FLASH AND PATTERN VISUAL EVOKED POTENTIALS IN THE DIAGNOSIS AND MONITORING OF DYSTHYROID OPTIC NEUROPATHY

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SUMMARY

Flash and pattern visual evoked potentials were recorded in 8 patients (13 eyes) with dysthyroid optic neuropathy (DON), diagnosed using the American Thyroid Association classification. All were treated with systemic steroids, but 4 patients (6 eyes) also required orbital decompression. Flash VEP (P2) and pattern VEP (P100) were recorded prior to and 2 weeks after commencing steroid treatment or decompression. Fifteen patients with Graves orbitopathy but without DON, and 20 healthy subjects, acted as controls. Before treatment visual acuity was reduced in 10 eyes and visual fields were abnormal in 5, but the VEP was abnormal in all 13, with the group mean amplitude of P2 and P100 significantly less than controls, and the group mean P100 latency significantly greater than controls. After treatment with high-dose steroids or surgical decompression there were significant improvements in the group mean amplitude of P2 and P100, and significant reductions in P2 and P100 latency; however, individually, improvements in amplitude were more significant than improvements in latency. We conclude that the VEP to flash and pattern stimuli provides a useful diagnostic and monitoring tool in patients with DON, combining objectivity with quantitative analysis.

Thyroid optic neuropathy is a serious although infrequent (5–8%)[1,2] complication of Graves orbitopathy requiring urgent management to avoid severe visual loss.[1] The diagnosis of dysthyroid optic neuropathy (DON) can be based on a variety of clinical features including decrease in visual acuity, visual field and colour vision abnormalities, optic disc changes or the presence of an afferent pupillary defect.[3] However, as previous authors have shown, orbital changes and visual symptoms can be variable and inconsistent, and the patient may be unaware of visual loss until advanced clinical changes have occurred.[1,3,5] Furthermore, the presence of DON may be subclinical, and masked by the more obvious signs of orbital congestion.[2,4]

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Although CT scanning will identify the severity of apical crowding, and therefore identify those at risk of DON,[2,3,4,6] Neigel *et al.*[2] suggest that once the clinician is alerted 'appropriate psychophysical and electrophysiologic testing should be carried out'. These tests may include colour vision analysis (F/100 or Ishihara), visual fields (Goldmann perimetry), pattern visual evoked potentials (VEP), and pattern ERG (PERG). In Neigel *et al.*'s study[2] of 58 patients with DON, 64% had abnormal colour vision, 66% had abnormal fields, whilst the pattern VEP was abnormal in 94%.

Other authors also support the use of the VEP as a sensitive indicator of optic nerve dysfunction in Graves orbitopathy.[8–10] Furthermore Boback *et al.*[11] have advocated the use of steady-state pattern VAP recordings in thyroid disease, and studies by Setala *et al.*[6,9] have identified changes in the waveform as well as the latency of the flash VEP in DON. However, recent work by Potts *et al.*[12] and Fells[13] supports the usefulness of colour contrast sensitivity along the tritan blue axis in preference to pattern VEP and PERG, and Suttorp-Schulten *et al.*[14] describe disturbances in luminance contrast sensitivity in a high percentage of patients with thyroid eye disease.

Various treatment regimes are advocated for the management of DON;[7,13] therefore, not only is early diagnosis important, but the response to any one form of treatment needs to be carefully monitored as patients not responding, or relapsing, after one treatment regime may respond to another.[1,4] There is clearly a need to have available an objective method to aid in both the diagnosis and monitoring of DON. This study aims to show the value of the flash and pattern VEP in the diagnosis of DON and the monitoring of patients' response to treatment.

PATIENTS AND METHODS

We reviewed the clinical presentation and the VEPs in all patients (n = 8) diagnosed and treated for DON at this centre in the past 7 years. Five patients had bilateral DON and 3 had only unilateral involvement. All 8 patients (age

range 26–73 years, mean age 49.1 years) (13 eyes) fulfilled the classification of the American Thyroid Association.[15] All patients had been diagnosed on the basis of CT scan abnormalities, in addition to at least one of the following: a reduction in Snellen visual acuity of >2 lines (10 eyes), field loss (5 eyes), afferent pupillary defect (APD) (3 eyes), or swollen discs (2 eyes). In addition 2 patients had unilateral exposure-related corneal pathology as well as an APD.

All patients were treated with systemic steroids, and 4 patients (6 eyes) also underwent surgical decompression.

VEPs had been recorded on all patients before and after treatment. The VEPs in the DON group were compared with those recorded in two control groups. One group consisted of 15 patients (age range 23–68 years, mean age 45.1 years) with Graves orbitopathy but no clinical evidence of DON (who represented all patients seen over the same time period as the DON group who had more than one VEP performed, and who were clinically euthyroid at the time of recording). These 15 patients were from a group of 84 patients with Graves orbitopathy but no clinical evidence of DON who underwent VEP investigation between 1986 and 1993. The other control group consisted of 20 randomly selected healthy subjects (age range 22–68 years, mean age 46.1 years) with no clinical evidence of neurological abnormality or ophthalmic disease. In the DON group there were 5 women and 3 men, and in the Graves orbitopathy without DON group there were 10 women and 5 men. In the normal control group there were 12 women and 8 men.

VEPs were performed to flash and pattern stimulation. The flash VEPs were obtained using a diffuse flash provided by a Grass photic stimulator producing a stimulus intensity of 2000 candela per metre (cd/m). Pattern VEPs were obtained using a black and white reversing chequerboard stimulus (80% contrast, 85 cd/m luminance) subtending 50′ of arc at the subject's eye at 50 cm. All recordings were transient using a stimulus rate of 2 Hz.

