Assessment of Saccadic Velocity at the Bedside

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ABSTRACT

Saccades are a key component for the assessment and diagnosis of Neuro-ophthalmological disorders. Traditionally, clinicians have been taught to use large amplitude saccades (LAS) to assess saccadic velocity (SV), when small amplitude saccades (SAS) may be more effective. This study aimed to evaluate the advantages of SAS over LAS by presenting a video to 108 clinicians where both methods were used to assess a patient with a unilateral partial 6th nerve palsy. SAS was the preferred method in identifying the 6th nerve palsy by 43/55 (78.2%) of Neurologists, and 36/53 (67.9%) of Ophthalmologists. These findings indicate that SAS may be a more effective method than LAS for determining SV.

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Introduction

Eye movement assessment is essential for screening and evaluating many types of Neuro-ophthalmological, strabismic and orbital disorders. Recognition of saccadic velocity (SV) abnormalities can assist the clinician in distinguishing between restrictive (mechanical) and paretic (neurological) eye movement disorders, as the latter exhibit slow SV.^{1–4}

Saccades are conjugate eye movements that rapidly centre objects, detected in the periphery, onto the fovea to ensure optimal visual acuity and perception.^{1,3,5} Clinically, saccadic movements are assessed by instructing the patient to fixate alternately on two distinct targets. The initiation of saccadic eye movements must always be under the control of the clinician, in order to avoid patient fatigue and confusion. Saccades may be tested in both horizontal and vertical planes, corresponding to the actions of the horizontal and vertical recti respectively. The principal objective at the bedside is for clinicians to determine SV.

However, determining SV in the clinical setting can be difficult. To improve the ability to detect a slow saccade, the clinician may need to compare the same movement between both eyes. For

example, in a patient with a unilateral left sixth nerve palsy, the abducting SV of the left eye may be compared with the abducting SV of the right eye. On the other hand, because of anatomical proximity, a comparison can be made with the adducting SV of the ipsilateral (left) eye. This is most conveniently done by asking the patient to make sequential fixation movements and refixation movements between two different visual targets. In assessing horizontal SV at the bedside, these targets can simply consist of the clinician's left index finger, and a pen in the clinician's right hand, both held upright for the patient to view alternately at the appropriate distance.²

In the laboratory environment, electrodiagnostic techniques are used. However, these require sophisticated neurophysiological equipment, are not readily portable to the bedside, and are often expensive. This compares with emergent clinical decision-making at the bedside, such as in an Emergency Department setting. For instance, a patient with head and orbital injuries may have headache and horizontal diplopia but with a diminishing Glasgow Coma Scale, warranting rapid exclusion of raised intracranial pressure.⁶ If the abduction of one eye demonstrates slow SV,

this presumed 6th nerve palsy strongly suggests the non-localising effect of raised intracranial pressure, and is dealt with accordingly. On the other hand, if the SV of this eye is normal, the clinician can confidently state that the diplopia in this scenario is due to defective abduction from a mechanical aetiology. This could include orbital haemorrhage, or orbital tissue entrapped in an orbital fracture.⁷ In this environment, portable saccadometers worn on the patient's head, as used in specific research on Huntington's disease, are not clinically applicable.⁸

Neurophysiological assessment of saccadic eye movements shows that they are rapid, reaching up to 600 degrees/second. Additionally, saccades exhibit increasing velocity at greater amplitudes.^{1,5,9,10} Therefore, at the bedside, as the clinician is attempting to recognise slow SV in a patient with an eye movement problem, the appropriate amplitude for SV testing may be vital in eliciting the definitive clinical sign.¹

Traditionally, clinicians have been taught to assess SV by using large amplitude saccades (LAS) of at least 20°. However, small amplitude saccades (SAS), of less than 20°, may be a more effective alternative in determining the reduced SV of eye movements. Currently, no literature exists comparing these two methods.

