DOI: 10.24938/kutfd.1402951 Kırıkkale Üniversitesi Tıp Fakültesi Dergisi 2024;26(2):142-148
Original Article *Özgün Araştırma*

THE USE OF NERVE MONITORIZATION IN PAROTID, SUBMANDIBULAR GLAND AND FACIAL SURGERY AND ITS EFFECT ON PROGNOSIS

Parotis, Submandibuler Bez ve Yüz Bölgesi Cerrahisinde Sinir Monitörizasyonu Kullanımı ve Prognoza Etkisi

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ABSTRACT

Objective: The facial nerve and its branches are at risk during facial surgery. The surgery with the highest risk is parotid and submandibular gland surgery. An attempt was made to determine threshold values in terms of paralysis in nerve monitoring parameters. These determined values could not be used to predict facial nerve function after surgery. The aim of this study is to investigate the relationship between the parameters detected by nerve stimulation during surgery and postoperative facial nerve dysfunction in patients who underwent parotid and submandibular gland surgery.

Material and Methods: A total of 29 facial nerve branches of 13 patients who underwent superficial parotidectomy or submandibular gland resection were examined. Patients were examined in two groups: those who did not develop paralysis after surgery and those who developed paralysis or sequelae. The relationship between the patient's pre- and postoperative House-Brackmann staging and potential changes detected during surgery was investigated.

Results: Paralysis was detected in 8 of 29 nerves that were stimulated, and the affected branches were the cervicofacial branch and the marginal mandibular branch. No difference was observed in the mean threshold stimulation values and responses determined before, during and at the end of dissection between patients who developed paralysis and those who did not.

Conclusion: Unlike the literature, it is determined that no electrophysiological measurement result can predict the postoperative phase as a result of ROC-curve analysis and logistic regression analysis. It is thought that these results are caused by the fact that the developing paralysis is at low stages and heal within one month.

Keywords: *Parotid cancer, submandibular gland neoplasms, facial nerve injury, intraoperative neurophysiological monitoring*

ÖZ

Amaç: Yüz bölgesi cerrahisi sırasında fasiyal sinir ve dalları risk altındadır. Bu riskin en fazla olduğu cerrahi ise parotis ve submandibuler bez cerrahisidir. Sinir monitörizasyon parametrelerinde paralizi açısından sınır değerler saptanmaya çalışılmıştır. Saptanan bu değerler cerrahi sonu fasiyal sinir fonksiyonunu tahmin etmekte kullanılamamıştır. Bu çalışmanın amacı parotis ve submandibuler beze cerrahi uygulanan hastalarda sinir stimülatörü kullanımı ile cerrahisi sırasında saptanan parametrelerin postoperatif fasiyal sinir fonksiyon bozukluğu ile ilişkilisinin araştırılmasıdır.

Gereç ve Yöntemler: Çalışmaya parotis veya submandibular bezde kitle nedeniyle opere edilen ve preoperatif fasiyal fonksiyonları doğal olan 13 hastanın toplam 29 fasiyal sinir dalı incelenmiştir. Hastalar cerrahi sonrası paralizi gelişmeyen ve paralizi veya sekel gelişen olmak üzere iki grupta incelenmiştir. Hastanın cerrahi öncesi ve sonrası House-Brackmann Evrelemesi ile cerrahi sırasında saptanan potansiyel değişiklikleri arasındaki ilişki araştırılmıştır.

Bulgular: Uyarım yapılan 29 sinirden 8'inde paralizi saptanmış olup etkilenen dallar servikofasiyal dal ve marjinal mandibular daldı. Paralizi gelişen ve gelişmeyen hastalar arasında diseksiyon öncesi, diseksiyon sırasında ve sonunda saptanan ortalama eşik uyarılma değerleri ve cevapları arasında fark gözlenmedi.

