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Original Article

Utilization of Averaging Process of Blink Reflex to Improve Diagnosis of Facial Nerve Palsy

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The conventional blink reflex has limited clinical application since it displays a wide range of change in the responses. Thus, we studied the blink reflex using the averaging process which is engaged in evoked potential studies in order to measure various responses such as latency, amplitude, and duration, which have been difficult to measure due to their wide ranges of changes. Among the Bell's palsy patient group, 13 patients who had the symptoms of incomplete palsy were examined to assess the results of the blink reflex through the averaging process. The subjects were 54 people in a normal group (108 eyes) and 18 patients (36 eyes) with Bell's palsy. For the study method, the conventional blink reflex and the blink reflex using the averaging process were measured for the people in the normal group, while in the Bell's palsy group, only the blink reflex using the averaging process was analyzed. In the case of the normal group, the blink reflex using the averaging process could measure all of the latency, amplitude, and duration. It was also observed that the latency, amplitude, and duration of R1, ipsilateral R2, and contralateral R2 significantly differed on the affected side of the Bell's palsy patients, compared to the unaffected side. The blink reflex using the averaging process should be more effective than the conventional method since the former can evaluate the latency, amplitude, and duration for Bell's palsy, while the latter can only assess latency.

Key Words: Blink reflex, Averaging process, Bell's palsy

INTRODUCTION

The blink reflex has been used in neurology departments as a type of clinical test since it can determine the pathological condition of the brainstem; it develops in the first or second glabella of the trigeminal nerve and facial nerve. The reflex was described by Overend in 1896 for the first time. In 1945, Wartenberg discovered that the blink reflex is also caused by other factors, and renamed it as the orbicularis oculi reflex (Kimura et al., 1969a; Kimura et al., 1969b; Shahani and Young, 1972); since Kimura developed methods of testing the reflex, it has been applied clinically in many different ways (Kimura and Lyon, 1972; Kim et al., 1996).

The blink reflex is displayed in the glabella due to electrical stimulation and it has been used for diagnosing clinical neuropathy. Currently, the blink reflex is known as a polysynaptic reflex that is composed of an afferent arc through sensory nerve fibers in the trigeminal nerve and an efferent arc through motor nerve fibers in the facial nerve (Shahani and Young, 1972).

The blink reflex is usually accompanied by two other reflexes: when the supraorbital nerve is stimulated, the orbicularis oculi muscles encircling both the left and right eyes are stimulated. In 1952, Kugelberg proved that

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electrical stimulation to the forehead brings two responses: early response (R1) and late response (R2). When the supraoribital nerve is stimulated, R1 is manifested on the ipsilateral side while R2 is manifested bilaterally (Kimura, 2001). R1 is usually stable and reproducible, with a biphasic or triphasic shape. On the other hand, R2 has a polyphasic shape; it tends to vary and become habitual from repeated stimulation (Shahani and Young, 1972). Reproducible R1 provides reliable evidence of nerve conduction, and changes in R2 help to determine the condition of the trigeminal nerve, facial nerve, or the brainstem, and to allow lesions to become localized (Goor and Pngerboer De Visser, 1976).

The R1 response is rather stable, and it is easy to measure the latency; however, the R2 response is diverse, and it is hard to measure the latency. Therefore, it is very important to help participants feel relaxed in order to reduce signal noise in testing blink reflex (Oh, 1993). It has been reported that the latency of the R2 response and the amplitude of R1 and R2 have low value as criteria due to the diversity and signal noise (Aramideh and Ongerboer de Visser, 2002; Bischoff et al., 1993; Kimura et al., 1969a; Kimura et al., 1969b; Kimura et al., 1977; Ham et al., 1995).

The averaging process is used for testing evoked potential (EP) because EP has very little response. The amplitude of EP ranges from several μV to less than μV; it is small in comparison to μV EEG 10mV or higher, to EMG mV, and to EKG. In the midst of such results from EEG, EKG, EMG, other biological signals and noises need an averaging process to solve the problem of potential small amplitude (Karl and Misulis, 2001). Use of the averaging process cancels the irregular responses and other noise while recording the average responses.

There is no published study that addresses measures to improve the blink reflex, as this reflex is difficult to measure due to the excessively wide scope of signal noise and variability. Accordingly, we aim to discover measures to improve this reflex through the averaging process used in an evoked potential test. Moreover, we attempt to apply these measures to the diagnosis of Bell's palsy.

This paper compared the conventional testing methods and averaging processing for blink reflexes of healthy people. The authors also observed the components that conventional tests had difficulty measuring due to the wide variability: latency, amplitude, and duration of response time. Finally, we also examined the usefulness of the blink reflex in diagnosing Bell's palsy.

