Convergence substitution for paralysed horizontal gaze

Bijan Beigi, Michael O’Keeffe, Patricia Logan, Peter Eustace

Abstract
Three patients with paralysed horizontal gaze are presented. Involuntary use of convergence to assist horizontal gaze was noted as a late feature. All patients showed (1) unilateral or bilateral horizontal gaze palsies (two patients had one and a half syndrome, the other had bilateral nuclear sixth nerve palsies), (2) addition of both eyes on attempted gaze into the paralysed field, (3) miosis which coincided with addition. Convergence substitution should be considered in the differential diagnosis of gaze induced strabismus.


Positive or negative vergence is a component of most conjugate eye movements, depending on the position of the object of regard.1 Preservation of convergence in gaze palsy is well described.2 3 In this paper three patients with horizontal gaze paralysis are presented. All are able to use convergence to obtain a useful range of horizontal gaze into the paralysed fields. The presence of miosis in all subjects confirmed the use of convergence.

Case reports

CASE 1
A 15-year-old girl presented in June 1989 with ataxia, neck stiffness, and blurring of the vision in the left eye. She had a history of glandular fever and left convergent strabismus with ambylopia. At her first ocular examination visual acuity was 6/9 in the right eye and 6/24 in the left eye. She had a small left convergent strabismus with left gaze palsy. Papilloedema and macular stars were noted. She also had truncal ataxia. Investigation revealed a benign cerebellar tumour with chronic hydrocephalus. The tumour was excised 1 week later. Histology reported a low grade astrocytoma. Postoperatively her vision deteriorated to 6/36 in the right eye and counting fingers in the left eye. She also showed the combination of a left horizontal gaze palsy and an internuclear ophthalmoplegia (INO) looking to the opposite side (one and a half syndrome) with atrophy of the left optic disc. Four months later she started to converge on attempted left gaze (Fig 1A and B), at the same time retraction of the left globe was noted. Pupil constriction occurred synchronously with attempted gaze to the left. Infrared oculo-graphic tracings of horizontal eye movements are shown (Fig 1C). These demonstrate the use of convergence on attempted lateral gaze to the left. Details of the findings on testing of other horizontal gaze subsystems are included in Table 1.

CASE 2
A 54-year-old woman presented in 1960 with cerebellar signs. A posterior fossa tumour was diagnosed for which she underwent craniotomies in 1960 and 1962. Postoperatively she developed right convergent strabismus with horizontal diplopia. In February 1992, she had a visual acuity of 6/12 in the right eye and 6/5 in the left eye. She had a right horizontal gaze palsy with an INO looking to the opposite side (one and a half syndrome). She also had a right lower motor neuron seventh nerve palsy and a right eighth cranial nerve palsy. Adduction was assisted by an active convergence accommodation effort on attempted dextroversion as shown by pupil constriction (Fig 2).

CASE 3
A 7-year-old boy who was born as a floppy baby with feeding difficulty and had an expressionless face as a result of bilateral seventh cranial nerve palsies. Bilateral nuclear sixth nerve palsies were also noted (asymmetrical horizontal gaze palsies). Moebius syndrome was diagnosed. He had a right convergent strabismus, for which binomial recti recessions were performed at the age of 3. At the age of 5, eye movements showed adduction with pupil constriction on attempted lateral gaze. These movements mimicked cross fixation but pupil constriction confirmed the use of vergence to assist paralysed horizontal gaze (Fig 3).

Discussion
In all conjugate eye movements, unless the object of regard is at infinity, some element of vergence is used. The information concerning both version and vergence must be synchronised. The mechanism by which this takes place is uncertain.1 Vergence, accommodation, and pupillary constriction are the components of the near triad.4 The stimuli for vergence eye movements are disparity of
images (fusional vergence) and retinal blur (accommodative vergence).\(^1\) Buttner-
Ennever and Akert have shown the anatomi-
cal substrate of convergence in vergence eye movement.\(^5\) The area of the brain
concerned with the control of convergence has been sited in the upper brainstem.\(^6\)\(^7\)
This is influenced by cells in the visual cortex which are stimulated by binocular
retinal input. Axons in the upper brainstem

reticular formation excite time locked cells
in a motor neuron pool adjacent to the sub-
nucleus of the oculomotor nerve for medial
rectus function bilaterally.\(^3\) In a recently
published model by Leigh and Zee an expla-
nation for the addition of vergence to all
eye movements, both saccadic and pursuit
where the eyes are not focused on infinity, is
proposed.\(^1\) Paralytic pontine exotropia in
bilateral internuclear ophthalmoplegia and
extropia in Webino syndrome,\(^8\) suggests
co-existent involvement of vergence input to
the oculomotor nuclei.\(^2\)

The three cases presented here are interest-
ing as all show the involuntary use of the
vergence accommodation synkinesis when the
horizontal gaze mechanism is paralysed.
These cases therefore support the suggestions
that both vergence eye movements driven
from the upper brainstem and horizontal gaze
movements driven by the pons act synergisti-
cally in all conjugate eye movements. Defect
of one system can leave the other one intact
(Fig 4).