Sonuç: Literatürden farklı olarak yapılan ROC-*curve* analizi ve lojistik regresyon analizi sonunda hiçbir elektrofizyolojik ölçüm sonucunun postoperatif evreyi öngöremediği saptandı. Gelişen paralizilerin düşük evrede olması ve bir ay içerisinde iyileşmesinin bu sonuçlara neden olduğu düşünüldü.

Anahtar Kelimeler: *Parotis tümörleri, submandibuler bez neoplazileri, fasiyal sinir yaralansı, intraoperatif nörofizyolojik monitörizasyon*

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Received / Geliş Tarihi: 12.12.2023 **Accepted** / Kabul Tarihi: 27.02.2024

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Doi: 10.24938/kutfd.1402951

INTRODUCTION

The facial nerve and its branches are at risk during facial surgery, the surgery with the highest risk is parotid and submandibular gland surgery. Although most parotid gland tumors are benign, the standard treatment of tumors of this gland is based on the principle of dissecting the facial nerve at the beginning of surgery. Temporary or permanent facial nerve paralysis develops in approximately 20% of patients who undergo parotid gland surgery (1). Factors that increase the risk of paralysis have been reported as deep lobe tumors, large tumors, prolonged surgery time, bleeding, revision surgery, and not using nerve monitoring (1,2). In case of paralysis development, the recovery period is on average 6 months. The incidence of paralysis decreases significantly with the use of intraoperative facial nerve monitoring (1). Submandibular gland tumors are mostly malignant, and the marginal mandibular branch of the facial nerve, which provides the functions of the lower lip, is at risk during surgery in this region.

During surgeries performed on the face, either due to trauma or mass, the facial nerve branch adjacent to the dissection area may be damaged. During these surgeries, detecting the facial nerve branches at the beginning of the surgery reduces the risk of damage and ensures safe surgery. Intraoperative nerve stimulation is a routinely used technique in facial surgery (3). Facial nerve monitoring allows the facial nerve to be located during surgery. With this technique, determining the normal values of the facial nerve potentials and interpreting the changes during surgery are warnings about nerve damage.

The aim of the study is to investigate the relationship between the stimulation thresholds and responses recorded before, during and at the end of surgery using nerve monitoring during surgery in patients who underwent superficial parotidectomy or submandibular gland excision, and the patient's post-surgical facial nerve function.

MATERIALS AND METHODS

In the prospective study, 29 facial nerve branches of 13 adult patients who underwent superficial parotidectomy or submandibular gland excision due to a mass in the parotid and submandibular glands at Kırıkkale University Faculty of Medicine Hospital and whose facial functions were normal before surgery were examined. The patients were examined in two groups: those who did not develop paralysis after surgery and those who developed paralysis or sequelae. House-Brackmann Staging, based on clinical examination, was used to evaluate the facial nerve functions of the patients before and after surgery. At the beginning of the operation, the relevant facial nerve branch was found in the patients and the nerve threshold stimulation potentials and responses detected before, during and at the end of the dissection were recorded using a nerve stimulator (NIM Response 3.0, US). The relationship between the patient's postoperative House-Brackmann staging and the potential changes and responses detected during surgery was investigated.

All patients gave informed written consent. The study was approved by the University of Kırıkkale Clinical Research Ethics Committee (date 09.2021, no:09/02) and supported by the University of Kırıkkale Scientific Research Project Committee (no: 2021/092).

Nerve Monitoring

Needle electrodes were used to record facial activity in the muscle areas innervated by the frontal, zygomatic, buccal and marginal mandibular nerves. Grounding and stimulator anode electrodes were placed on the sternum. A stimulation probe was incorporated into the sterile operator. All electrode cables were connected to a circuit box and necessary adjustments were made. During surgery, electrical stimulation was given to the facial nerve branches via a stimulation probe as soon as they were first detected before the dissection, in the middle of the dissection, and after the dissection was completed. The threshold stimulation value was determined by starting from 0.05 mA and increasing it by 0.05, and the response occurring during this stimulation was recorded in μV.