Thus, at the bedside, the clinician's aim is to demonstrate in a specific patient with a defective eye movement that this patient's saccade is slow, representing neurologic dysfunction. This study hypothesises that it is easier for the clinician to

recognise slow saccades with SAS rather than LAS.

Materials and methods

A patient with a left unilateral, partial 6th nerve palsy was video-recorded during assessment of that eye's abducting and adducting saccades with both SAS and LAS technique (see Supplementary File). This provided a built-in control of normal SV during adduction, which could be compared with the abnormal, slow SV during abduction.

A total of 108 Neurology and Ophthalmology Consultants was recruited prospectively for one day each of one International Neurology conference and another International Ophthalmology conference, both held in Australia. This cohort consisted of 55 Consultant Neurologists and 53 Consultant Ophthalmologists. Participants were asked to observe a video of a patient with a left unilateral, partial 6th nerve palsy (see Supplementary Video). Participants were told that, as expected, the abducting SV was slow. The participants were then asked to determine whether recognising the slow saccade was more easily achieved by looking at the video of this patient's SAS or LAS. There was no limit to the number of times participants could view the recording.

During this video assessment of eye movements, participants were encouraged to blink and rest their own eyes to minimise the risk of fatigue, in order to avoid inaccurate observations. Each participant was then asked to fill out a questionnaire (Figure 1), indicating whether the LAS or SAS

Saccades Study

1) In which video was a slowed saccadic movement more noticeable?

- ☐ LARGE AMPLITUDE SACCADDES
- ☐ SMALL AMPLITUDE SACCADDES

2) Comments:

A) INITIALS: _____

B) SPECIALTY

☐ NEUROLOGY
(SUB-SPECIALTY : _____)

☐ OPHTHALMOLOGY
(SUB-SPECIALTY : _____)

☐ OTHER : _____

Figure 1. Questionnaire given to participants to complete after viewing the video.

method was more effective in demonstrating the pathological, slow saccade. The sequence in which the LAS and SAS assessments were viewed was alternated between each participant.

The preferred technique of the authors for testing SV is delineated in the Supplementary File.

Results

For the Consultant Neurologists, 78.2% (43/55) indicated that evaluation of SAS was more effective in demonstrating the slow saccade (Figure 2).

For the Consultant Ophthalmologists, SAS was preferred by 67.9% (36/53) for detecting the slow saccade (Figure 3).

Qualitative comments

Qualitative feedback from the two Consultant groups involved was received regarding saccadic testing techniques. Those who had indicated a preference for LAS often cited reasons involving technical difficulty: “I can’t tell with SAS because the distance is too small”. They also expressed a lack of familiarity with small amplitude testing for saccades: “I have never examined saccades using small amplitude before”.

In some cases, this was the first time a Consultant Neurologist or a Consultant Ophthalmologist had distinguished between LAS and SAS testing methods. Some Consultants, after repeatedly viewing the video, found that the slow abducting saccade was easier to detect with the SAS method: “It does seem clearer this way after watching the video for a while”.

Figure 2. Preference of neurologists for detecting slow saccades.

Figure 3. Preference of ophthalmologists for detecting slow saccades.

Discussion

To the knowledge of the authors, this study is the first to compare SAS and LAS for clinical examination of SV. The study demonstrated a preference for the use of SAS by both Consultant Neurologists and Consultant Ophthalmologists in detecting slow saccades.

Recognition of slow SV with SAS may be due to the underlying physiology of saccadic eye movements. There is a known linear relationship between saccadic amplitude and SV in saccades up to 20° , as can be seen from the work of Leigh et al. (Figure 4).^{1,5,9–12} As the SV is more rapid at higher amplitudes, a decrease in this velocity, caused by a neurological abnormality, will be harder to detect. Thus, the recognition of slow SV can be readily achieved at lower amplitudes as the saccade is inherently slower.

