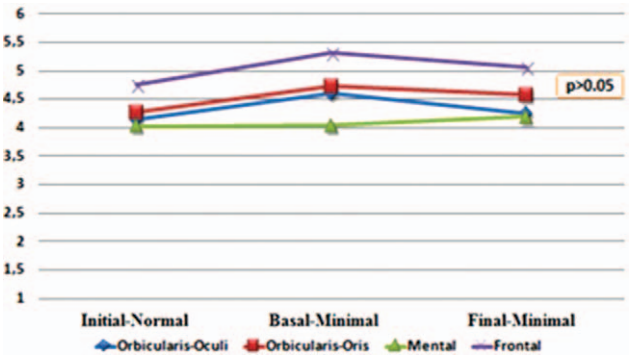

FIGURE 3. Latency values of the facial nerve branches in the groups.

study, fasciculations of the mimic muscles and accompanying electromyographic changes were seen quite clearly when the facial nerve was stimulated with a stimulus threshold of 0.3 mA both at the beginning and at the end of surgery.

The third important finding of our study was the observation of differences in the amplitudes and latency values of the facial nerve branches. In the study by Bernat et al,[14] investigating facial monitoring in vestibular schwannoma operations, while the muscles innervated by the mental branch had higher amplitude values, lower amplitude values were observed in the muscles innervated by the frontal branch. In this study, the muscles related to the mental branch also had higher amplitude values than the muscles related to the frontal branch. Such a difference was demonstrated for the first time in facial nerve monitoring conducted at parotid surgery. The differences between those muscle groups are explained by differences in their motor end plates. Higher amplitudes are generated in muscles where myofibrils at bone attachment sites have a greater number of clustered motor end plates.[15] However in orbicularis oculi and orbicularis oris, motor end plates are scattered around the muscle, thus lower amplitude responses are generated.[15] It is the number of activated axons which determine the amplitude. Since the mental nerve had higher amplitude, it means that more facial nerve axons were depolarized, which also points to a more powerful effect.[16] In this study, latent periods of the mental nerve were lower than those of the other nerves, while the frontal nerve had the highest latent periods (Fig. 3). Although latency differences were statistically insignificant, the higher number of axons activated in the mental nerve might be the cause for the decreased latent periods.

Correlation analysis of our study did not reveal a significant correlation between the amplitude and latency values, and stimulus thresholds. Previous studies with facial nerve monitoring were mostly related to cerebellopontine angle tumors. Studies investigating the facial nerve and its branches in parotidectomies are limited and since impulses are delivered more laterally as compared with cerebellopontine angle tumors, various electrophysiological characteristics may differ. Turel et al's[17] recent study on vestibular schwannoma also did not observe any significant correlation between the amplitudes and latency values, and postoperative facial nerve functions. However, there are not sufficient studies on this subject conducted with facial nerve monitoring in parotid surgery.

Correlation analysis of our study revealed a significant correlation between frontal dissection distances and stimulus thresholds, while no significant correlation was found between mental dissection distances and stimulus thresholds. Since parotid tumors are frequently located at the lower half of the gland, dissection is more often conducted at the mental branch, while frontal branch dissection is relevantly less required. However, even though the dissection distance is shorter for the frontal branch, it has a more pronounced effect on the main trunk. That pronounced effect may be due to the fact that the frontal branch has a different length, width, and tension than the mental branch.

TABLE 2. Dissection Distance, Tumor Size, Operative Time

Parameters	Mean ± Standard Deviation
Frontal branch dissection distance (mm)	17.71 ± 9.6
Mental branch dissection distance (mm)	36.53 ± 11.3
Tumor size (mm)	15.46 × 22.57
Operation time (min)	71.96 ± 15.6

Statistical analyses showed no significant correlations among the dissection length, tumor size, and operation time. Unless the tumor is very small usually similar extent of neural dissection is applied in most parotidectomy operations for the removal of the tumor. That may be the reason for the insignificant correlation among dissection distance, operation time, and tumor size.

In our study, we aimed to investigate subclinical electrophysiological changes that might occur during facial nerve manipulation and traction in parotidectomy patients. The results of our study indicated that the surgical dissection of facial nerve in patients undergoing parotidectomies did not cause any alteration in electrophysiological stimulus thresholds. No significant difference was observed between stimuli thresholds measured before the dissection of the facial nerve (Group 2) and after the tumor was removed (Group 3) (Fig. 2). This study is a first in medical literature showing that a meticulous surgical dissection did not cause any electrophysiologically measurable impairment of the facial nerve, as far as facial nerve monitoring could reveal. Interestingly, amplitude and latency between the Group 2 and 3 measurements were comparable in the temporarily paretic 5 patients relieving within 7 days postoperatively.

CONCLUSION

An experienced surgeon conducting a highly meticulous facial nerve dissection during parotidectomy operations would cause no subclinical electrophysiological injury to the nerve. When facial nerve monitoring is employed in such operations, a stimulus intensity of 0.3 mA will be sufficient to evoke an adequate response for evaluating nerve function, and will prevent any probable nerve injury due to elimination of higher stimulus intensities.

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