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 20.0 software was used for the data analysis. Data were given as mean ± standard deviation (SD), median (minimum-maximum) values, or numbers and percentages. The Independent Samples t-test was used to compare parametric data, and the Mann-Whitney U test to compare non-parametric data. Categorical data were analyzed with Fisher's Exact test. The paired samples t-test and Wilcoxon signed rank test were used to compare the patient's repeated measurement values. Correlations between patient data were analyzed with Spearman's rho correlation test. ROC-curve test and logistic regression test were performed to predict the risk of postoperative grade. A value of $p<0.05$ was considered statistically significant.

RESULTS

Superficial parotidectomy was performed in 8 patients and submandibular gland resection was performed in 5 patients. Of the 29 nerves stimulated, 8 were the main trunk, 8 were the temporofacial branch, 8 were the cervicofacial branch, and 5 were the marginal mandibular branch. The demographic characteristics of the patients according to the surgery performed, the average threshold stimulation values (mA) and responses (μV) determined before, during and at the end of the dissection are presented in Table 1. After surgery,

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paralysis was detected in 8 of 29 branches, and the affected branches were the cervicofacial branch and the marginal mandibular branch (3,5). Stage 2 paralysis was detected in 7 of these branches and stage 3 paralysis was detected in 1.

Table 1: Demographic data of the study population and mean or median electrical stimulus and response values according to the type of surgery

		PAROTID	SUBMANDIBULAR		
GROUP		**Mean±SD/ Median (min-max)/ N (%)**	**Mean±SD/ Median (min-max)/ N (%)**	**t/ Z/ X^2**	**p**
Age		60.40±6.58	45.75±12.44	2.404*	0.035
Sex	Female	4 (30.8)	2 (15.4)	3.745‡	0.053
	Male	1 (7.7)	6 (46.2)		
Removing side	Left	3 (60)	4 (50)		
	Right	2 (40)	4 (50)		
Pre-dissection mA		0.17 (0.05-0.50)	0.10 (0.05-0.25)	-1.266†	0.205
Intra-dissection mA		0.15 (0.05-0.40)	0.15 (0.05-0.30)	-0.246†	0.806
Post-dissection mA		0.15 (0.05-0.40)	0.25 (0.05-0.40)	-0.029†	0.977
Pre-dissection µV		223 (105-886)	118 (100-1721)	-1.126†	0.260
Intra-dissection µV		262 (105-1452)	140 (100-1257)	-1.650†	0.099
Post-dissection µV		286 (104-1480)	213 (100-812)	-0.577†	0.564
Postoperative Grade	1	2 (15.4)	8 (61.5)	5.482‡	0.035
	2	2 (15.4)	0 (0.0)		
	3	1 (7.7)	0 (0.0)		

(*) t value. Independent samples t test; (†) Z value. Mann Whitney U test; (‡) X^2 value. Fisher's exact test. p<0.05

Data including statistical comparison of electrical stimulation and response values of the branches before dissection, in the middle of dissection and after dissection are presented in Table 2. According to these results, a statistically significant difference was detected in the responses obtained from the cervicofacial branch before and during dissection (p=0.036), before and after dissection (p=0.036), and no difference was observed in the amount of electrical stimulation.

Demographic characteristics of the patients according to House-Brackmann staging, average threshold values and responses determined before, during and at the end of dissection are presented in Table 3. No difference was observed in the mean threshold stimulation values and responses determined before, during and at the end of dissection between patients who developed paralysis and those who did not. Comparison of average stimulation thresholds and responses according to branches and postoperative stage is given in Table 4. As a result of this analysis, no significant difference was detected in the stimulation thresholds and responses of any branch according to the postoperative stage.

As a result of the correlation analysis, no statistical correlation was found between the patients' postoperative stage and electrophysiological measurement results. Additionally, as a result of the ROC-curve analysis and logistic regression analysis, it was determined that no electrophysiological measurement results could predict the postoperative phase (Table 5).