For the pattern VEP a check size of 50′ was chosen as it is large enough to be seen by a patient with early lens or corneal opacities and yet still stimulates the central magnocellular pathways, particularly ganglion receptor fields within the perifoveal region, the axons of which are more likely to be affected by orbital compression than axons from ganglion cells responding to smaller check stimuli.

Two recording channels were employed using silver/silver chloride electrodes placed over the occipital cortex 3 cm either side of the inion (01, 02) and referred to an electrode placed over the mid-frontal cortex (Fz) (reference positive). Recordings were made using either a Nicolet C4 or a Nicolet CA1000 clinical averager, but in all cases the same equipment was used on each individual for consecutive recordings.

A pre-treatment flash and pattern VEP had been recorded in all patients with DON, and these VEPs were also recorded over a period of 2 weeks following commencement of steroid treatment or orbital decompression. In 3 of the 6 patients treated with high-dose steroids the VEP was recorded every 2–4 days during the 2 weeks of treatment (see Fig. 1–4).

The 6 patients (10 eyes) whose VEPs were monitored whilst they were on high-dose steroid treatment were receiving between 60 and 90 mg prednisolone daily throughout the 2 week period.

All 4 patients (6 eyes) who underwent orbital decompression, were receiving <10 mg prednisolone daily at the time of surgery, although 2 patients (3 eyes) had previously undergone high-dose steroid treatment.[4,7]

In those patients with Graves orbitopathy, who acted as non-treatment controls, consecutive VEPs were analysed that had been recorded no more than 1 month apart.

Measurements were made of the peak-to-peak amplitude and absolute latency of P2 (flash) and P100 (pattern). As well as identifying individual changes in P2 and P100 amplitude and latency after treatment, statistical comparison, using the paired *t*-test, was also made of the group mean amplitude and latency of P2 and P100 between the recordings made before and after treatment, compared with the control groups. A further comparison was made between the group mean percentage improvement in the amplitude of the VEP after treatment in the steroid and decompression groups and the group mean percentage variation in amplitude in the Graves control group, which was the group mean percentage variation in amplitude between consecutive recordings. Similar comparisons of latency variation (in milliseconds) were also made.

RESULTS

Pre-treatment recordings revealed that there was a significant reduction in group mean amplitude of P2 and P100 components in the DON group compared with either control group (see Table I). The group mean latency of the P2 and P100 components was also significantly longer in the DON group compared with controls. Eleven of the 13 eyes with DON exhibited P100 amplitude reductions which were either relative (an interocular difference of >25%) or absolute (a value <4 μV, which is the normal standard in this unit). Seven eyes had a delay of P100, but of these 4 eyes were relative delays only (interocular difference >8 ms, being beyond the upper limit of normal. Eight of the 13 eyes with DON exhibited a pre-treatment reduction in amplitude of the P2 component. Although the mean P2 latency improved after treatment, only 1 eye was beyond the normal range of P2 (>130 ms).

A 'W'-shaped (negative P100) response to pattern was noted in 3 eyes (see Fig. 6). This waveform abnormality also resulted in a delay of P100 to >120 ms, and was present in 2 patients, 1 of whom exhibited P100 components of normal amplitude in both eyes. One of the 3 patients with clinically unilateral DON had a reduction in the P100 component in the presumed normal eye, but the other 2 patients had normal VEPs in their clinically normal eye.

Amongst the controls with Graves disease the group mean amplitude of P2 and P100 was not significantly different from the normal control group (see Table I); how-

Table I. VEP amplitude and latency in patients with DON recorded before and 2 weeks after treatment with high-dose steroids compared with controls

Group	*n* eyes	Flash (P2)				Pattern (P100)			
		Amplitude		Latency		Amplitude		Latency	
		***	‡‡‡‡	*		***	‡‡	**	
DON (pre-treatment)	10	7.00	(1.10)	118.4	(5.79)	5.30	(0.89)	116.1	(4.71)
		†				††			
DON (post-treatment)	10	9.61	(1.43)	108.3	(5.47)	8.06	(0.80)	111.4	(4.89)
Graves control	30	12.40	(1.05)	110.1	(2.65)	8.55	(0.73)	111.0	(1.86)
Graves conttrol (1 month later)	30	12.72	(1.19)	111.2	(2.04)	7.55	(0.78)	109.7	(2.13)
Normal control	40	11.72	(1.16)	109.6	(2.08)	8.97	(0.59)	108.2	(1.19)

Values are the mean (standard error).
* $p<0.05$, ** $p<0.01$, *** $p<0.005$ compared with normal control.
† $p<0.05$, †† $p<0.01$ compared with pre-treatment recording.
‡‡ $p<0.01$, ‡‡‡‡ $p<0.001$ compared with Graves control group.

ever, in 5 patients the VEPs were not normal, with 2 eyes showing a reduction of P2 amplitude, 4 eyes a delay of P100 latency, and in 6 eyes a reduced P100 amplitude (<4 μV). In 3 eyes there was a 'W'-shaped P100. In the other 69 patients with Graves orbitopathy without DON, who had VEPs from 1986 to 1993, 12 patients (16 eyes) had abnormal VEPs (reduced P2, 5 eyes; reduced P100, 7 eyes; delayed P100, 6 eyes; 'W'-shaped P100, 4 eyes).

