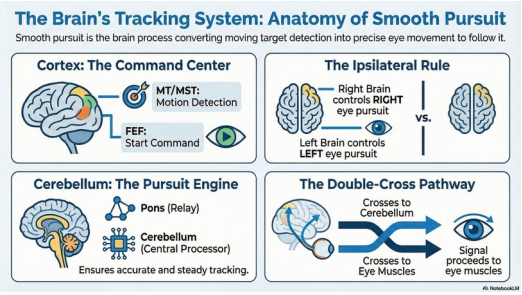
Smooth Pursuit — Clinical Cheat Sheet

OVERVIEW & DEFINITIONS



Definition: Slow, continuous eye-tracking movement following smooth visual target motion (<30°/sec). A conjugate binocular response that maintains foveal fixation on a moving object.

Purpose: Assess cortical-cerebellar-brainstem integration; the most sensitive early marker of neurodegenerative disease and a key indicator of central vestibular dysfunction.

Key Metric — Gain: Gain = actual eye velocity / target velocity. Normal >0.85 at 0.5 Hz. Gain declines with increasing stimulus frequency and is age-dependent.

Neural Pathway: Cortex (V5/MT area, MST) → nucleus pontis basalis → cerebellum (flocculus, vermis) → brainstem nuclei (CN VI, III). Lesion at any level disrupts smooth tracking.

NEURAL PATHWAY COMPONENTS & LESION EFFECTS

Structure	Function	Lesion Effect	Distinguishing Features
V5/MT Cortex	Motion detection, velocity encoding	Reduced gain (<0.70), contralateral bias	Pursuit asymmetry with intact saccades
Nucleus Pontis	Relays cortical motion signal to cerebellum	Pursuit deficit (rare isolated lesion)	Usually combines with brainstem signs
Cerebellar Flocculus	Gain learning, smooth phase maintenance	Saccadic intrusions, inability to smooth track	Catch-up saccades interrupt pursuit
Brainstem VI/III	Motor output for eye velocity	Reduced velocity, staircase pattern	Conjugate deficiency, normal saccades
Vestibular (VOR)	Head tracking vestibular input	Asymmetric gain if unilateral vestibular loss	Worse with head movement during pursuit

CLINICAL ASSESSMENT PROTOCOL

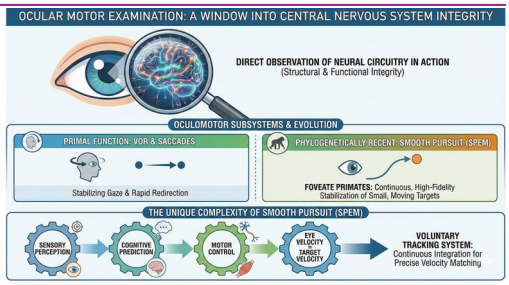
A. Setup: Infrared eye tracker (minimum 250 Hz), alert patient, fixation motivation maintained throughout, minimal head movement with chin rest.

B. Stimulus: Sinusoidal or ramp target motion. Recommended frequencies: 0.2 Hz (age-sensitive baseline), 0.5 Hz (standard), 1.0 Hz (exposes subclinical deficits).

C. Directional Testing: Horizontal rightward/leftward, vertical upward/downward. Assess directional asymmetry which suggests lateralised pathology.

D. Recording & Analysis: Quantify pursuit gain, catch-up saccade frequency, latency, and directional asymmetry at each frequency. Apply age correction factor.

PURSUIT GAIN INTERPRETATION MATRIX



Gain Range	Classification	Suspected Pathology	Next Steps
0.90-1.05	Normal (at 0.5 Hz)	Intact cortical-cerebellar-brainstem pathway	No further oculomotor testing needed
0.80-0.89	Borderline (age-dependent)	Medication effect, fatigue, early disease	Repeat; compare with age norms; test at higher freq
0.60-0.79	Moderately reduced	Cortex (MT/MST), cerebellum, or degenerative	MRI brain; cerebellar function battery
0.40-0.59	Significantly reduced	Brainstem stroke, advanced cerebellar ataxia	Urgent neuroimaging; neurology referral
>1.05 or <0.40	Severely abnormal	Advanced cerebellar degeneration, MSA	MRI + genetic testing if familial

SACCADIC INTRUSIONS & CATCH-UP ANALYSIS

Finding	Description	Frequency Significance	Localisation
Catch-up saccades	Small saccades closing velocity gap	Normal if <1 per cycle	Abnormal: cerebellar flocculus, brainstem
Back-up saccades	Saccades in opposite direction to target	Always abnormal	Brainstem or cortical lesion
Square-wave intrusions	Brief saccade away then return	>2 per second abnormal	Cerebellar, basal ganglia, or cortical
Staircase pattern	Multiple small steps instead of smooth	Replaces pursuit entirely	Severe cerebellar or brainstem disease

DIFFERENTIAL DIAGNOSIS & CLINICAL INTERPRETATION

Bilateral Reduced Gain: Medications (sedatives, anti-epileptics), aging, fatigue, inattention — always exclude these before attributing to pathology.

Unilateral Reduced Gain: Ipsilateral cortical lesion (V5/MT), contralateral cerebellar lesion, or peripheral vestibular hypofunction with visual tracking deficit.

Frequency-Dependent Loss: Normal at low frequency but impaired at high (>0.5 Hz) — suggests early cerebellar disease. High frequencies expose subclinical deficits.

Pursuit vs Saccade Pattern: Isolated pursuit deficit with normal saccades = cortical or cerebellar. Both impaired = brainstem. Saccade-only = basal ganglia.

Age Correction: Gain declines ~0.1% per year after age 40. Always use laboratory-specific age-matched normative data for interpretation.

Medication Checklist: Benzodiazepines, phenytoin, carbamazepine, gabapentin, alcohol, and opioids all reduce pursuit gain. Document medications before testing.