MATERIALS & METHODS

Subjects for this study were 108 eyes of healthy people and 18 Bell's palsy patients. The subjects were selected from patients in the neurology department; the patients had no history of cranial nerve and brainstem lesions or central nervous system or other systemic diseases; patients with possible peripheral neuropathy such as those with diabetes mellitus were excluded.

The patient group was composed of 18 people who had been diagnosed with Bell's palsy in the department of neurology during a three-month period (August, 2010 ~ November, 2010). People with damaged facial nerves or the possibility of peripheral neuropathy were excluded from the patient group. Every participant was given detailed information on the study; after receiving informed consent from the participants and approval from the IRB Committee of the hospital in Gyeonggido province, the study proceeded.

The blink reflex was tested with Sierra Wave from Cadwell (USA) and during the test, the room temperature was kept at 22~26℃. The participants were told to lie down on a bed straight and to close their eyes slightly. Two ways using the Kimura method and the averaging process method were used. Each test was done at random, with a 5-minute-long break in between. For recording potentials, a disposable surface electrode with a 9 mm-diameter was used; the sweep speed was 10msec per section, with the sensitivity set at 200 μV and the filter set at 1~5,000 Hz. Electrodes were attached in the same way as in the conventional testing method. Electrodes for the blink reflex test were attached as follows: the action potential was on the lateral canthus of the bilateral orbicularis oculi muscle, the standard electrodes were attached to the inner canthus of the bilateral orbicularis oculi muscle, and the ground electrodes were attached to the chin. Stimulation was given on the eyebrow where the supraorbital nerve passes; when the tester was pushing the stimulator with his or her hand,

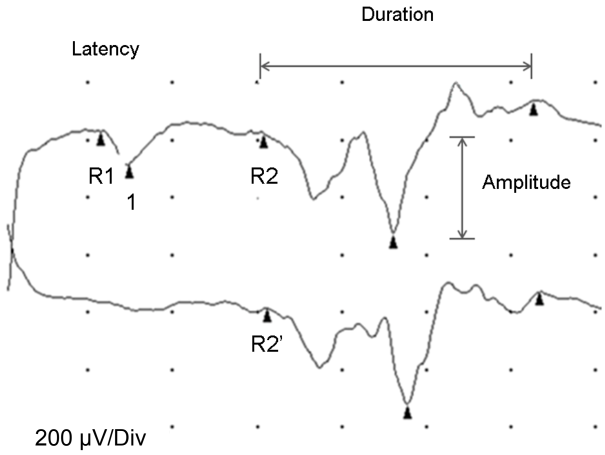

Fig. 1. Measurement of amplitude and duration in the blink reflex using averaging process. The measurement of amplitude in the averaging process used the peak to peak amplitude. The duration of R2 response was time between the first deflection and the last deflection.

the subject felt pain from the pressure that the tester was applying. In order to minimize the muscle activity from pain, a bar electrode was used. In addition, since the lack of muscle relaxation can cause signal noise, patients were allowed to hear the muscle contraction by turning on the speaker; to prevent facial muscles from contracting, patients were asked to hold their mouths agape. As for the degree of stimulation, supramaximal stimulation was given for 0.1 msec. The intervals between the 5 stimulations were each 10 seconds to prevent habituation from frequent stimulation.

The method of recording potentials differed based on the test; conventional tests were measured in the same manner-among 5 potentials, the ipsilateral R1 with the shortest latency, the R2 response, and the contralateral R2 response were measured. On the other hand, blink reflex using the averaging process was stimulated 5 times, and with one average potential, the ipsilateral R1, the R2 response, and the contralateral R2 response latency, amplitude, and duration were measured. Latency was measured from the beginning point of stimulation to the first deflection; the conventional test and the test using the averaging process were the same. The measurement of amplitude in the averaging process used the peak-to-peak amplitude: the duration of the R2 response was the time between the first deflection and the last deflection (Fig. 1).

The patient group was divided into incomplete palsy and complete palsy groups. Based on the results of the blink reflex, there are two potential types of palsy: incomplete palsy and complete palsy. In the presence of incomplete palsy, ipsilateral R1, R2 response latency is prolonged when the paralyzed side is stimulated; contralateral R2 response latency is prolonged when the side without a lesion is stimulated. In the presence of complete palsy, the corresponding side does not have any response.