Steroids

Of the 10 eyes with DON treated with high-dose systemic steroids, 7 exhibited a reduction in the amplitude of the pre-treatment P100 components to <4 μV (see Figs. 1–4). All 7 eyes improved to within normal limits of amplitude (>4 μV), although there remained a significant interocular difference in 4 eyes. Three eyes had a delay of the pre-treatment P100 component. In all 3 this was a delay to >120 ms, including the 1 patient (2 eyes) with a normal P100 amplitude. In 1 eye the amplitude of P100 was too low to measure the latency. In 3 eyes the latency recovered to normal values.

The group mean improvement in P100 amplitude which correlated with a group mean percentage improvement of 103.5% was significantly greater ($p<0.001$) than the mean amplitude variation amongst the Graves control group (see Tables II and III). The group mean latency in P100 improvement was –4.7 ms, which was also a significant ($p<0.05$) improvement compared with the mean control (Graves group) variation.

Four eyes with DON in this treatment group also had a reduction in the amplitude of the pre-treatment P2 to <4 μV, all of which improved to within normal limits (>4 μV) after treatment with systemic steroids, although 2 eyes still exhibited a persistent interocular difference of >25%. One other eye exhibited a comparative reduction (>25%) in P2 amplitude, which recovered after treatment.

The group mean improvement in P2 amplitude, which correlated with a group mean percentage improvement of 73.8% (see Tables II and III), was significant ($p<0.05$) compared with the mean amplitude variation amongst the Graves control group. Although the pre-treatment P2 component was within normal limits of latency (<130 ms) in all but 1 eye, after treatment there was a significant reduction ($p<0.01$) (–5.1 ms) in group mean latency compared with the Graves control group.

In comparing the worse affected eye with the less affected eye amongst those patients treated with high-dose systemic steroids the group mean percentage improvement in P2 amplitude was 103% in the worse eye, and 9.7% in the better eye. For P100 the group mean percentage improvement was 145% in the worse eye and 44% in the better eye.

Decompression

Of the 6 eyes (4 patients) that were surgically decompressed, 3 eyes (2 patients) had relapsed after their steroid dose had been reduced. The remaining 3 eyes were surgically decompressed for progressive exophthalmos with concurent DON. None of the 6 eyes had received high-dose systemic steroids[4,7] within the month prior to decompression.

Five eyes showed a reduction in the amplitude of the P100 component to <4 μV pre-decompression, and P2 was reduced in 2 eyes (see Table I, and Figs. 1–5). Following decompression surgery these amplitude reductions returned to normal in all but 1 eye which had concurrent severe corneal pathology, where only a recovery of P2 occurred. Following decompression the percentage group mean flash VEP amplitude increased by 167%, and the pattern VEP amplitude by 129% (see Table III). This was significantly greater than the group mean percentage variation of the Graves control group ($p<0.001$ in either case) but was not significantly different from the percentage increase seen following steroid treatment.

The P100 component was delayed in 4 eyes and subsequently improved after decompression. In 1 other eye the amplitude was so reduced as to make measurement of latency impossible. After decompression the P100 returned to normal limits of amplitude and latency in all but 1 eye. No delays in P2 were noted.

Following decompression the group mean latency of the flash VEP was shortened by 3.3 ms, and the pattern VEP by 15.2 ms, which again was significantly less ($p<0.05$ to flash and $p<0.001$ to pattern) than the group mean variance in latency exhibited by the Graves control group. The P100 latency differences were more significant ($p<0.025$) than in the group treated with high-dose steroids (see Table I).

