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Evaluation of lip sensory disturbance using somatosensory evoked magnetic fields

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HIGHLIGHTS

- We evaluated unilateral sensory disturbance of the lip by the unilateral lip-stimulated somatosensory evoked fields.
- Stimulation of the lip on either sideinduced response at 25 ms in all healthy volunteers, which was not detected by affected-side stimulation in patients.
- Response at 25 ms can be an objective and effective parameter to indicate lip sensory abnormality.

ABSTRACT

Objective: To evaluate lip sensory dysfunction in patients with inferior alveolar nerve injury by lip-stimulated somatosensory evoked fields (SEFs).
Methods: SEFs were recorded following electrical lip stimulation in 6 patients with unilateral lip sensory disturbance and 10 healthy volunteers. Lip stimulation was applied non-invasively to each side of the lip with the same intensity using pin electrodes.
Results: All healthy volunteers showed the earliest response clearly and consistently at around 25 ms (P25m) and at least one of the following components, P45m, P60m, or P80m, over the contralateral hemisphere. The ranges of the peak latencies were 23–33, 42–50, 56–67, and 72–98 ms for right-side stimulation and 23–34, 46–49, 52–68, and 71–90 ms for left-side stimulation. Affected-side stimulation did not evoke P25m component in any patients, but invoked traceable responses in 5 patients whose latencies were 57, 89, 65, 53, and 54 ms. Unaffected-side stimulation induced P25m in 2 patients at 27 and 25 ms, but not in the other 4 patients.
Conclusion: The P25m component of lip SEFs can be an effective parameter to indicate lip sensory abnormality.
Significance: Lip sensory dysfunction can be objectively evaluated using magnetoencephalography.

1. Introduction

Iatrogenic inferior alveolar nerve (IAN) injury causes complication of the patients due to its resultant sensory impairment of the lower lip, chin, and lower teeth (Kobayashi et al., 2006; Lee et al., 2011). For example, previous reports have documented that the incident rate of IAN injury by third molar extraction varied from 2% to 17% (Renton et al., 2005; Hatano et al., 2009; Leung and Cheung, 2009; Cilasun et al., 2011; Long et al., 2012). However, precise evaluation and management of lip sensory abnormality is difficult because there is no quantitative testing battery. Commonly-used sensibility tests, e.g., two-point discrimination (TPD), have low reproducibility and reliability because they depend on the patient's subjective reporting of sensory information. Thus, a means of quantitative objective measurement is needed.

Our previous studies demonstrated that the evoked cortical response for tongue stimulation measured by magnetoencephalography (MEG) can serve as an objective method to detect sensory disturbance of the tongue caused by unilateral lingual nerve damage

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(Maezawa et al., 2008, 2011). In those studies, we calculated the laterality of the somatosensory evoked magnetic fields (SEFs) for affected-side and unaffected-side (control-side) stimulation of the tongue to estimate the asymmetry of the cortical activation between stimulus sides. However, this method has limited application for patients with bilateral deficits because it requires a control-side and cannot be applied to disturbances caused by surgeries such as sagittal split ramus osteotomy (SSRO), which carry major risks of IAN damage (Westermark et al., 1998; Panula et al., 2001). To evaluate sensory abnormality of the lip using MEG, we need an objective indicator of lip SEFs that does not require a control-side.

The aim of the study was to investigate the unilateral lip SEFs in patients with unilateral IAN injury, which can be used for evaluating the lip sensory dysfunction.

2. Materials and methods

2.1. Subjects

We recruited 6 right-handed patients with sensory disturbance of the lower lip after minor oral surgery underwent at privately owned dental clinic (4 men and 2 women aged 32–56 years; mean 47.6 years) (Table 1). All of the patients met 3 requirements: (1) The sensory defect was caused by unilateral IAN injury; (2) Rating of the subjective sensation of the affected area was lower than half of that of the unaffected area; (3) TPD of the affected area exceeded 5 mm. For comparison, 10 right-handed volunteers (6 men and 4 women aged 24–62 years; mean 39.1 years) without a history of neurological illness were recruited. There was no significant difference in age between the healthy volunteers group and the patients group by Mann–Whitney U-test ($p = 0.147$). Written informed consent was obtained from all participants, which followed the study protocol approved by the Ethics Committee, Kyoto University Graduate School of Medicine.