The collected data were processed with the SPSS (Statistical Package for the Social Science) Version 19.0 program. Frequency test, including the number of participants, age, and gender, was used to analyze the general characteristics of participants. Paired sample *t*-test was used to compare the differences in the results of the conventional test and the averaging process of the healthy group. Independent sample *t*-test was used to compare the differences in latency, amplitude and duration of the healthy and incomplete palsy group on blink reflex using averaging process. In the averaging process, independent sample *t*-test and Mann-Whitney U test were done to compare the differences in latency, amplitude and duration of their affected and unaffected side. Statistical significance was accepted with $P<0.05$.

RESULTS

This study had two groups of subjects: a healthy group of 54 people (108 eyes) and a group of 18 patients were tested for blink reflex with the conventional test and the averaging process test.

General characteristics of healthy and patient groups

The general characteristics of the healthy group were 54 people including 27 men (50.0%) and 27 women (50.0%). The average age was 43.24 years old (18~75). The general characteristics of the patient group were 18 people including 7 men (38.9%) and 11 women (61.1%).

The patient group was composed of 7 men and 11 women, and their average age was 52.17 years old (25~77). Categorized based on the palsy side, people with right-sided palsy were 10 (55.6%) people, and people with left-sided

Table 1. Difference in blink reflex between conventional test latency and averaging process latency (n=108)

Measurement	Method		t-value	P-value
	Conventional	Averaging Process		
R1 latency (msec)	10.70 ± 0.62	10.48 ± 0.61	5.491***	<0.001
Ipsilateral R2 latency	31.17 ± 3.34	30.96 ± 3.08	1.923	0.057
Contralateral R2 latency	31.68 ± 3.44	30.94 ± 3.38	6.673***	<0.001
Ipsilateral R2 duration (msec)		35.49 ± 5.42		
Contralateral R2 duration		35.78 ± 5.76		
R1 amplitude (μV)		164.66 ± 85.76		
Ipsilateral R2 amplitude		151.85 ± 59.77		
Contralateral R2 amplitude		122.37 ± 61.20		

Values are Mean ± SD. ***P<0.001.
Abbreviation: R1, early response; R2, late response.

palsy were 8 (44.4%); categorized based on the type of palsy, people with complete palsy were 5 (27.8%), and people with incomplete palsy were 13 (72.2%).

Descriptive statistics of blink reflex in healthy group using conventional test and averaging process

The descriptive statistics of the healthy group's conventional test are shown below. The results of analysis showed R1 latency (10.70 ± 0.62), ipsilateral R2 latency (31.17 ± 3.34), and contralateral R2 latency (31.68 ± 3.44).

The descriptive statistics of the healthy group by using the averaging process test are as follows: R1 latency (10.48 ± 0.61), ipsilateral R2 latency (30.96 ± 3.08), contralateral R2 latency (30.94 ± 3.38), ipsilateral R2 duration (35.49 ± 5.42), contralateral R2 duration (35.78 ± 5.76), R1 amplitude (164.66 ± 85.73), ipsilateral R2 amplitude (151.85 ± 59.77), and contralateral R2 amplitude (122.37 ± 61.20) (Table 1).

The results showed that the differences in R1 latency in the healthy group's conventional test R1 latency and averaging process test were significant (t=5.491, P<0.001). The difference between conventional test ipsilateral R2 latency and averaging process test ipsilateral R2 latency was not significant. The difference in conventional test contralateral R2 latency and averaging process test contralateral R2 latency was significant (t=6.673, P<0.001).

As a result, R1 and contralateral R2 had shorter latency than in the conventional test, while in ipsilateral R2 there was no significant difference, while latency was shortened from the conventional test (Table 1).

Difference between healthy group and incomplete palsy patients in blink reflex using averaging process

In the averaging process test, R1 latency in the healthy group and in incomplete palsy patients showed a significant difference (t=6.794, P<0.001). Ipsilateral R2 latency of contralateral the healthy group and the incomplete palsy patients did show a significant difference (t=7.722, P<0.001). Contralateral R2 latency of the healthy group and the incomplete palsy patients also displayed a significant difference (t=6.586, P<0.001). In the averaging process test, the ipsilateral R2 duration of the healthy group and that of the incomplete palsy patients showed a significant difference (t=5.118, P<0.001). Contralateral R2 duration of the healthy group and of the incomplete palsy patients demonstrated a significant difference (t=5.810, P<0.001). In the averaging process test, R1 amplitude of the healthy group and the incomplete palsy patients also showed a significant difference (t=14.619, P<0.001). Ipsilateral R2 amplitude of the healthy group and the incomplete palsy patients displayed a significant difference (t=6.151, P<0.001). Contralateral R2 amplitude of the healthy group and the incomplete palsy patients also demonstrated a significant difference (t=4.796, P<0.001) (Table 2).