DISCUSSION

Nerve monitoring was first developed to monitor cranial nerve functions and integrity during skull base surgery. Intraoperative facial nerve monitoring is a method recommended for routine application in skull base, face and head and neck surgery (4,5). Studies have found that the threshold potential detected after surgery in patients using intraoperative facial nerve monitoring during facial region surgery is associated with the paralysis that develops after surgery (6,7). The rate of paralysis in any branch of the facial nerve after parotid surgery is 45-52% after partial surgery and 79% after total parotidectomy (6,8).

The predictive effect of facial nerve monitoring parameters has been demonstrated in many neuro-otological studies (4,9,10). It has been stated that stimulation thresholds above 0.05 mA together with response levels lower than 240 µV can be used to predict paralysis lasting more than 1 year after vestibular schwannoma surgery (4). The threshold potential before dissection, which is measured during intraoperative monitoring of the facial nerve in parotid surgery and is considered normal, is 0.22 mA, and the threshold potential after dissection is 0.24 mA (6). In patients who developed early paralysis after surgery, the threshold potential was found to be higher (0.27 mA), and as a

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result of ROC analysis, it was stated that if 0.25 mA was taken as the limit value, it could be used as an indicator of early paralysis with 47% sensitivity and 82% specificity (6). It has been stated in the literature that electromyographic (EMG) potential changes detected by intraoperative continuous EMG monitoring of the facial nerve during surgery have no relationship with post-surgical facial nerve function (11,12).

Table 2: The comparison of electrical stimulus and response of the branches at the beginning, during and after the dissection

Group	Stimulated nerve branch	Variable	Median (min-max)	Z	p
PAROTİD GLAND	Main truncus	Predissection mA	0.20 (0.10-0.50)	-1.289	0.197
		During dissection mA	0.15 (0.05-0.40)		
		Predissection mA	0.20 (0.10-0.50)	-0.425	0.671
		Postdissection mA	0.15 (0.10-0.40)		
		During dissection mA	0.15 (0.05-0.40)	-1.633	0.102
		Postdissection mA	0.15 (0.10-0.40)		
		Predissection µV	337.5 (186-886)	-0.169	0.866
		During dissection µV	291 (156-597)		
		Predissection µV	337.5 (186-886)	-0.700	0.484
		Postdissection µV	303 (171-635)		
		During dissection µV	291 (156-597)	-1.183	0.237
		Postdissection µV	303 (171-635)		
	Cervicofacial branch	Predissection mA	0.20 (0.05-0.40)	-1.841	0.066
		During dissection mA	0.15 (0.20-0.40)		
		Predissection mA	0.20 (0.05-0.40)	-1.342	0.180
		Postdissection mA	0.15 (0.05-0.40)		
		Intraoperative mA	0.15 (0.20-0.40)	-1.633	0.102
		Postdissection mA	0.15 (0.05-0.40)		
		Predissection µV	200 (141-662)	-2.100	**0.036**
		Intraoperative µV	261 (105-1452)		
		Predissection µV	200 (141-662)	-2.100	**0.036**
		Postdissection µV	393 (104-1480)		
		During dissection µV	261 (105-1452)	-1.120	0.263
		Postdissection µV	393 (104-1480)		
	Temporofacial branch	Predissection mA	0.15 (0.15-0.40)	-0.535	0.593
		During dissection mA	0.15 (0.13-0.40)		
		Predissection mA	0.15 (0.15-0.40)	-0.849	0.396
		Postdissection mA	0.20 (0.13-0.40)		
		During dissection mA	0.15 (0.13-0.40)	-1.732	0.083
		Postdissection mA	0.20 (0.13-0.40)		
		Predissection µV	202.5 (105-414)	-1.540	0.123
		During dissection µV	234.5 (116-428)		
		Predissection µV	202.5 (105-414)	-0.560	0.575
		Postdissection µV	207 (116-645)		
		During dissection µV	234.5 (116-428)	-0.338	0.735
		Postdissection µV	207 (116-645)		
SUBMANDIBULAR GLAND	Marginal branch	Predissection mA	0.10 (0.05-0.25)	-1.342	0.180
		During dissection mA	0.15 (0.05-0.30)		
		Predissection mA	0.10 (0.05-0.25)	-1.342	0.180
		Postdissection mA	0.25 (0.05-0.40)		
		During dissection mA	0.15 (0.05-0.30)	-0.447	0.655
		Postdissection mA	0.25 (0.05-0.40)		
		Predissection µV	118 (100-1721)	-0.674	0.500
		During dissection µV	140 (100-1257)		
		Predissection µV	118 (100-1721)	-0.405	0.686
		Postdissection µV	213 (100-812)		
		During dissection µV	140 (100-1257)	0.000	1.000
		Postdissection µV	213 (100-812)		