In case 1 a unilateral blindness and in the
other two cases suppression prevented
diplopia being troublesome to the patients.
Variable diplopia is a symptom of gaze
induced strabismus. In such circumstances
various clinical possibilities should be ruled
out.\(^9\) Convergence substitution for paralysed
gaze should be considered as one of the
causes of gaze induced strabismus. Normally
the presence of miosis myopia and vergence
eye movements in the presence of any distur-
bance of eye movement suggests a functional
condition, ‘near reflex spasm’. In all our cases
the use of the accommodation, convergence,
miosis synkinesis was involuntary with no
additional features to suggest the functional
use of this triad.

The other clinical situation where miosis
accompanies vergence in an abnormal way
is misdirection regeneration of the oculomotor
nerve, the ‘pseudo-Argyll-Robertson pupil’.
There was no evidence that any of our patients
had a third nerve palsy at any time during their
illness and therefore this possible diagnosis did
not arise. Neither was there any evidence of
misdirection innervation of oculomotor and
abducens nerve as simultaneous constriction
of the pupil is absent in such conditions.\(^10\)\(^11\)

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**Table 1: Ocular motility finding**

<table>
<thead>
<tr>
<th>Patient</th>
<th>VA</th>
<th>Cover test</th>
<th>Convergence used in</th>
<th>Horizontal pursuits</th>
<th>Horizontal saccades</th>
<th>Vestibulo-ocular reflex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>R 6/36 LCS</td>
<td>Left gaze</td>
<td>Saccadic pursuits, L gaze palsy, R INO</td>
<td>Hypometric, reduced velocity</td>
<td>Defective</td>
<td></td>
</tr>
<tr>
<td>Case 2</td>
<td>R 6/12 LCS Right gaze</td>
<td>Saccadic pursuits, R INO</td>
<td>Hypometric, reduced velocity</td>
<td>Defective</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 3</td>
<td>L 6/9 LCS</td>
<td>Asymmetrical limited abduction, adduction</td>
<td>Hypometric, reduced velocity</td>
<td>Defective</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

INO=internuclear ophthalmoplegia, LCS=left convergent strabismus, RCS=right convergent strabismus, add=abduction, add=adduction.
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Figure 2 Horizontal eye movements of case 2. (A) Convergence and bilateral pupillary constriction on attempted dextroversion. (B) Limitation of adduction and abduction in laevoversion, with abducting nystagmus.

Figure 3 Horizontal ocular movements of case 3. (A) Primary position of gaze. Note the pupil size. (B) Right gaze assisted by accommodative convergence, shown by bilateral miosis. (C) Left gaze also assisted by convergence substitution. (D) Oculographic tracing of the horizontal pursuits of case 3. At 1 second the patient has started to follow the target to the left. At 3 seconds both eyes have adducted. At 4 seconds the patient has started to look to the right. Both eyes have converged at 5 seconds.

We have reported three cases with disturbance of horizontal gaze in whom adduction with pupillary constriction in both eyes was noted on attempted gaze into the paralysed field. The vergence mechanism is used in this situation to assist horizontal gaze. This clinical entity is commoner than is recognised and should be considered in the differential diagnosis of gaze induced strabismus. This observation is also clinical support for Leigh and Zee's model of convergence suggesting synchronised co-existence of the vergence and version system in conjugate eye movements. Our patients have used the vergence system in the absence of the version system to assist limited gaze.
Figure 4 A diagram of vergence system. The middle nucleus represents the mesencephalic reticular formation for vergence located dorsolateral to the oculomotor nucleus. It drives medial recti subnuclei bilaterally (— —). Note the separate pathways for horizontal gaze driven by PPRF (— —). LR = lateral rectus, MR = medial rectus, III = oculomotor nucleus, IV = trochlear nucleus, VI = abducens nucleus, MLF = medial longitudinal fasciculus, PPRF = paramedian pontine reticular formation.

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