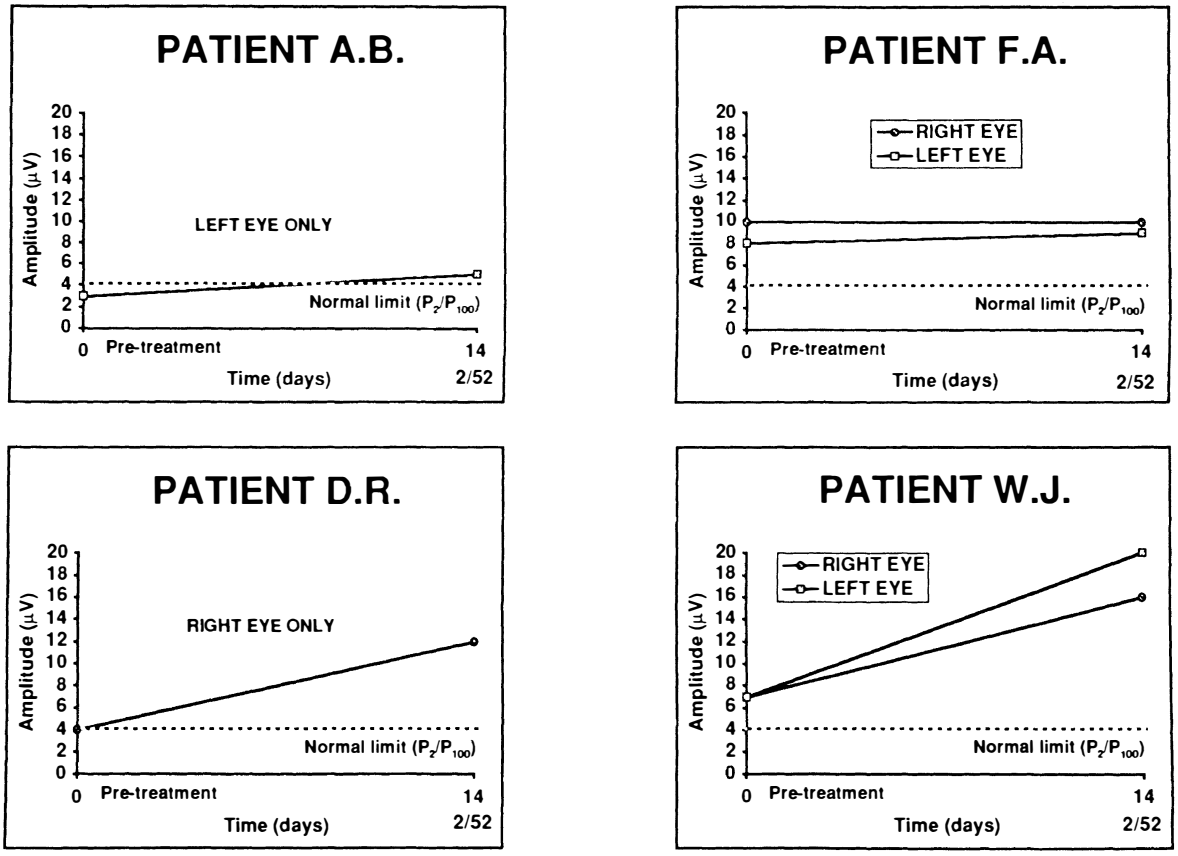

Fig. 1. *P2 amplitude versus time in days in patients who were surgically decompressed.*

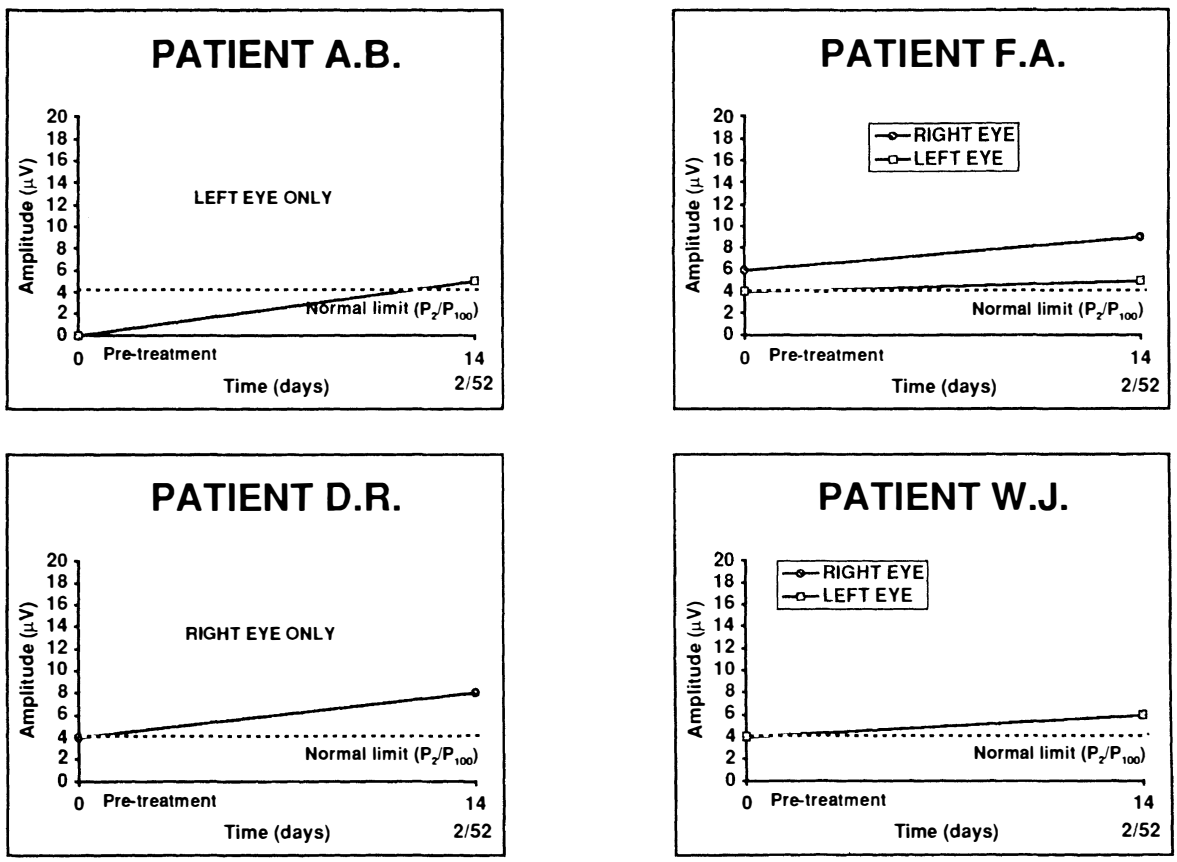

Fig. 2. *P100 amplitude versus time in days in patients who were surgically decompressed.*

