# SACCADIC VELOCITIES

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**Abstract**

*Saccadic eye movements are controlled by the voluntary oculogyric system of the frontal cortex. Saccades are rapid and precise conjugate eye movements from one fixation point to the next. Saccadic velocities are discussed, together with case examples of oculomotor disorders and saccadic recordings.*

**Key words:** *Oculomotor disorders, adduction saccades, abduction saccades.*

The study of saccadic movements to diagnose and treat oculomotor disorders is not new. In 1966 Von Noorden and Preziosi[1] demonstrated under and over shooting of saccades in patients with multiple sclerosis and spinocerebellar degeneration. In the 1970 New Orleans Symposium on Strabismus, Jampolsky[2] mentioned saccadic eye movements in evaluating extraocular muscle paresis. Since then the study of saccadic eye movements has assisted in the diagnosis and treatment of oculomotor disorders and aided in the understanding of their pathology. The following paper aims to describe, firstly saccadic eye movements and their importance, secondly techniques of recording, thirdly oculomotor disorders which have been studied using the saccadic velocity recorder and fourthly the significance of saccadic velocity records and recordings for the ophthalmologist and orthoptist.

In a voluntary saccade, signals from the retina pass via the optic nerve to the lateral geniculate body and then to area 17 of the occipital lobe. Connecting fibers carry the signal to areas 18 and 19. According to Scott[3] the signal then goes to the frontal eye fields. The saccadic signal descends via the corticobulbar tract to the mesencephalic reticular formation and ultimately to the appropriate oculomotor nuclei.

A saccade is the most rapid movement the oculomotor system is capable of making. Its object is to direct the eyes from one target in the visual field to another in the shortest possible time.

Saccadic eye movements have the following characteristics:

1. Velocity—200°/sec-500°/sec range.
2. Acceleration—17 000-35 000°/sec$^2$.
3. Accurate to 0.2°.
4. The reaction time or latent period between the stimulus and the initiation of the saccade increases with the magnitude of the saccade.
5. Once a saccadic eye movement is initiated its direction and velocity are not influenced by voluntary effort.
6. Saccadic speed is direction sensitive.

The velocity of adduction saccades is faster than abduction saccades. Saccades toward

primary position or centering saccades are faster than decentering saccades.

Saccadic eye movement involves a total inhibition of the antagonist and rapid contraction of the agonist muscle. The duration and velocity of these movements are therefore dependent upon strength of the agonist and show moderate changes easily. Reduction in saccadic velocity is an excellent index of qualitative reduction in muscle function. Conversely recovery of velocity is an index of recovery in muscle function.

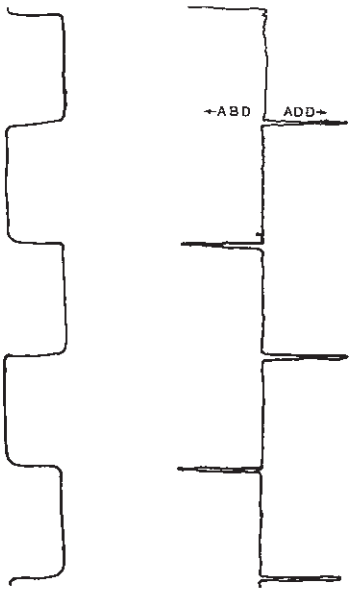


*Figure 1:* Tracing of normal subject. Right eye. Left tracing = eye position. Right tracing = velocity channel. Shows corresponding channels equal in abduction (ABD) and adduction (ADD).

There are various ways of studying saccades; i.e., observation, photography, after-images, transducers, photoelectric, electromyography and electrooculography. Currently in use at Westmead Centre is the saccadic velocity recorder (electrooculography). The recorder utilises five miniature electrodes. For horizontal measurements electrodes are placed temporally and medially at each canthus and a neutral centrally over the brow. For vertical measurements electrodes are placed above the brow and below the lower lid and a neutral at the lateral canthus. The eye is considered to be an electrical dipole, with the cornea as positive and the posterior pole negative. Any eye movement or change in position, changes the transorbital potential. The electrical changes are graphically displayed to indicate changes in eye position, velocity and acceleration.

Several important facts must be kept in mind when saccades are being measured. In patients with limitation of movement, the saccades are measured within the fields in which the eyes are able to move, except in patients with myasthenia gravis where the eye movement study must be made in the direction of the apparent ocular weakness before and after tensilon administration. To determine whether the saccadic velocity is abnormal, the examiner can compare it with—(1) established norms, (2) the saccadic velocity of the agonist, or (3) the saccadic velocity of the contralateral muscle (i.e., each eye independently).

A restriction can be differentiated from a weakness by comparing a duction to a version, by comparing forced ductions, or by measuring saccades. The velocity of a weak muscle will be slowed. If restriction is responsible for the limitation of the movement, the saccadic tracing will be of normal speed up to a point where the restriction quickly curtails the movement thereby causing trailing off (seen in Figure 2).

The velocity recorder is also designed to test pursuit or tracking movements, optokinetic movements, position maintenance, vergence testing and standard electronystagmography.

Saccadic velocities have aided in the evaluation of the following conditions: congenital myotonia, concomitant horizontal strabismus, double elevator palsy, Duane's syndrome, esotropia resulting from head injury, internuclear ophthalmoplegia, lateral rectus palsy,[4] mechanical restrictions and paresis following blow and fractures, Moebius syndrome, multiple sclerosis, myasthenia gravis,[5] nystagmus blocking syndrome, orbital tumour, retinal detachment, slipped muscle one

day after strabismus surgery,[6] senile ptosis, third nerve palsy and thyroid eye disease.