Table 1
Profiles of the patients with unilateral lip sensory disturbance.

Pt	Sex	Age (year)	Affected side	Period (month)	Oral surgery
1	M	45	R	6	Mandibular cyst removal
2	F	32	L	1.5	Impacted tooth extraction
3	M	46	L	36	Mandibular cyst removal
4	M	51	R	2	Mandibular cyst removal
5	M	56	L	2	Mandibular cyst removal
6	F	56	R	2	Implant operation

Pt, patient number; M, male; F, female; L, left; R, right.

2.2. Sensibility tests of the lip in patients

TPD and tactile sensation of the affected- and unaffected-sides were evaluated in a quiet room by the same observer (HM) similarly to our previous study (Maezawa et al., 2011). Subjects were requested to close their eyes, and sensibility tests were started.

TPD was evaluated by 5 grades: ⩽5 mm and >5, 10, 15, and 20 mm using the Disk-Criminator (Kono Seisakusyo, Chiba, Japan) with 4 stepwise spaces between 5 and 20 mm. Subjects were instructed to indicate with their fingers whether they felt one or two-points during the application of the Disk-Criminator.

Tactile sensation was also classified into 5 grades from S1 to S5, indicating most severe to mildest impairment, using a perception tester (Kono Seisakusyo, Chiba, Japan). The perception tester is composed of four discrete monofilaments having different diameters to produce 4 steps of stimulus magnitude. The monofilament was applied to the same point as electrical stimulation (2 cm lateral to the midline of the lower lip crust) with sufficient force until it bended, and held for 2 s. Subjects were required to gesture "yes" each time when they sense the application of the monofilaments. The force expressed by S1, S2, S3, and S4 corresponded to 2.83, 3.61, 4.31, and 6.65 using filament marking number by Semmes–Weinstein monofilaments, respectively (Semmes et al., 1960; Weinstein, 1962).

2.3. Lip stimulation

The right- and left-sides of the lower lip (2 cm lateral to the midline) were stimulated separately using an electrical stimulator (SEN7203, Nihon Kohden, Tokyo, Japan) through a pair of pin electrodes non-invasively as described previously (Maezawa et al., 2008, 2011). Biphasic current square pulses (0.5 ms for 1 phase) were used to reduce stimulus artifact effectively. Inter-stimulus interval was 1.00 s. A stimulus intensity at 3 times the sensory threshold for the unaffected area was used for both sides in the patients. The intensity for the healthy volunteers was thrice the sensory threshold for each side. In total, 600 responses were averaged in each session. The unaffected-side was stimulated first in the patients. The order of stimulus side was counterbalanced for the healthy volunteers.

2.4. MEG recordings

SEFs were recorded with a whole-head neuromagnetometer (Vectorview; Elekta Neuromag, Helsinki, Finland). This device had 102 trios that are composed of a magnetometer and a pair of

Table 2
Sensory function of the lip detected by sensibility tests and electrophysiological findings.

Pt	Sensibility tests		Sensory threshold (mA)		Intensity[a] (mA)		mABS (fT/cm)		P25 m	
	TPD (mm)	TS	U	A			U	A	U	A
1	15	S2	0.25	2.5	0.75		19.5	4.6	○	×
2	20	S2	0.07	2.8	0.21		10.1	2.3	○	×
3	20	S3	0.09	0.55	0.27		16.1	3.6	×	×
4	20	S2	0.20	0.75	0.60		11.3	2.6	×	×
5	15	S3	0.15	0.85	0.45		17.1	3.2	×	×
6	20	S3	0.20	1.7	0.60		16.3	2.9	×	×
		Mean	0.155	1.53	0.465					
Healthy volunteers			R	L	R	L	R	L		
		Mean	0.125	0.114	0.375	0.342	13.80	14.72		

[a] Thrice the sensory threshold of the unaffected-side in the patients. Pt, Patient number; TPD, Two-point discrimination; TS, Tactile sensation; U, Unaffected side; A, Affected side; R, Right; L, Left; Intensity, Stimulus intensity; ○, Detected; ×, Non-detected.