Introduction to Measuring Jitter

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Neuromuscular jitter: what is it, and how is it measured?
Endplate potentials
Endplate potentials & action potentials

Elmqvist et al, 1964
SFEMG: signals from 1 muscle fiber
The selectivity of SFEMG results from:

- The electrode construction
- High-pass filter (500Hz)
CNEMG: signals from 2 - 15 muscle fibers
Concentric
0.07 mm$^2$

Single fiber
0.0005 mm$^2$
SF vs CN electrodes
SF vs CN electrodes

- SFE
- CNE 36G
SF vs CN electrodes

SFE

CNE 36G

CNE 25G
Jitter with non-SFE

- Payan, 1978 – “Blanket principle”
- Weichers, 1985; Clark & Eisen, 1985 – jitter with MNE
- Ertas, 2000 – compared SFE & CNE
- Sarrigiannis, 2006 – sensitivity of CNE jitter for MG in Orb oculi = 95%
  - 36G CNE; 2kHz high pass filter; normal limits determined by ROC in 20 controls; 56 MG patients
- Benatar, 2006 – “ “ “ “ “ “ in frontalis = 76%
  - 36G CNE; 2kHz high pass filter; SFE normal limits; 21 MG patients
Why use CN electrodes to measure jitter?

• Re-usable electrodes are not allowed or available in many places.
• CN electrodes don’t need to be serviced.
• They’re cheaper. (Though SF electrodes can cost less per use in the long-term.)
• They’re sharper & somewhat less painful.
Limitations of using CN electrodes to measure jitter

- Precise measurement of jitter requires great attention to CN signal configuration, thus studies take longer.
- CNEs are less directional, thus harder to position.
- CNEs don’t maintain position in the muscle as well.
- Stimulation studies are difficult except in facial muscles.
- Cannot measure FD with CNEs.
Measuring Jitter with CN Electrodes

Use smallest CNE available – DCF 25 (orange base)

25mm x 30G, Area = 0.019 mm²
SFEMG electrode

DCF 25 electrode
Equipment settings for measuring jitter

- **LF Filter**: to remove distant signals
  - SFEMG electrode – 500 Hz
  - CN electrode – 1000 Hz
- **Gain**: typically 0.2-0.5 mV/div (to see signals clearly)
- **Sweep**: typically 0.5 ms/div (to see jitter & late components)
- **Signal triggered delay**: to show components before and after the trigger point
Measuring jitter during axonal stimulation
Measuring jitter during axonal stimulation – frontalis muscle

Recording electrode (SFE)

Stimulating electrode

Surface stimulation

Needle stimulation
Measuring jitter during voluntary activation

Electrode position for measuring jitter with voluntary activation
Measuring Jitter with SF or CN Electrodes

Use 500 Hz LF filter for SFE, 1000 Hz for CNE

May use voluntary or stimulation activation

Record widely across the width of the muscle

**With Voluntary Activation**

Maintain constant activation rate
Record 20 pairs: ≥15 pairs must be of acceptable quality

**With Stimulation Activation**

Stimulation frequency: 5-10 Hz
(10 is preferred)
Record 30 APs: ≥ 20 APs must be of acceptable quality
Jitter Measurement Techniques

Voltage Level vs Peak Detection
Voltage level technique

Acquisition trig level

start

stop
**Voltage level technique**

- Acquisition trig level
- Start
- Stop

**Peak detection technique**

- Calc peak start
- Calc peak stop
- Acquisition trig level
How to calculate the jitter?

- The IPI can be affected by factors other than neuromuscular variability, e.g., slow trends due to electrode movement, VRF effects of variable firing rate.
  - Standard deviation of IPI would be increased by trends.
  - Mean difference of consecutive IPI’s (MCD) is relatively unaffected by trends.
  - Mean sorted difference (MSD) corrects for affect of firing rate
Inter-Potential Interval (IPI) (jitter)
Inter-Potential Interval (IPI) (jitter)
Inter-Discharge Interval (IDI) (rate)
Calculating jitter: MCD
(Mean difference between *consecutive* IPIs)
Calculating the jitter

• MCD – corrects for trends
• Mean Difference between consecutive Sorted intervals (MSD) – corrects for effect of variable firing rate
• Use the lower of these as the jitter
Jitter comparison
How does measuring jitter improve your routine EMGs?

