Intraoperative Monitoring of Facial Nerve Motor-Evoked Potentials in Children

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■ OBJECTIVE: **To determine whether transcranial motor-evoked potential monitoring of the facial nerve (FNMEP) during eloquent tumor resection is feasible in children and can predict both immediate and postoperative facial nerve (FN) function.**

■ METHODS: **We included 24 consecutive procedures involving 21 patients (median age 5.5 years, range 5 months to 15 years, 8 female) who were operated on with FNMEP monitoring by the first author in 2013 and 2014. During surgery, we maintained a constant response amplitude by increasing the stimulation intensity and aimed to establish a warning criterion based on the "threshold-level" method. A threshold increase of greater than 20 mA for eliciting the FNMEP in the most reliable facial nerve target muscle was considered to be a prediction of reduced postoperative facial nerve function and consequently, a warning was given to the surgeon. The preoperative and early postoperative function was documented with the House-Brackmann grading system.**

■ RESULTS: **Monitoring of the FNMEP was feasible in all the surgeries in at least one facial nerve target muscle. The orbicularis oris muscle yielded the best result (95% of the trials), followed by the mentalis (87%) and orbicularis oculi muscles (86%). The median stimulation threshold was initially 65 mA (range 40–110 mA) for the FNMEP and 60 mA (15–220 mA) for the motor-evoked potential of the thenar muscles. The FNMEP deterioration showed a sensitivity of 100% for House-Brackmann deterioration and specificity of 74%.**

■ CONCLUSIONS: **Intraoperative FNMEP monitoring is feasible and safe in infants and children. We found no evidence that the procedures and thresholds should differ from FNMEP monitoring in adults. FNMEP monitoring provides valid evidence for FN function in pediatric eloquent area surgery; its use is complementary to direct electrical FN stimulation and continuous EMG monitoring of FN target muscles.**

INTRODUCTION

Surgery near pyramidal or corticobulbar tracts or the motor cranial nerve, particularly in the cerebellopontine angle, carries a risk of impaired motor function, also through damage to the facial nerve (FN). Among the technical measures to preserve FN function, intraoperative neurophysiological monitoring (IONM) has become mandatory and its use is increasing (3). During surgery, IONM serves to communicate impending nerve damage to the surgeon and to predict the postoperative neurologic state. As a standard method of IONM, direct electrical stimulation (DES) of

Key words
- Infants
- Facial nerve
- House-Brackmann grade
- Motor-evoked potentials
- Pediatrics
- Threshold-level

Abbreviations and Acronyms
CI: Confidence interval
CPA: Cerebellopontine angle
DES: Direct electrical stimulation
EMG: Electromyography
FN: Facial nerve
Fneg: False negative
FNMEP: Facial nerve motor-evoked potential
FP: False positive
FPR: False-positive rate
HB: House-Brackmann
IONM: Intraoperative neurophysiologic monitoring
MEP: Motor-evoked potential
TES: Transcranial electric stimulation
TN: True negative
TP: True positive
WHO: World Health Organization

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the FN serves to elicit compound muscle potentials recorded from FN target muscles. DES is used to identify the FN in the surgical field and to map its course as well as to intermittently test the FN function. As another standard method, continuous electromyography (EMG) of FN target muscles provides continuous feedback on FN activity.

More recently, the facial nerve motor-evoked potential (FNMEP) has been introduced (4, 8). The FNMEP activates the motor pathway proximate to the surgical field by transcranial electric stimulation (TES) of the motor cortex and records the responses in the FN target muscles. With this technique, the supranuclear tract and FN function can be monitored continuously. Despite this advantage, FNMEP has not become a standard tool of IONM, possibly because of artifacts in the signals and uncertainties in the interpretation of the results. Particular care is necessary to avoid confounding the muscle response to stimulation through the corticobulbar tract with muscle response to peripheral stimulation. This confounding is illustrated in **Figure 1**.

In adult patients, most authors use a decrease in the FNMEP response amplitude as a warning criterion (1-4, 10, 13); however, FNMEP responses have inherent variability and are difficult to quantify. In addition, high FNMEP stimulation intensity is needed to achieve the maximal FNMEP response at baseline so that subsequent response deterioration can be assessed. In an earlier publication (14), we monitored the increase in the stimulation threshold needed to elicit the FNMEP to communicate with the surgeon and to predict postoperative function of the facial nerve.

