Percutaneous Threshold of Facial Nerve Stimulation Predicts Facial Canal Dehiscence

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ABSTRACT

Objective: Preoperative temporal bone high-resolution computed tomography (HRCT) is used to assess middle ear and mastoid anatomy. However, HRCT is an unreliable method of detecting facial canal dehiscence. We aimed to determine if preoperative transcutaneous facial nerve (FN) stimulation could predict middle ear facial canal dehiscence.

Study design: Retrospective review.

Setting: Tertiary referral academic hospital.

Patients: Adult patients who underwent otologic surgery at our institution from January 2015 through February 2017 were identified and their charts were reviewed. Selection criteria included presence of preoperative FN stimulation and HRCT.

Intervention: Using an FN stimulator placed on the skin over the stylomastoid foramen, the FN was stimulated at amperages ranging from 0.01—30 milliamperes (mA). Thresholds to waveform formation and amplitudes of the elicited compound muscle action potential (CMAP) were recorded at all electrodes.

Main outcome measures: Threshold to CMAP, average threshold to CMAP, threshold to maximum amplitude of CMAP, and maximum amplitude of CMAP.

Results: 70 patients met inclusion criteria. Of the 24 with intraoperatively confirmed dehiscences, 10 were identified by the attending surgeon on HRCT and 2 were identified on official radiology report. Mean lowest threshold to CMAP (5.1mA v. 9.1mA), and mean threshold to CMAP (8.2µV v. 11.8µV) of dehiscent versus non-dehiscent nerves were significantly different ($p<0.05$).

Conclusions: Iatrogenic facial nerve injury is one of the most devastating potential complications of otologic surgery. The use of facial nerve stimulation is a simple and cost-effective tool that can give the surgeon presurgical confirmation of facial nerve anatomy.

INTRODUCTION

- Iatrogenic injury to the facial nerve is a devastating complication of otologic surgery. Fallopian canal dehiscence increase the risk of facial nerve injury.
- Natural dehiscences of the facial nerve are common, and otologic disease requiring surgical intervention increases dehiscence rates and their extent.
- High resolution computed tomography (HRCT) scanning is used to preoperatively assess the facial nerve but has its limitations. Fuse et al. (1996) reported that HRCT imaging coincides with surgical findings in 75% of cases with 66% sensitivity and 84% specificity.
- In this retrospective review, we propose that preoperative facial nerve stimulation thresholds may predict dehiscence of the facial nerve canal.

METHODS

- Retrospective review of otologic procedures at our institution performed from January 2015 to Feburary 2017.
- Intraoperatively, neurophysiologists placed percutaneous electrodes: four on the operated side and one in the orbicularis oris on the contralateral side as a control (Figure 1).
- A monopolar Prass probe was used to stimulate the facial nerve transcutaneously at the stylomastoid foramen with stimulus parameters as follows: cathodal, constant current, 200 µsec pulse, 3.1 Hz, intensity 0.1—30 mA.
- The following parameters were measured preoperatively:
  1) Threshold to compound muscle action potential (CMAP), which was defined as the lowest intensity (mA) at which a response was recorded from that muscle.
  2) Average threshold to CMAP in all muscles tested (mA).
  3) Threshold to Maximum Amplitude of CMAP (mA).
  4) Maximum Amplitude of the CMAP (µV).

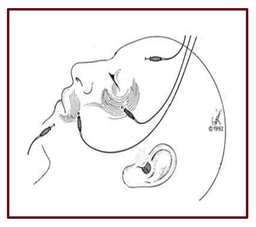


Figure 1. Electrodes placed in frontalis, orbicularis oculi, orbicularis oris and the mentalis on the operated side. Contralateral electrode not shown.

RESULTS

Demographics	
70 patients included	
Mean age (range)	49.1 (20 – 71)
Female	33 (47.1%)
Male	37 (52.8%)
Right Sided Surgery	28 (40%)
Left Sided Surgery	42 (60%)
BMI (avg D v. ND)	29.2 v. 27.5 (P=0.2)
HRCT skin thickness (mm) (avg D v. ND)	7.5 v. 6.6 (P=0.09)

Pathologies	
Cholesteatoma	25
Chronic otitis media	20
Conductive hearing loss	9
Sensorineural hearing loss	6
Chronic tympanic membrane perforation	4
Otosclerosis	3
Canal cholesteatoma	2
Other*	2

*Other procedures include subtotal petrousectomy and labrinthectomy.

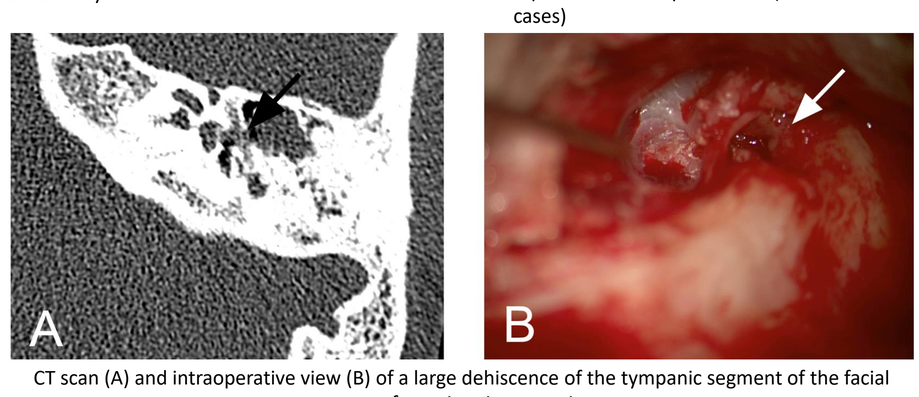
Procedures	
Tympanomastoidectomy	41
Ossiculoplasty	13
Myringotomy	12
Tympanoplasty	9
Canalplasty	6
Stapedotomy	3
Cochlear implant	4
Other*	2