Wilcoxon signed ranks test, p<0.05

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Table 3: Demographic data and mean stimulus and response according to grade

GROUP		GRADE 1 Mean ± SD/ Median (min-max)/ N (%)	GRADE >1 Mean ± SD/ Median (min-max)/ N (%)	t/ Z/ X^2	p
Age		48.50±12.47	61±8.89	-1.596*	0.139
Sex	Female	3 (23.1%)	3 (23.1%)	4.550‡	**0.033**
	Male	7 (53.8%)	0 (0.0%)		
Removing side	Left	5 (38.5%)	2 (15.4%)	0.446‡	0.800
	Right	5 (38.5%)	1 (7.7%)		
Pre-dissection mA		0.15 (0.05-0.50)	0.20 (0.05-0.40)	-0.025†	0.980
Intra-dissection mA		0.15 (0.10-0.40)	0.15 (0.05-0.40)	-0.026†	0.979
Post-dissection mA		0.15 (0.05-0.40)	0.25 (0.05-0.40)	-0.866†	0.386
Pre-dissection µV		250 (105-886)	200 (100-1721)	-0.757†	0.449
Intra-dissection µV		259 (100-1452)	253.50 (105-1257)	-0.458†	0.647
Post-dissection µV		245 (100-1480)	393 (104-812)	-0.610†	0.542

(*) t value. Independent samples t-test; (†) Z value. Mann Whitney U test; (‡) X^2 value. Fisher's exact test. p<0.05

Table 4: Comparison of mean or median electrical stimulus and response values according to the branches and grade

GROUP	Stimulated nerve branch			Pre-d mA – Intra-d mA	Pre-d mA – Post-d mA	Intra-d mA – Post-d mA	Pre-d mV – Intra-d mV	Pre-d mV – Post-d mV	Intra-d mV – Post-d mV
Parotid gland	Main truncus	**Grade 1**	Z	-1.289	-0.425	-1.633	-0.169	-0.700	-1.183
			p	0.197	0.671	0.102	0.866	0.484	0.237
		Grade >1		-	-	-	-	-	-
				-	-	-	-	-	-
	Cervicofacial branch	**Grade 1**	Z	-1.342	-1.000	-1.000	-1.604	-1.604	0.000
			p	0.180	0.317	0.317	0.109	0.109	1.000
		Grade >1	Z	-1.342	-1.000	-1.414	-1.214	-1.483	-1.214
			p	0.180	0.317	0.157	0.225	0.138	0.225
	Temporofacial branch	**Grade 1**	Z	-0.535	-0.849	-1.732	-1.540	-0.560	-0.338
			p	0.593	0.396	0.083	0.123	0.575	0.735
		Grade >1	Z	-	-	-	-	-	-
			p	-	-	-	-	-	-
Submand-ibular gland	Marginal branch	**Grade 1**	Z	-1.000	0.000	-1.000	-0.447	-0.447	-1.000
			p	0.317	1.000	0.317	0.655	0.655	0.317
		Grade >1	Z	-1.000	-1.342	-1.000	-1.069	-0.535	-0.535
			p	0.317	0.180	0.317	0.285	0.593	0.593

Pre-d: Pre-dissection, Intra-d: Intra-dissection, Post-d: Postdissection, Wilcoxon Signed Ranks test, p<0.05

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Table 5: ROC-curve analysis and logistic regression analysis