In children, the motor system is not fully matured. For the corticospinal tract, the predictive power of MEP has been documented (6); however, D-waves might be absent in very young children (15). Given these findings, we aimed to investigate the feasibility and safety of FNMEP monitoring during neurosurgical interventions in children and infants and whether FNMEP would similarly predict FN function in a pediatric population.

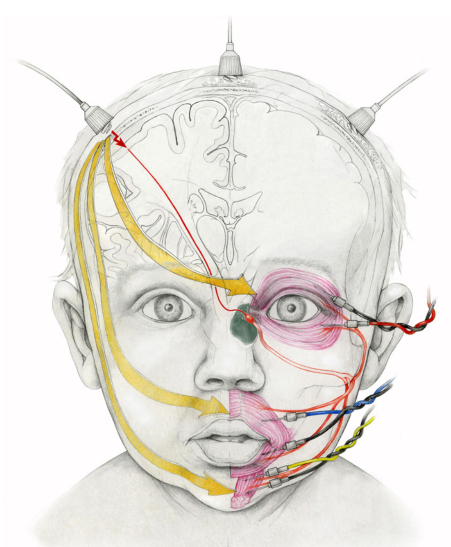

Figure 1. Activation of the corticobulbar tract versus peripheral stimulation of facial nerve (FN) target muscles. During activation of the corticobulbar tract, anodal stimulation of the motor cortex (*red arrow*) elicits activation of the lower motor neurons in the FN nucleus of the brainstem where FN target muscles are activated. Additionally, as a confounder, peripheral stimulation (*yellow arrows*) might activate FN target muscles, although at shorter latencies and in response to single stimulation pulses.

PATIENTS AND METHODS

Patient Selection

We included all consecutive pediatric patients in 2013 and 2014 who were operated on by the first author (O.B.) for eloquent lesions requiring facial nerve monitoring in which the last author (J.S.) performed the IONM. The collection of personal patient data was prospective. The scientific workup was approved upfront by the institutional ethics review board (Kantonale Ethikkommission KEK-ZH 2012-0212). The selection criterion resulted in a series of 24 surgical procedures in 21 patients (median age 5.5 years, range 5 months to 15 years, 8 female). The patient characteristics are listed in **Table 1**.

Pathology and Treatment

Table 1 lists the patients' pathology. Fourteen patients were operated on for astrocytoma, 6 for ependymoma, and 4 for other pathologies (glioblastoma, medulloblastoma, aneurysmatic bone cyst, glioneuronal tumor). The lesions are depicted in **Figure 2A** together with postoperative images (**Figure 2B**) to estimate the extent of resection.

Neurologic Assessment

The House-Brackmann (HB) Grading System (range 1–6; grade 1: normal facial muscle function, grade 6: total palsy) was used to determine the facial nerve function (House and Brackmann, 1985). The preoperative scores and postoperative scores at the first postoperative day were obtained by a pediatric neuro-oncologist (M.A.G).

Anesthesia Management

Following our standard protocol for neurosurgical interventions, anesthesia was induced with intravenous application of Propofol (1.5-2 mg/kg) and Fentanyl (2-3 μg/kg). The intratracheal intubation was facilitated by Atracurium (0.5 mg/kg). Anesthesia was maintained with Propofol (5-10 mg/kg/h) and Remifentanil (0.1-2 μg/kg/min).

Neurophysiologic Monitoring Technique

IONM with continuous EMG of the FN target muscles was recorded using the ISIS system (inomed Medizintechnik GmbH, Emmendingen, Germany; www.inomed.com). DES for the precise localization of the FN in the surgical field was initiated with 0.2 mA at a large distance from the FN and was reduced to a minimal current of 0.05 mA as long as the FN was well identified. TES for the FNMEP was performed using a constant current stimulator with a maximal stimulator output 220 mA. The upper-limb motor-evoked potential (MEP) and FNMEP responses were amplified and filtered (100–3000 Hz) before display.