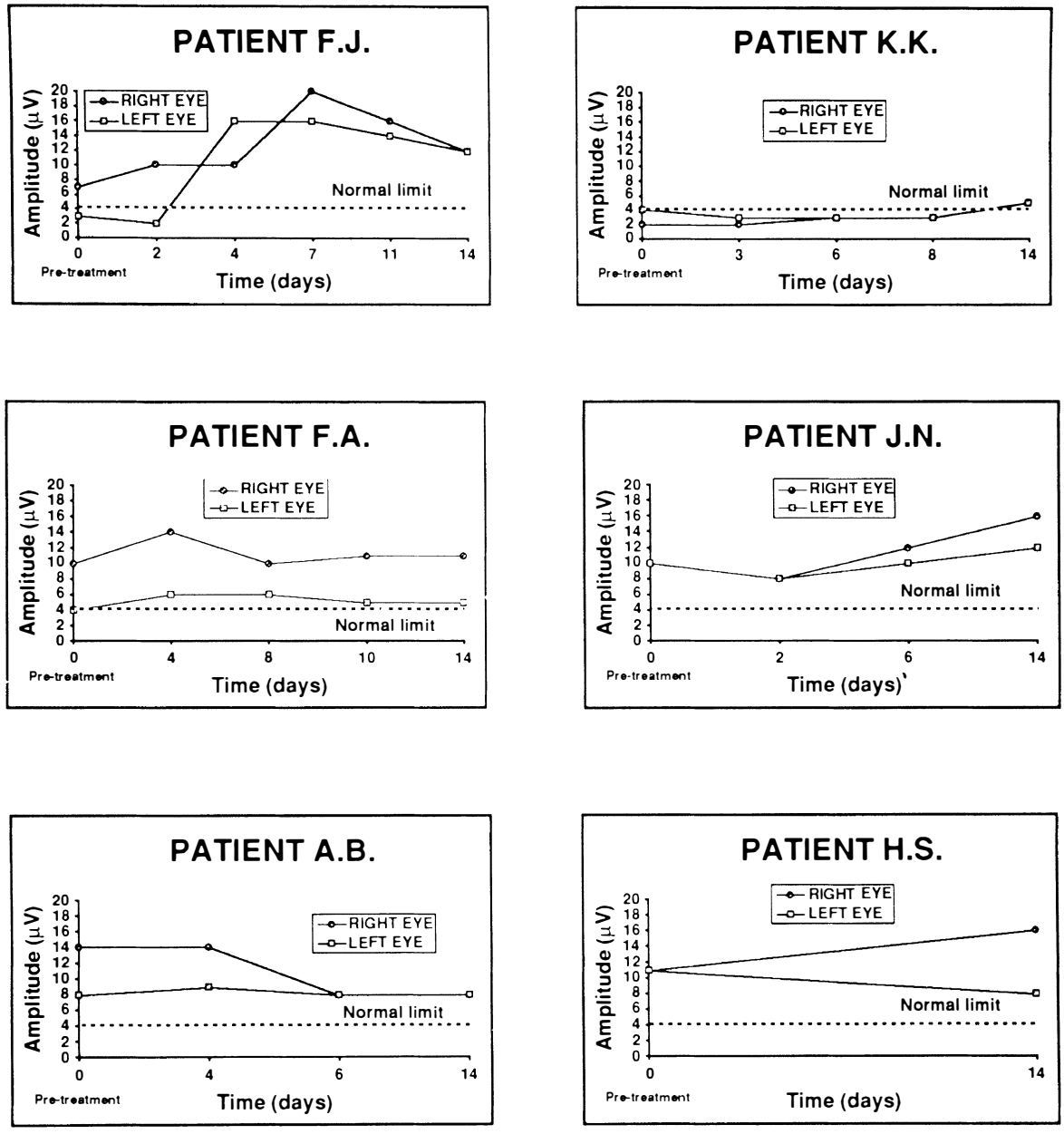

Fig. 3. *P2 amplitude versus time in days in patients treated with high-dose systemic steroids.*

Table II. VEP amplitude and latency in patients with DON recorded before and 2 weeks after surgical decompression compared with with controls

Group	*n* eyes	Flash (P2)				Pattern (P100)			
		Amplitude		Latency		Amplitude		Latency	
DON (pre-treatment)	6	6.83 *** ‡‡‡‡	(0.92)	112.0	(4.46)	3.67 **** ‡‡‡‡	(0.81)	129.2 *** ‡‡‡	(7.13)
DON (post-treatment)	6	13.12 †††	(1.65)	106.7	(3.34)	6.50 ††	(0.67)	114.0 ††	(4.47)
Graves control	30	12.40	(1.05)	110.1	(2.65)	8.55	(0.73)	111.0	(1.86)
Graves control (1 month later)	30	12.72	(1.19)	111.2	(2.04)	7.55	(0.78)	109.7	(2.13)
Normal control	40	11.72	(1.16)	109.6	(2.08)	8.97	(0.59)	108.2	(1.19)

Values are the mean (standard error).
*** $p<0.005$, **** $p<0.001$, compared with normal control.
†† $p<0.01$, ††† $p<0.005$ compared with pre-treatment recording.
‡‡‡ $p<0.005$, ‡‡‡‡ $p<0.001$ compared with Graves control group.