• Your ear becomes attuned to variability in the pitch of MUPs during EMG.

• You can then hear unstable MUPs
  o Trigger on them, turn up the LF filter
  o Increase display speed
  o Superimpose MUPs & observe waveform variability
Assessing MUP stability
Registrants for this course receive a 50% discount. Use the discount code Sanders50 when ordering.
Guidelines for SFEMG - New publication
Read the full publication here.

Events where SFEMG is included

- Brazilian Congress of Clinical Neurophysiology and the Latin American Congress of Clinical Neurophysiology, Sao Paulo:
  * Aua 14 (Wednesday) 1h30pm to 3h30pm: Demonstrative Session: Analysis of the "jitter" with concentric needle. - "Single Fiber" Electromyography: Voluntary and stimulated – Sanders, Kouyoumdjian, Machado

- AANEM in Austin, TX:
  * Oct 18 90 minute SFEMG "Course" – Sanders & Massey
  * Oct 19 90 min SFEMG workshop – Sanders & Massey

New Videos
A series of new videos about "Jitter in Reinnervation" is now available.

Recent Publications


SFEMG Online Videos available
An extensive series of instructional videos on all aspects of the SFEMG technique is available online here. They can also be found on YouTube: Search for "SFEMG" or click here.
### SFEMG Videos

**Introduction**
- The Authors
- The SFEMG Book
- AID Title Survey

#### Principles of SFEMG
- Needle, Selectivity, and Instrumentation
- Fiber Density Measurements
- Jitter Phenomenon and Stimulation SFEMG
- Jitter Measurement During Voluntary Activation
- Quality Control in SFEMG
- Jitter during Voluntary Activation and Stimulated Velocity Recovery Function

#### Technical Aspects of SFEMG
- Trigger and Delay Line
- Filters
- Amplitude Variation in SFEMG Signals
- Jitter Display as Dots in Sequential Histograms
- Care of Electrodes

#### SFEMG: Recording and Analysis
- **Volitional**
  - Frontalis
  - Biceps Brachi
  - Extensor Digitorum Communs

- **Stimulation SFEMG**
  - Frontalis, Needle Stimulation
  - Frontalis, Surface Stimulation
  - Orbicularis Oculi
  - Extensor Digitorum Communs
  - Tibialis Anterior

- **Fiber Density**
  - Extensor Digitorum Communs

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### Jitter: Measurement and Interpretation
- Jitter Appreciation
- Technical Block (False Trigger)
- Triangular Jitter potentials
- Recognizing Trends
- Visualizing Jitter in Triplet Potential
- Selecting the Trigger in a Multi-spike Potential
- Analyzing Jitter in a Multi-spike Potential
- Spindle Muscle Fiber
- Direct Muscle Stimulation
- High Jitter Without Blocking
- Flash (Sensory Jitter)
- Neuromuscular Blocking
- Neuromuscular Blocking: Difficult
- Pathetic Transmission
- E Response
- Axon Reflex

### Measuring Jitter with Concentric Electrodes
- Techniques: Extensor Digitorum Communs
- Action Potential Summation in Ch EMG

### Interviews with the Authors
- Diagnosis
  - Diagnostic strategy
  - Pre and Post Sympathterapy Differential
  - Normal Limits for Repetitive Nerve Stimulation
  - When Repetitive Nerve Stimulation is Abnormal
  - Longitudinal Studies
  - Fiber Density in Motor Neuron Disease
  - Fiber Density in Neuromuscular Junction Disease
- Reports
- Technical
  - Concentric Needle for Jitter Analysis
  - Number of Discharges
  - Multi-spike Analysis
  - Outliers and Mean Values
- Learning SFEMG
  - Why Learn SFEMG
  - How To Learn SFEMG
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