Trigeminofacial reflex: a means of detecting proximity to ophthalmic and maxillary divisions of the trigeminal nerve during surgery

Clinical article

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Object. The aim in this paper was to localize and detect incipient damage to the ophthalmic and maxillary branches of the trigeminal nerve during tumor surgery.

Methods. This was an observational study of patients with skull base, retroorbital, or cavernous sinus tumors warranting dissection toward the cavernous sinus at a university hospital. Stimuli were applied as normal during approach to the cavernous sinus to localize cranial nerves (CNs) III, IV, and VI. Recordings were also obtained from the facial muscles to localize CN VII. The trigeminofacial reflex was sought simply by observing a longer time base routinely.

Results. Clear facial electromyography responses were reproduced when stimuli were applied to the region of V1, V2, and V3. Response latency was increased compared with direct CN VII stimuli seen in some cases. Responses gave early warning of approach to these sensory trigeminal branches.

Conclusions. The authors submit this as a new technique, which may improve the chances of preserving trigeminal sensory branches during surgery in this region. (http://thejns.org/doi/abs/10.3171/2014.7.JNS13612)

Key Words • trigeminofacial reflex • skull base • monitoring • peripheral nerve

The necessity of cranial nerve (CN) monitoring in skull base surgery cannot be overstated. It is an essential aid in establishing the ultimate goal of maximal tumor excision with minimal nerve damage and provides immediate feedback of nerves at risk for injury. Early reports relate to monitoring of the facial nerve (CN VII) in vestibular schwannoma surgery, where electrical or mechanical stimulation of this nerve was performed and a facial muscle response was detected visually. Electromyography (EMG) response detection was later introduced as a more accurate method of monitoring and is still used to this day.

Furthermore, intraoperative nerve monitoring has expanded to include that of other CNs (the oculomotor [CN III], trochlear [CN IV], and abducens [CN VI] nerves). Being performed in patients under general anesthesia and in distorted anatomy, monitoring is largely limited to motor nerves, the stimulation of which yields an immediate perceivable response: a muscle twitch or an EMG spike. This is in contrast to the recording of cortical sensory evoked potential, which, although possible, is technically challenging and does not give immediate intraoperative feedback due to the need to average a response to several stimuli.

Both the ophthalmic (V1) and maxillary (V2) divisions of the trigeminal nerve (CN V) form part of the wall of the cavernous sinus and lie close either to skull base tumors or to the field of approach to them. Identification of these divisions is mainly achieved by visualization in relation to anatomical landmarks. However, anatomy is distorted in the setting of a tumor and therefore alternative modalities of localization and/or monitoring are necessary, but unfortunately these modalities are still lacking.

We address this gap by reporting our observation in some patients who underwent skull base surgery of the elicitation of facial muscle EMG responses to stimulation of the trigeminal nerve. This represents a well-described reflex, the trigeminofacial reflex, and we believe that routine intraoperative monitoring using the trigeminofacial reflex is useful in identifying divisions of the trigeminal nerve (especially sensory divisions), reducing the risk of injury to them. To our knowledge, this is the first descrip-
tion of the intraoperative use of this technique to localize the V1 and V2 branches of CN V in patients under general anesthesia who are undergoing skull base surgery.

**Methods**

The report was formulated from observations of intraoperative monitoring findings, and as such no ethics approval was required. A retrospective search was conducted through a university hospital database for patients who underwent cranial surgery requiring neurophysiological monitoring, and especially those with dissection around the cavernous sinus, between 2009 and 2012. Intracranial access was gained through a cranio-orbitozygomatic extradural approach exposing the foramen rotundum and/or foramen ovale. Free-run and triggered EMG monitoring was performed via subdermal needles inserted into facial muscles (the frontalis, nasalis, mentalis, and buccinator muscles) to localize CN VII, and the reflex was noted with observation of a longer time base routinely. We report on the patients who had EMG evidence of long-latency response in CN VII to stimulation of V1, V2, or the mandibular branch (V3). The results are then presented in context of the known literature.

**Results**

One to two patients undergo skull base surgery via the aforementioned approach every month at the researched unit. Eight patients were identified in whom the trigeminofacial reflex was demonstrated. Of these patients, 4 underwent brainstem tumor surgery and the remaining 4 underwent retroorbital/pericavernous tumor excision. Reflexes elicited are detailed in Table 1. Of note is that stimulation of the maxillary branch resulted in stimulation of the nasalis muscle, whereas stimulation of the opthalmic branch resulted in a response in the frontalis muscle, and that of the mandibular branch resulted in a response in the mentalis muscle. The latency between stimulation and response ranged from 12 to 32.5 msec. Figures 1 and 2 show representative EMG tracings.

