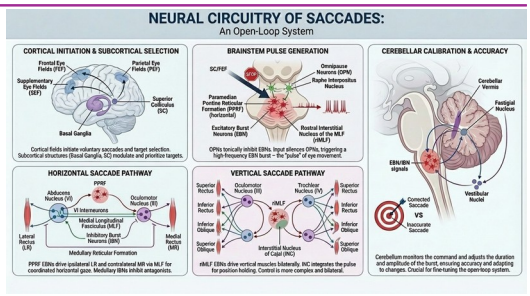
Saccades — Clinical Cheat Sheet

OVERVIEW & DEFINITIONS



Definition: Rapid, ballistic eye movements (150-600°/sec) for gaze shifting between targets of interest. The fastest eye movement and a fundamental component of visual scanning and orientation.

Neural Pathway: Frontal eye fields (FEF) → superior colliculus (SC) → paramedian pontine reticular formation (PPRF) → abducens nucleus (CN VI) → medial longitudinal fasciculus (MLF) → CN III nucleus.

Types: Reflexive (visual target-driven), voluntary (volitional command), predictive (anticipatory timing), memory-guided (delayed response), and anti-saccade (inhibitory control task).

Clinical Value: Essential marker of brainstem oculomotor control; abnormalities localise to specific neural structures with high specificity for brainstem, cerebellar, and cortical disease.

SACCADE PARAMETERS & NORMAL VALUES

Parameter	Definition	Normal Range	Clinical Significance
Latency	Time from target onset to saccade initiation	100-200 ms	Delayed: brainstem/motor disease; express: 60-80 ms
Peak Velocity	Maximum eye speed during the saccade	400-600°/sec	Slow (<300°/sec): PPRF/CN VI lesion, myasthenia
Amplitude/Gain	Actual displacement vs target displacement	0.95-1.05 ratio	Hypometric (<0.90): brainstem; hypermetric (>1.10): cerebellum
Duration	Total saccade time (amplitude-dependent)	30-100 ms	Extended: brainstem pathology, fatigue, medication
Main Sequence	Peak velocity vs amplitude relationship	Linear	Violations suggest cerebellar or brainstem disease

CLINICAL ASSESSMENT PROTOCOL

A. Setup: Infrared video eye tracker (minimum 250 Hz sampling rate), patient fixates center target in a dark room, fully alert and cooperative.

B. Calibration: Pre-test with ±5° and ±10° step targets to establish gain baseline for accuracy reference across all amplitudes tested.

C. Amplitude Testing: Random step paradigm: 5°, 10°, 20°, 30° amplitudes; test horizontal, vertical, and oblique planes. Minimum 5 trials per amplitude.

D. Stimulus Conditions: Gap task (200 ms delay pre-target) evokes express saccades; overlap task (target before offset) delays latency — dissociates reflex from voluntary control.

E. Recording: Measure latency, peak velocity, accuracy (gain), duration, and bilateral symmetry. Exclude early/late responses; report mean ± SD.

SACCADE ABNORMALITIES & PATHOLOGY MATRIX

CLINICAL SACCADIC FINDINGS: DESCRIPTION, CLUES & CAUSES

Saccadic Finding	Description and Clues	Common Causes / Context
Hypermetric Saccades	**Eyes overshoot target, then correct back.** Visualized as an eye moving past a red target then quickly returning.	Cerebellar stroke, MS, Zellweger syndrome
Hypometric Saccades	**Eyes undershoot target.** Visualized as an eye stopping short of a red target.	Parkinson's, Cerebellar degenerations, Normal aging
Slow Saccades	**Reduced peak velocity.** Visualized as a slow, drifting arrow to the target.	SCA2, Pontine stroke Phenytoin
Increased Latency	**Long reaction time to start saccade.** Visualized as a clock icon with a delay before eye movement.	PD, Frontal deficit (TBI), Benzodiazepines
Square-Wave Jerks (SWJ)	**Involuntary small saccades off target then back.** Visualized as an eye momentarily jerking away and returning.	PSP, Cerebellar disorders Fatigue, Normal aging
Opsoclonus / Flutter	**Burst of back-to-back saccades.** Visualized as chaotic, rapid, conjugate eye movements.	Paraneoplastic OMS Toxic (Phenytoin)
INO (Internuclear Ophthalmoplegia)	**Slow adducting eye saccade.** Visualized as two eyes, one moving quickly, the other lagging in adduction.	Multiple Sclerosis, Brainstem stroke
Vertical Gaze Palsy	**Impaired vertical saccades.** Visualized as difficulty or inability to look up or down.	PSP, Midbrain Stroke, Pineal region tumour
"Round-the-Houses"	**Indirect arc trajectory for vertical targets.** Visualized as a curved path to reach a vertical target.	Progressive Supranuclear Palsy, Severe midbrain lesion

Abnormality	Description	Localisation	Associated Pathology
Slowed Velocity	Peak velocity <300°/sec, sluggish	PPRF, nucleus VI, nucleus III	Brainstem stroke, myasthenia gravis, Guillain-Barré
Hypometric	Undershoot (gain <0.85); corrective saccades	PPRF, cerebellum, or fatigue	Brainstem lesion, cerebellar ataxia, Parkinsonian
Hypermetric	Overshoot (gain >1.15); oscillation	Cerebellar lateral hemisphere	Cerebellar degeneration, spinocerebellar ataxia, MS
Saccadic Intrusions	Unintended saccades during fixation	Brainstem, cerebellum, cortex	Ataxic neuropathy, Parkinsonian disease, ADHD
Square-Wave Jerks	Paired saccades away then return (0.5-2 Hz)	Cerebellum, brainstem	Normal if low freq; pathologic if high amplitude
Ocular Flutter/Opsoclonus	High-frequency arrhythmic (>10 Hz)	Cerebellum, brainstem, toxic	Paraneoplastic, anti-Hu antibodies

LOCALISATION GUIDE: SACCADE DEFECTS

Structure	Lesion Effect	Additional Signs	Key Diagnostic Marker
FEF (Cortex)	Contralateral slow saccades, preserved VOR	Contralateral motor weakness	Ipsilateral pursuit intact
Superior Colliculus	Bilateral saccade slowing, "ocular apraxia"	Vertical gaze limitation	Loss of reflexive saccade control
PPRF (Brainstem)	Ipsilateral saccade paralysis, VOR intact	Ipsilateral CN VI palsy	"One and a half" syndrome if MLF
MLF (Brainstem)	INO: adduction deficit, convergence intact	Contralateral gaze limitation	Adduction lag on horizontal saccade
Cerebellum	Hypermetric saccades, dysmetria	Limb dysmetria, nystagmus	Violation of main sequence
Basal Ganglia	Slowed vertical saccades (PSP), freezing	Hypokinesia, rigidity	Progressive supranuclear palsy hallmark

ADVANCED SACCADE TASKS & CLINICAL INTERPRETATION

Anti-Saccade Test: Patient looks opposite to target; tests volitional saccade control (FEF/DLPFC). Error rate >25% suggests cortical dysfunction or dementia.

Memory-Guided Saccades: Target flashed during delay period; tests working memory circuits. Errors suggest prefrontal or dorsolateral prefrontal pathology.

Vertical Saccades: Critical marker — isolated vertical slowing in alert patient = PSP or MSA. Horizontal normal with vertical slow = favourable localisation.

Age Effects: Latency increases ~1 ms/year after 40; velocity decreases ~0.5%/year. Always use age-appropriate normative data.

Medication Effects: Antiepileptics, antipsychotics, antihistamines slow saccades; benzodiazepines increase latency. Document all medications before testing.