Table 2. Difference between the healthy group and incomplete palsy patients group on blink reflex using averaging process

Measurement	Group	N	Mean	SD	*t*-value	*P*-value
R1 latency	Normal subject	108	10.48	0.61	6.794***	<0.001
	Incomplete palsy	13	14.02	1.86		
Ipsilateral R2 latency	Normal subject	108	30.96	3.08	7.722***	<0.001
	Incomplete palsy	13	38.09	3.67		
Contralateral R2 latency	Normal subject	108	30.94	3.38	6.586***	<0.001
	Incomplete palsy	13	37.55	3.78		
Ipsilateral R2 duration	Normal subject	108	35.49	5.42	5.118***	<0.001
	Incomplete palsy	13	51.18	10.90		
Contralateral R2 duration	Normal subject	108	35.78	5.76	5.810***	<0.001
	Incomplete palsy	13	25.14	9.49		
R1 amplitude	Normal subject	108	164.66	85.73	14.619***	<0.001
	Incomplete palsy	13	29.93	14.82		
Ipsilateral R2 amplitude	Normal subject	108	151.85	59.77	6.151***	<0.001
	Incomplete palsy	13	47.11	38.80		
Contralateral R2 amplitude	Normal subject	108	122.37	61.20	4.796***	<0.001
	Incomplete palsy	13	39.44	31.62		

***$P<0.001$.
Abbreviation: R1, early response; R2, late response.

Differences in affected side and unaffected side in the patient group

The analysis showed that the differences in incomplete palsy latency between the affected side and the unaffected side in the patient group were great: R1 (t=6.208, P<0.001), ipsilateral R2 (t=4.249, P<0.001), contralateral R2 (t= 3.579, P=0.002). The patient group's incomplete palsy duration also demonstrated significant differences between the affected side and the unaffected side in ipsilateral R2 (t=-2.553, P=0.017) and contralateral R2 (t=-3.451, P= 0.002). The differences in the amplitude of the affected side and the unaffected side in the patient group's incomplete palsy were also significant: R1 (t=-3.191, P=0.008), ipsilateral R2 (t=-3.300, P=0.003), and contralateral R2 (t=-3.496, P=0.002) (Table 3). The results of the complete palsy patients were excluded because they had no response to compare.

DISCUSSION

Blink reflex can detect central lesion including trigeminal nerve disorder or brainstem lesion since the reflex arc is composed of 5th cranial nerve, reflex center with sensory nerve fiber and facial nerve. It can also monitor any abnormality in diabetic mellitus chronic nephritis, and peripheral neuritis. There have been many reports on the blink reflex related to Acoustic neuroma, multiple sclerosis, stroke, Wallenberg syndrome, other brainstem lesions, diabetic peripheral neuropathy lesion and chronic renal failure (Kimura et al., 1969a; Kimura et al., 1969b; Shahani and Young, 1972; Oh, 1993; Kim et al., 1996). As such, blink reflex test has a great clinical value. As mentioned above, the blink reflex is a very useful test for diagnosing abnormalities along the pathways of peripheral nerves and central nerves. However, its value for clinical application is limited due to the variability and signal noise. For this reason, this study attempted to apply the blink reflex using averaging process.

This study conducted the blink reflex test using the conventional test and the averaging process test, compared the results, and examined the latency, amplitude, and duration, which were hard to measure with the conventional test due to their wide variability. This paper also attempted to examine the usefulness of the blink reflex for Bell's palsy.

Table 3. Difference in latency, duration and amplitude of affected side and unaffected side of patient group's incomplete palsy on blink reflex using averaging process

Side	R1	Ipsilateral R2	Contralateral R2
		Latency	
Affected side	14.02 ± 1.86	38.09 ± 3.67	37.55 ± 3.78
Unaffected side	10.46 ± 0.89	32.68 ± 2.76	32.39 ± 3.57
t-value	6.208***	4.249***	3.579**
P-value	<0.001 (<0.001)	<0.001 (<0.001)	0.002 (0.002)
		Duration	
Affected side		51.18 ± 10.90	25.14 ± 9.49
Unaffected side		62.39 ± 11.49	37.71 ± 9.09
t-value		-2.553*	-3.451**
P-value		0.017 (0.017)	0.002 (0.001)
		Amplitude	
Affected side	29.93 ± 14.82	47.11 ± 38.80	39.44 ± 31.62
Unaffected side	144.88 ± 129.05	142.72 ± 97.00	133.10 ± 91.27
t-value	-3.191**	-3.300**	-3.496**
P-value	0.008 (<0.001)	0.003 (0.001)	0.002 (<0.001)

Values are Mean ± SD. *$P<0.05$, **$P<0.01$, ***$P<0.001$
†*P*-value in parentheses, *P*-value of the nonparametric statistics.
Abbreviation: R1, early response; R2, late response.