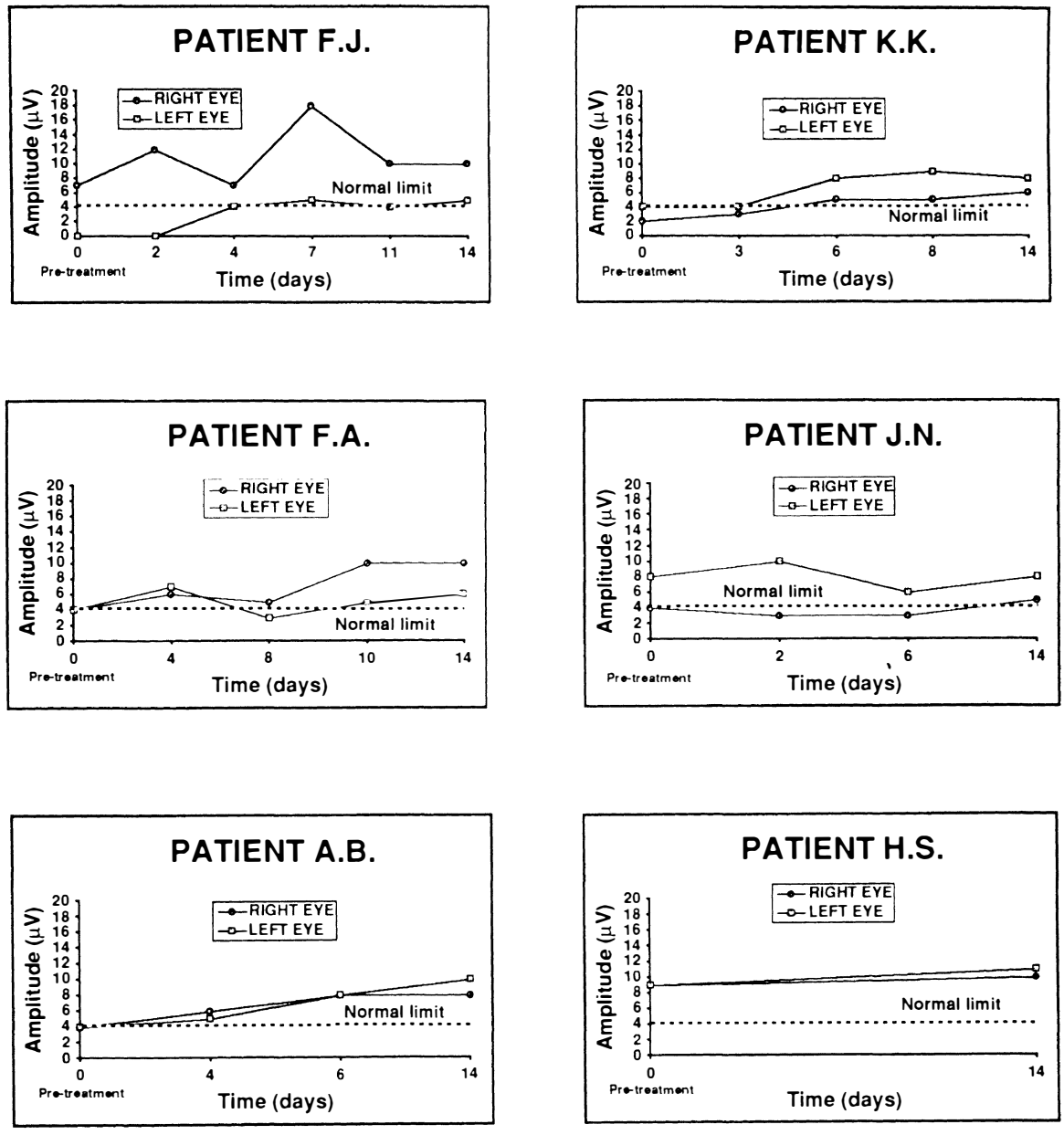

Fig. 4. *P100 amplitude versus time in days in patients treated with high-dose systemic steroids.*

Table III. Mean percentage change in VEP amplitude, and mean latency change after treatment, in patients with DON compared with mean variation in controls with Graves' disease

Group	*n* eyes	Amplitude				Latency			
		P2		P100		P2		P100	
DON (post-steroids)	10	* 68.82	(37.7)	**** 103.5	(42.6)	** −5.13	(3.18)	* −4.73	(2.34)
DON (post-decomposition)	10	**** 167.3	(60.9)	**** 129.4	(74.7)	* −3.31	(2.08)	**** −15.20	†††† (2.05)
Control (Graves)	30	25.89	(1.58)	−11.42	(0.97)	1.10	(2.40)	−0.29	(2.01)

Values are the mean (standard error).
* $p<0.05$, ** $p<0.01$, **** $p<0.001$ compared with controls.
†††† $p<0.001$ compared with steroid group.

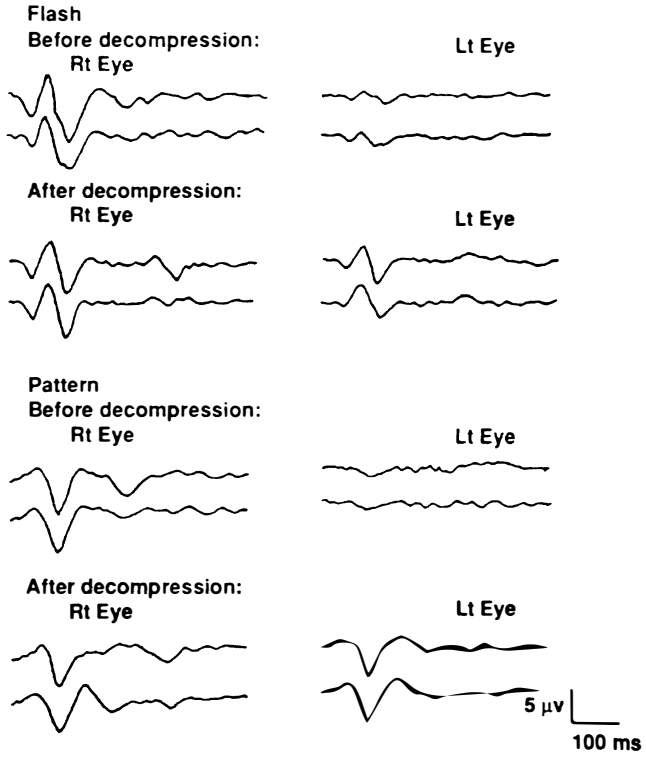

Fig. 5. *Patient A.B. (man aged 73 years). VEP recordings before and 2 weeks after left orbital decompression.*