Interestingly, stimulation of brainstem nuclei at the cervicomedullary level in Case 3 was associated with an

**Discussion**

Our results show that a clear EMG response was elicited in facial muscles in response to stimulation to an intracranial nerve while dissecting toward and around the cavernous sinus. These nerves were distinct from CNs III, IV, and VI, which provoked responses in ocular muscles and rather resulted in activation of facial muscles. Given the location of the stimulated nerves and the known anatomy, these nerves were believed to be divisions of the trigeminal nerve. The prolonged latency of approximately 12–33 msec noted between stimulus and EMG response is perhaps unsurprising given the range of trigeminofacial reflexes known—classically the R1 and R2 of the blink reflex.1,7

It was clear in our subjects that these long latency responses were not the result of direct facial stimulation;

**TABLE 1: Summary of cases in which the potential trigeminofacial reflex was observed**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Muscle Response Documented</th>
<th>Latency of the Response (nearest msec)</th>
<th>Additional Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>frontalis</td>
<td>33</td>
<td>vestibular schwannoma</td>
</tr>
<tr>
<td>2</td>
<td>mentalis</td>
<td>16</td>
<td>petrous apex meningioma</td>
</tr>
<tr>
<td>3</td>
<td>platysma</td>
<td>18</td>
<td>cervicomedullary junction tumor</td>
</tr>
<tr>
<td>4</td>
<td>nasalis</td>
<td>24</td>
<td>cavernous sinus/retrororbital decompression</td>
</tr>
<tr>
<td>5*</td>
<td>nasalis &amp; mentalis</td>
<td>—†</td>
<td>retroorbital tumor</td>
</tr>
<tr>
<td>6</td>
<td>nasalis</td>
<td>—†</td>
<td>cavernous sinus meningioma</td>
</tr>
<tr>
<td>7</td>
<td>nasalis &amp; mentalis</td>
<td>12</td>
<td>petroclival meningioma</td>
</tr>
<tr>
<td>8</td>
<td>nasalis</td>
<td>22</td>
<td>cavernous sinus retrororbital meningioma</td>
</tr>
</tbody>
</table>

* First case.
† Unfortunately, although the intraoperative neurophysiological report comments on activation in the nasalis muscle after stimulation of CN V, the EMG graph is unavailable.
Trigeminofacial reflex in skull base surgery

the links between facial and trigeminal are well known. The basis of these brainstem reflexes has been discussed in detail by Cruccu et al.\(^3\)

Of note is the observation in Case 3 of a reflex-type response recorded from electrodes inserted into the cricothyroid muscle through the platysma muscle. This was noted at the time of stimulation at the cervicomedullary junction. Given the above discussion, the latency and the known anatomy of the trigeminal nucleus, which extends into the high cervical spinal cord,\(^12\) it is not unreasonable to attribute this observation also to a trigeminofacial reflex, resulting in stimulation of the platysma muscle. However, a number of alternate explanations exist, including a delayed direct response in cricoarytenoid muscles to potential stimulation of the vagal nucleus.

The earliest description of the trigeminofacial reflex is thought to be that by Overend who, in 1896, reported a blinking response to gentle tapping of the forehead.\(^13\) Later, the pathway adopted by this response along with other trigeminal-facial communications were described.\(^2\) Physiologically, the reflex is thought to play a role in modulating syllabic speech.\(^5\) However, it was Sindou et al.\(^17,18\) who first referred to the communication as the trigeminofacial reflex and implemented it in surgical localization, where they proposed an application for the phenomenon in thermorhizotomy for trigeminal neuralgia. Not only did they find that different facial muscle groups respond to stimulation of different divisions, but they also observed that these responses were reproducible.\(^18\)

We reported our observation of what we believe to be trigeminofacial reflexes in attempting to localize CNs III, IV, and VI. These findings, to our knowledge, have not been previously described in skull base surgery. It is our opinion that this reflex can be used to efficiently and effectively localize and monitor the sensory branches of CN V. We therefore propose the implementation of monitoring these reflexes as a novel technique in the localization and monitoring of V1, V2, and V3 in skull base surgery in patients under general anesthesia. The application of this technique would constitute a significant step forward in the safety and efficacy of skull base surgery.

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**Fig. 2.** Case 1. Electromyography tracings. **Left:** Direct response in the frontalis muscle to facial nerve stimulation at 8 msec. **Right:** Delayed response in the frontalis muscle at approximately 33 msec after trigeminal stimulation.

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**Fig. 3.** Case 3. Electromyography tracing showing a direct response in the cricothyroid muscle (or perhaps even the overlying platysma) at the time of cervicomedullary junction stimulation (line 1) followed by a delayed response at around 18 msec.
This technique is in contradistinction to that of monitoring cortical somatosensory evoked potentials described earlier. The latter relies on a stimulation probe being applied to the nerve for several stimuli to average a response at the cortex—rather slow for intraoperative use—or probe stimulation used to record sensory responses from paired needles placed adjacent to supra-and infraorbital notches and the mandibular branch of the trigeminal nerve. We tried this latter technique in parallel with monitoring the normal EMG responses in 1 case and found it to be less sensitive, since the trigeminofacial reflex in contradistinction is seen directly as the nerve is stimulated from an exploring stimulating probe.

This observational study nonetheless has limitations. We report our observations during routine monitoring of patients, and further validation of this technique is required to prove its reproducibility and accuracy. Also, at times it is believed that false positives were seen with dural stimulation, although the reflex was elicited after accessing the dura mater in most cases. Moreover, the technique is dependent on the presence of an intact reflex arc and is unlikely to be beneficial when damage to this or relevant pathways is suspected as documented in the study by Cruccu et al.3

Conclusions

We observed direct EMG responses to intraoperative stimulation of sensory branches of the trigeminal nerve. These have been previously described as trigeminofacial reflexes and were shown to be division-specific and reproducible. We therefore propose the routine observation of this reflex as a novel technique in intraoperative monitoring during skull base surgery.

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Disclosure

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Author contributions to the study and manuscript preparation include the following. Conception and design: Forster, Kamel. Acquisition of data: AlMasri, Brown, Forster. Analysis and interpretation of data: AlMasri, Forster. Drafting the article: AlMasri, Brown. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: AlMasri. Study supervision: Forster, Kamel.

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