Conventional testing methods could not eliminate the wide variability, and the usefulness of the blink reflex was limited. The averaging process, therefore, was suggested to complement the limited clinical use of the blink reflex.

Other researchers reported that amplitude and duration had no value due to the disperse standard deviation and the great variability (Goor and Pngerboer De Visser, 1976; Kimura et al., 1969b; Ham et al., 1995). In the study of Bell's palsy patients, duration and amplitude were reported to decrease in comparison to unaffected side, but the latency is more meaningful (Kimura et al., 1976). However, the results of this study, using the averaging process, indicated that the latency, amplitude, and duration of R1, ipsilateral R2, and contralateral R2 of incomplete palsy patients among Bell's palsy patients all decreased in comparison to the unaffected side, while there was no response in complete palsy. In addition, 1 out of 13 incomplete palsy patients manifested clearer changes in amplitude and duration than in latency.

Nerve excitability tests and nerve conduction studies can be useful indicators for diagnosing Wallerian degeneration that develops in the distal part of the affected side in Bell's palsy; however, such tests cannot measure the function of the facial nerve proximal part or of intratemporal segment lesions in Bell's palsy, while blink reflex can monitor the changes in intraosseous segments of the facial nerve and the central region. In Bell's palsy, the prolonging of latency in R1 and R2 response from the affected side completely disappears when the bilateral sides are stimulated, and the unaffected side shows normal R2 response; when the unaffected side is stimulated, the unaffected side shows normal R1 and R2 response; it is reported that the latency of R2 response is beyond the normal range and less useful than the latency of R1 response while it is more useful than the amplitude and duration (Goor and Pngerboer De Visser, 1976; Kimura et al., 1969a; Kimura et al., 1976; Oh, 1993). In this study, the latency, amplitude, and duration in R1 response as well as in R2 response all showed significant change.

The increased latency of the blink reflex in Bell's palsy implies demyelinating degeneration and the decreased amplitude implies axonal degeneration. In addition, duration indicates the range of nerve conduction, so the amplitude and duration can help with localization of the lesion and determination of the severity. Therefore, examining the latency, amplitude, and duration of the blink reflex by using the averaging process to diagnose Bell's palsy can be more useful than conventional testing, which can measure only latency.

In a study of monitoring the blink reflex for prognosis of Bell's palsy, Schenck and Manz observed 30 patients and reported that R1 or R2 within the first 10 days is a sign for improvement, and otherwise a sign for digression (Manz and Schenck, 1975). Kimura et al. reported that patients whose orbicularis oculi muscles can be kept excited from continuous stimulation until the blink reflex comes back have good prognosis (Kimura et al., 1969a). Similarly, Neau et al., in a study with 91 subjects, reported that patients with R1 within the first 10 days had good prognosis (Neau et al., 1992). However, this study did not include the prognosis of blink reflex, which is a limitation of this study.

The latency, amplitude, and duration of the blink reflex can be affected by non-pathologic factors: the psychological condition of the subject, medication, wakefulness, and frequency of electrical stimulation all affect the blink reflex response. When a subject is nervous, the amplitude of R1 response decreases, while the amplitude of R2 increases. When a subject is sleeping, R1 response is either reduced or not induced at all, while the latency of R2 response is delayed (Kimura J, 2001). When stimulation is given repeatedly, it becomes habituated, reducing the amplitude and duration. Therefore, it was reported that stimulation should not be given more frequently than once every 5 seconds (Rushworth, 1962). Other researchers argued that the stimulation should not be given at intervals of less than 7 seconds, or even 10 seconds (Oh, 1993). Therefore, the subjects in this study were given stimulation every 10 seconds while the subjects were awake. They were given a break between the tests.

This study is not without limitations: first, the patient group was selected from among Bell's palsy patients only. Second, there was not a prognosis made for Bell's palsy patients based on their condition's severity. Third, many components were discovered during the blink reflex using the averaging process, but these components could not be observed in other diseases. Therefore, future studies should cover these limitations.

The results of this study indicate that the blink reflex using the averaging process should be more effective than the conventional method since the former can evaluate the latency, amplitude, and duration for Bell's palsy, while the latter can only assess latency. Therefore, based on these findings, the authors intend to facilitate the averaging process in the research on various diseases that may benefit from the blink reflex.

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