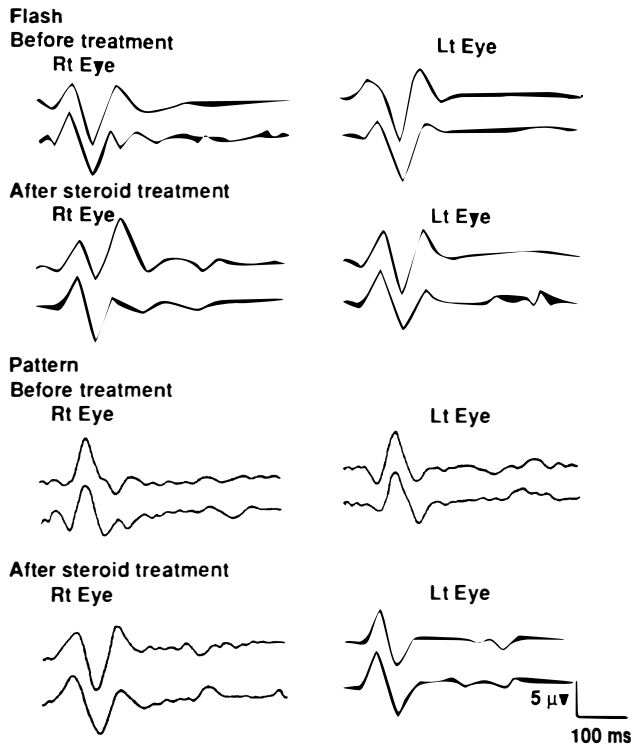

Fig. 6. *Patient H.S. (woman aged 68 years). VEP recordings before and after 2 weeks high-dose steroid treatment. Note the 'W'-shaped pattern waveform before treatment, which resolved after treatment.*

DISCUSSION

The results of this retrospective study of the VEP in dysthyroid optic neuropathy have confirmed the finding of other authors[2,16] that the VEP pattern stimulation is a sensitive diagnostic indicator of optic nerve compression in this condition. However, it is notable that in our study reductions in pattern amplitude occurred more frequently than delays, whereas other authors have emphasised delay as the main feature of abnormality.[8,16] A study of 33 patients with 'endocrine orbitopathy' by Wijngaarde and Von Lith[16] found that there was no significant reduction in group mean amplitude of responses to a 1° chequerboard stimulus, but delays in these responses were often seen. In studies by Setala *et al.*[8,9] 15 patients with DON were assessed using the flash VEP before and up to 7 years after orbital decompression. They found that before treatment there was a significant delay of the group mean major positive component, but only 5 eyes exhibited an amplitude reduction. They also observed that at 6 months after surgery there were no significant improvements in amplitude or latency. However, another study by Van Lith *et al.*[17] on the effects of optic nerve compression on the pattern VEP indicated that both amplitude reductions and delays do occur and the incidence of one or the other depends on the site and size of the lesion.

To our knowledge this is the first study to use a combination of flash and pattern VEP to identify optic nerve compression. As well as amplitude and latency changes we have also taken into account waveform abnormalities ('W'-shaped response; see Fig. 6) which occurred in 23% of eyes. This phenomenon has been previously described by Setala *et al.*,[8,9] and most probably represents a mechanical compressive or torsional effect on nerve fibres, resulting in some nerve fibres conducting differently to others within the same nerve in response to the same stimulus.

It was notable that taking into consideration all patients with DON there was a significant (108.8%) improvement in group mean P2 amplitude after treatment. This percentage improvement is similar to that seen to pattern stimuli (113.3%), suggesting that in monitoring terms the flash VEP is as sensitive as the pattern VEP. Furthermore, in those patients who had relapsed following a reduction in steroid treatment, and who therefore required surgical decompression, the VEP had deteriorated significantly to both flash and pattern stimuli at this time. Indeed, such reductions represented objective evidence of a need to carry out surgical decompression, and the deterioration in the VEP (particularly to flash) was one of the principal deciding factors for this option in clinical management, especially where clinical signs were obscured by corneal pathology.

The increases in VEP amplitude and reductions in latency were similar following treatment with systemic steroids or surgical decompression, although the reduction in P100 latency was more significant in the surgically decompressed group. However, this latter finding may be explained by the fact that the VEPs tended to be poorer in this group prior to surgery, thus making exact latency measurements more difficult.

There remains some debate concerning the value of the

various psychophysical and electrophysiological tests in the diagnosis and monitoring of DON. More recently Potts *et al.*[12] and Fells[13] have cited the use of colour contrast sensitivity loss along the tritan axis as the most sensitive indicator of increasing DON. The use of pattern stimulation in the VEP and PERG is limited by the influence of a number of factors many of which are unrelated to the disease process. Notable amongst these are opaque media, incorrect refraction, and poor patient compliance,[18,19] and psychophysical tests may also be limited by these factors.