Various examples of the above conditions have been studied at Westmead Centre. The history, examination findings and velocity recordings of the following patients are reviewed.

1. *Mrs B.K. Left Lateral Rectus Palsy*

A 43 year old woman presented four months after a motor vehicle accident. She had a left esotropia of approximately 80$^{\Delta}$, in the primary position. Abduction of the left eye was 5° medial to the midline, visual acuity R 6/12 N5
L 6/9 N5

Forced duction showed restriction to abduction, saccadic velocities showed barely measurable abduction saccades in the left eye. Right eye showed normal saccadic velocities. There has been no sign of resolution. Surgery has been planned. The saccadic velocity is less than 25% normal.

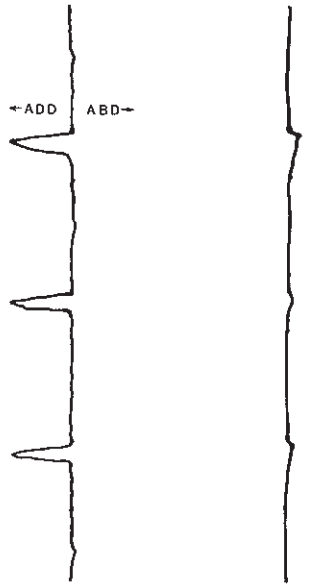


*Figure 2:* Patient 1. Mrs B.K. Left eye. Left tracing=velocity channel. Right tracing=eye position. Shows normal left adduction and trailing off on attempted left abduction.

2. *Mr S.I. Bilateral Duane's Palsy*

A 21 year old male presented with a history of "straight eyes" until the age of 11 years. Photos and previous archives from eye tests at an early age confirmed this. He now has a 35$^{\Delta}$ alternating esotropia with some diplopia at times, fixing right.

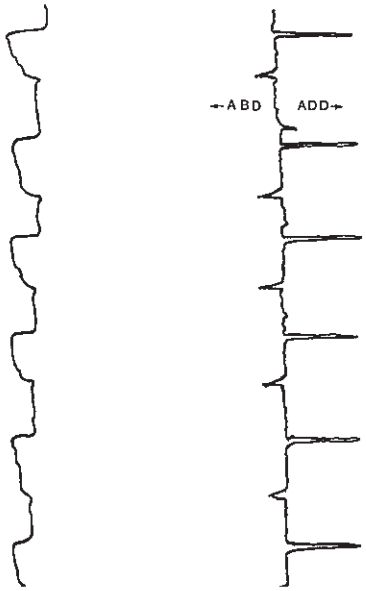


*Figure 3:* Patient 2. Mr S.I. Example of Right eye. Left tracing=eye position. Right tracing=velocity channel. Shows low velocity in right abduction and normal velocity in right adduction.

Visual acuity R 6/6 N 4.5
L 6/4-2 N 4.5

Ocular movements showed poor abduction and marked retraction right and left. (Adduction right and left was also reduced.) Saccadic velocities showed poor and slow abduction of both eyes. Surgery is being planned.

3. *Mrs T.B. Progressive External Ophthalmoplegia*

A 39-year-old woman presented with progressive ptosis over the past five years, worsening over the past 18 months. She had a moderate exophoria with very slow recovery in the near position and left esotropia for distant

fixation, with no diplopia. Visual acuity
R 6/6 N 4.5
L 6/12 N 5.

Ocular movements revealed limitation in extreme positions of gaze and reduced convergence to 10 cm. Tensilon test was negative.

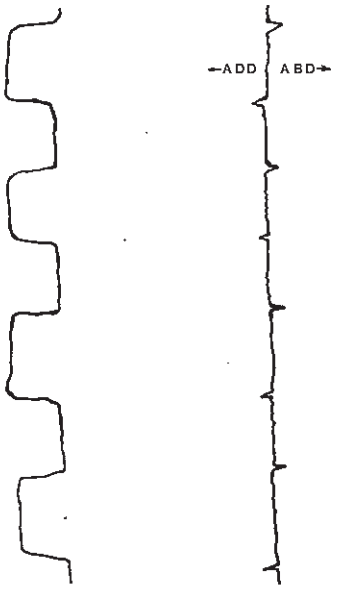


*Figure 4:* Patient 3. Mrs T.B. Example of Right eye—targets 10° amplitude. Left channel=eye position. Right channel=velocity channel. Shows marked reduction in abduction and adduction.

All other ocular and medical examinations were normal and electromyography of orbicularis, upper and lower limb muscles showed no signs of myopathic changes. Saccadic velocities were markedly reduced in both eyes for adduction and abduction and were more reduced for greater eye excursions.

Velocities were suggestive of tight antagonists. The findings were supportive of the diagnosis of progressive external ophthalmoplegia.

This patient has recently had lid surgery and is coping well. Her saccadic velocities will be repeated in the future to document any changes.

The study of saccadic eye movements has aided in the diagnosis and treatment of many oculomotor disorders. Saccadic velocities can become a useful diagnostic aid for the ophthalmologist and recording of eye movements and calculation of saccadic velocities can become a useful role for the orthoptist.

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