SAS may also be particularly beneficial when testing saccades in the elderly. In this group, saccades are recognised to be of lower velocities and to require longer reaction times.¹¹ LAS performed in this population group can result in difficulties locating the target, often requiring the individual to make several saccades of approximately 15° , alongside smaller corrective saccades, before the target is reached.¹¹ In contrast, a single saccadic movement can be achieved in this group utilising SAS, allowing the clinician to focus more accurately on assessing SV.

Figure 4. By permission of Oxford University Press, USA. Plot from 'The Neurology of Eye Movements' by Leigh and Zee (2015) demonstrating the relationship between saccadic peak velocity and amplitude from 10 normal subjects.¹

It should be noted that these proven physiological properties have all been identified through the use of electrodiagnostic techniques performed in Neurophysiology laboratories.^{1,5,9–13} The real-world, non-laboratory differences between SAS and LAS may in some cases be more subtle and less perceivable. These observations, naturally, are subject to clinician bias.

A notable example of this is the clinical versus laboratory detection of the slow adducting SV in the setting of an internuclear ophthalmoplegia (INO).¹⁴ Indeed, in 2003, Frohman et al.¹⁴ determined that in a group of 18 patients with INO, mild slowing of adduction, that had been confirmed by electrooculography (EOG), was not detected by 71% of 209 clinicians. Whilst clinical testing is inherently less accurate than the EOG confirmation of the disorder, the poor detection rate reported by Frohman's group may be explained by several confounding factors.

Firstly, the saccades tested in Frohman et al.'s study were generally of large amplitude (approximately 20°), thus potentially masking slow SV. Secondly, the specific technique of testing saccades was not reported except to say that light emitting diodes (LEDs) were used in a 'pseudorandom' fashion during the EOG assessment, and in an unknown fashion during clinical testing. Thirdly, the fixing eye preference was not documented, so that the patient's ability to achieve the desired saccade ipsilateral to the INO may have been degraded. Fourthly, it was not documented whether the patients were viewing the targets with both eyes open, or just with the eye with the INO. Fifthly, it is not clear whether the patients were encouraged to blink, and to have a frequent rest from their saccadic efforts. This is relevant because during continued saccadic testing, the extraocular muscles fatigue, the patient's ocular surface becomes dry and uncomfortable due to lack of blinking, and Bell's phenomenon may take over, disrupting the integrity of the saccade.¹⁵ This can be due to one eye suppressing whilst the other eye searches for the next target, or because the heterotropic eyes may have been attempting to reach the target independently. Sixthly, the clinicians ranged from Medical students, to Neurologists, to Neuro-ophthalmologists.¹⁷ For the patients with

moderately-severe INO, the Medical students were less likely to report the reduced SV of the adducting saccade (median 54%) as compared with the Ophthalmology residents (79%), Neurology residents (72%), Neurologists (77%), MS specialists (91%), and Neuro-ophthalmologists (91%). This clear variability in successful observation of the defective adducting SV intrinsically impacts upon the reliability of Frohman et al.'s results.

Additional studies focussing on the practicalities of using SAS and LAS, especially in differing severities of abnormal eye movements, should inform clinicians not only as to the existence of these two techniques, but also to the utility of each. Theoretical advantages of SAS that are yet to be explored include the avoidance of any diplopia that can occur with an incomitant squint, the minimisation of pain if a painful orbital condition is present, and the reduction of confounders such as blinking during a LAS.

Conclusion

Testing of saccadic eye movements is an integral component of Neurological and Ophthalmological assessment. This study demonstrated that in two cohorts of Neurologists and Ophthalmologists, the majority preferred SAS to LAS in order to recognise the reduced SV of slow saccadic eye movements. This may be attributable to the theoretical physiological benefit in better recognising slow saccades because of their smaller amplitudes, as inherently a LAS with a fast SV, may mask a pathologically slow SV. In conclusion, the authors believe that utilising SAS can enhance the identification of slow saccades. Subsequently, improvements in diagnosis, and therefore patient management, may be made by employing this technique among clinicians at all levels.

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Declaration of interest

No author has a financial or proprietary interest in any material or method mentioned.

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