When considering improvements in the VEP after treatment it is important to identify any factors unrelated to recovery of visual function as a potential cause for such improvements. Having established that the flash VEP is largely unaffected by factors not related to the functional state of the central visual pathways, it is nevertheless possible that the improvements in the VEP are merely a steroid effect unrelated to improvements in visual function. However, such a steroid effect would be expected to be equally distributed between the two eyes. This was clearly not the case since in patients treated with high-dose systemic steroids, the percentage improvement in the amplitude of the P2 component in the worse affected eye was more than 10 times that of the less affected eye, and for the P100 component this relative improvement was more than 3 times. Similarly, other factors which may affect VEP amplitude such as changes in background EEG activity must also be insignificant. It has also been reported[20,21] that changes in thyroid state alter the VEP, particularly in terms of latency. Seven of the 8 patients studied were euthyroid at the time of recording the VEP; therefore it is unlikely that this was a significant factor in providing the recorded improvements in the VEP.

The results of our study identify the use of the flash VEP as well as the pattern VEP as a robust and sensitive monitoring tool in cases of DON, particularly as the amplitude of the flash VEP is largely unaffected by the ocular media, refraction or compliance.[22] Whilst in diagnostic terms reductions and delays in P100 are more indicative of DON, the flash VEP would appear to be a useful addition to the pattern VEP, PERG and colour contrast sensitivity.

Key words: Dysthyroid optic neuropathy, Flash visual evoked potential, Graves orbitopathy, Pattern visual evoked potential, Steroids, Surgical decompression.

REFERENCES

1. Trobe JD. Optic nerve involvement in dysthyroidism. Ophthalmology 1981;88:488–92.
2. Neigel JM, Rootman J, Belkin RI, Nugent RA, Drance SM, Beattie CW, *et al.* Dysthyroid optic neuropathy:the crowded orbital apex syndrome. Ophthalmology 1988;95:1515–21.
3. Kennerdell JS, Rosenbaum AE, El-Hoshy MH. Apical optic nerve compression of dysthyroid optic neuropathy on computed tomography. Arch Ophthalmol 1981;99:807–9.
4. Trobe JD, Glaser JS, Laflamme P. Dysthyroid optic neuropathy: clinical profile and rationale for management. Arch Ophthalmol 1978;96:1199–209.
5. Day RM, Carroll FD. Optic nerve involvement associated with thyroid dysfunction. Arch Ophthalmol 1962;67:43–51.
6. Feldon SE, Weiner JM. Clinical significance of extraocular muscle volumes in Graves' ophthalmopathy. Arch Ophthalmol 1982;100:1266–9.
7. Panzo GJ, Tomsak RL. A retrospective review of 26 cases of dysthyroid optic neuropathy. Am J Ophthalmol 1983;96: 190–4.
8. Setala K, Raitta C, Valimaki M, Katevuo V, Lamberg RA. The value of visual evoked potentials in optic neuropathy of Graves' disease. J Endocrinol Invest 1992;15:821–6.
9. Setala K, Raitta C, Valimaki M, Katevuo K, Lamberg BA. Visual evoked potentials in Basedow's ophthalmopathy before and after orbital decompression or retrobulbar irradiation. Exp Clin Endocrinol 1991;97:344–7.
10. Batch JA, Lepre F. Early diagnosis of Graves' optic neuropathy using visual evoked responses. Postgrad Med J 1990;66:664–6.
11. Boback P, Friedman R, Mitchell B, Goodwin J, Anderson R. Visual evoked potentials to multiple temporal frequencies. Arch Ophthalmol 1988;106:936–40.
12. Potts MJ, Fells P, Falcao-Reis F, Bucetti S, Arden GB. Colour contrast sensitivity, pattern ERGs and cortical evoked potentials in dysthyroid optic neuropathy. Invest Ophthalmol Vis Sci 1990;31:ARVO abst 932.
13. Fells P. Management of dysthyroid eye disease: mini review. Br J Ophthalmol 1991;75:245–6.
14. Suttorp-Schulten MSA, Tijseen R, Mourits M, Apkarian P. Contrast sensitivity function in Graves' ophthalmopathy and dysthyroid optic neuropathy. Br J Ophthalmol 1993;77: 709–12.
15. Werner SC. Modification of the classification of the eye changes of Graves disease. Am J Ophthalmol 1977;83: 725–7.
16. Wijngaarde R, Van Lith GHM. Pattern evoked potentials in endocrine orbitopathy. Doc Ophthalmol 1979;48:327–32.
17. Van Lith GHM, Vijfvinke-Bruinenga S, Graniewski-Wijnands H. Pattern evoked cortical potentials and compressive lesions along the visual pathways. Doc Ophthalmol 1982;52:347–53.
18. Arden GP. The assessment of visual function in patients with opacities: a visual evoked potential method using a laser inferometer. In: Desmedt JE, editor. Visual evoked potentials in man: new developments. Oxford: Clarendon Press, 1977:381–400.
19. Berson EL. Electric phenomenon in the retina. In: Moses RA, editor. Adler's physiology of the eye. 7th ed. St Louis: CV Mosby, 1981:466–529.
20. Avramides A, Papamargaritis K, Mavromatis I, Saddic G, Vyzantiadis A, Milonas I. Visual evoked potentials in hypothyroid and hyperthyroid patients before and after achievement of euthyroidism. J Endocrinol Invest 1992;15: 821–6.
21. Huang TS, Chang YC, Lee SH, Chen FW, Chopra IJ. Visual, brain stem auditory and somatosensory evoked potential abnormalities in thyroid disease. Thyroidol Clin Exp 1989; 1:137–42.
22. Harding GFA. Origin of visual evoked cortical potentials components. In: Arden GB, Heckenlively JR, editors. Principles and practice of clinical electrophysiology of vision. St Louis: Mosby Year Book, 1991:132–42.