*Other diagnoses include Meniere's disease and osteoradionecrosis. Revision procedures comprised 30% (21 cases)

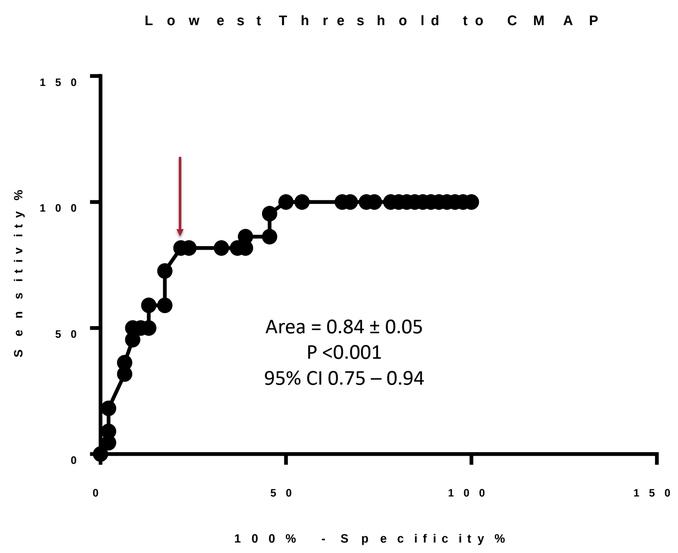
Dehiscence Visualized intraoperatively in 24 patients* (34.3%).

	Successful Identification of Dehiscence	Sensitivity	Specificity	PPV	NPV
Radiology Report	2/24**(8.3%)	12.5%	84.7%	30%	65%
Surgeon CT read	10/24*** (41.6%)	45.4%	73.9%	45.5%	70.8%

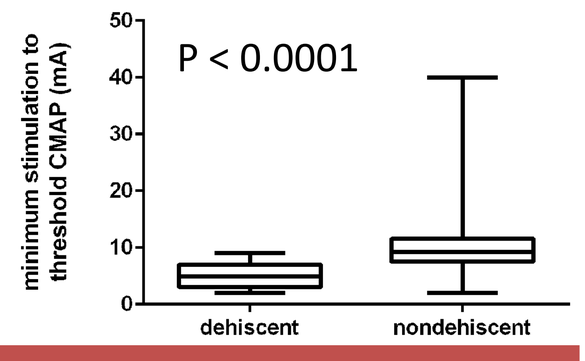
*Two patients with facial nerve canal dehiscences that had prior surgery had foreign materials over the dehiscent region (one with thick Silastic and one with thick cartilage). All statistical data presented in this results section has excluded these patients.
**An additional 3 scans were noted to have questionable dehiscence. Number of successful identifications increases to 3/24 (12.5%) if questionable scans were counted as dehisced scans.
***An additional 2 patient scans were noted to have possible dehiscence. Neither patient had dehiscence present intraoperatively.



CT scan (A) and intraoperative view (B) of a large dehiscence of the tympanic segment of the facial nerve of a patient in our series.

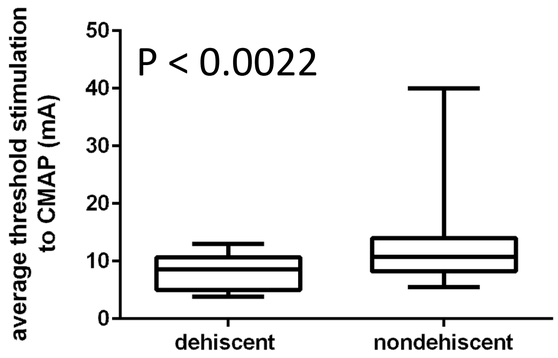


AUROC showing that lowest threshold to CMAP is a very accurate way to predict facial canal dehiscence. Red arrow pointing to the deflection point of the curve. This corresponds with an accurate cut off of <7.2mA (sensitivity 81.2%, specificity 78.26%).



For dehiscent nerves , only 4 values were greater than 7mA. For nondehiscent nerves, only 4 values were less than 5 mA. If the cutoff for likely or possible dehiscence is set at 7 mA, then the specificity is 81.8%, the specificity is 78.3%, the positive predictive value is 64.3% and the negative predictive value is 90%.

Lowest Threshold to CMAP (mA)*		
	Dehiscence	No Dehiscence
Mean	5.1 ± 2.4	9.1 ± 5.5
Median (range)	4.85 (2-9)	9.25 (2-40)



For dehiscent nerves , 4 values were greater than 7.5. For nondehiscent nerves, 4 values less were than 5 mA. If the cutoff for likely or possible dehiscence is set at 7.5 mA, then the specificity is 81.8%, the specificity is 67.4%, the positive predictive value is 54.5% and the negative predictive value is 88.5%.

Average Threshold to CMAP (mA)*		
	No Dehiscence	Dehiscence
Mean	8.2 ± 3.0	11.8 ± 5.5
Median (range)	8.55 (3.9-13)	10.75 (5.5-40)

DISCUSSION

- To improve our ability to predict fallopian canal dehiscences preoperatively, we have developed a novel method utilizing percutaneous stimulation of the facial nerve at the stylomastoid foramen
- Lowest and average threshold to CMAP were significantly different between the dehisced and non dehisced groups.
- Using a preoperative percutaneous facial nerve stimulation threshold of around 7mA will accurately predict facial nerve canal dehiscence.
- Preoperative percutaneous facial nerve stimulation is a simple and cost effective method to accurately predict facial nerve canal dehiscence.