ROC-Curve for prediction of the postoperative grade				
Variable(s)	**AUC**	**p**	**95% Confidence Interval**	
			Lower	**Upper**
Pre-dissection mA	0.500	1.000	0.233	0.767
Pre-dissection mV	0.422	0.525	0.184	0.660
Intra-dissection mA	0.503	0.980	0.253	0.753
Intra-dissection mV	0.444	0.647	0.203	0.684
Post-dissection mA	0.594	0.446	0.337	0.850
Post-dissection mV	0.597	0.431	0.343	0.851

Logistic regression test for prediction of the postoperative grade						
Variable(s)	**B**	**Wald**	**p**	**Odds ratio**	**95% Confidence Interval**	
					Lower	**Upper**
Pre-dissection mA	-0.065	0.572	0.449	0.937	0.793	1.108
Pre-dissection mV	0.003	1.955	0.162	1.003	0.999	1.008
Intra-dissection mA	-0.012	0.017	0.896	0.988	0.820	1.190
Intra-dissection mV	-0.004	1.197	0.274	0.996	0.988	1.003
Post-dissection mA	0.118	1.635	0.201	1.125	0.939	1.349
Post-dissection mV	0.003	0.944	0.331	1.003	0.997	1.010

AUC: Area under the curve

In our study, stimulation thresholds and responses to the main trunk, cervicofacial branch, temporofacial branch and marginal mandibular nerve revealed during parotid and submandibular gland surgery before, during and after dissection were measured and their relationships with post-surgical facial functions were examined. Paralysis was detected in 27.6% of the 29 branches examined. This rate is low compared to the literature (6). 62.5% of these paralysis was observed in the cervicofacial branch, 37.5% in the marginal mandibular branch, 87.5% in stage 2, 12.5% in stage 3, and all of them recovered within one month. Consistent with the literature, the average stimulation threshold was found to be between 0.17-0.25 mA (6). The responses detected after these warnings varied between 118-342 μV. When the stimulation thresholds and responses were determined for each nerve branch before, during and after dissection were compared, no significant difference was detected in branches other than the cervicofacial branch. While no significant difference was detected in the stimulation thresholds of the cervicofacial branch, a significant increase was observed in the responses before and during dissection and before and after dissection. Unlike the literature, no difference was observed between the mean threshold stimulation values and responses determined before, during and at the end of dissection between patients who developed paralysis and those who did not, both when all data were evaluated and when individual branches were examined. As a result of the correlation analysis, no statistical correlation was found between the patients' postoperative stage and electrophysiological measurement results.

As a result of ROC-curve analysis and logistic regression analysis, unlike the literature, it was determined that no electrophysiological measurement result could predict the postoperative phase. It was thought that these results were caused by the fact that the developing paralysis was at a low stage and healed within one month.

Limitations of the study include the small number of patients and branches examined and the small number of branches that developed paralysis. In addition, as a result of superficial parotidectomy cases being included in the study and total parotidectomy patients not being included in the study due to the small number, short-term and low-grade paralysis was observed, and therefore it was thought that no predictive parameters were detected.

Conflict of interest: There is no conflict of interest between the authors.

Researchers' Contribution Rate Statement:

Concept/Design: EC, EG, BŞ, ZŞ, NBM, BB; Analysis/Interpretation: EC, EG, BŞ, ZŞ, NBM, BB; Data Collection: EC, EG, BŞ, ZŞ, NBM, BB; Writer: EC, EG, BŞ, ZŞ, NBM, BB; Critical Review: EC, EG, BŞ, ZŞ, NBM, BB; Approver: EC, EG, BŞ, ZŞ, NBM, BB.

Support and Acknowledgment: The research is supported by University of Kırıkkale Scientific Research Project Committee (no: 2021/092).

Ethics Committe Aproval: The study was approved by University of Kırıkkale Clinical Research Ethics Committee (date: 09.2021, no:09/02)

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Doi: 10.24938/kutfd.1402951

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