Motor Unit Number Estimation (MUNE), particularly with MUNIX

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Principle for MUNE

1. Record compound muscle action potential (CMAP). This is a sum of all motor unit potentials (MUPs). Analyze CMAP amplitude or area.
2. Obtain MUPs and Estimate average MUP amplitude or area
3. # MUs = CMAP amplitude / MUP amplitude

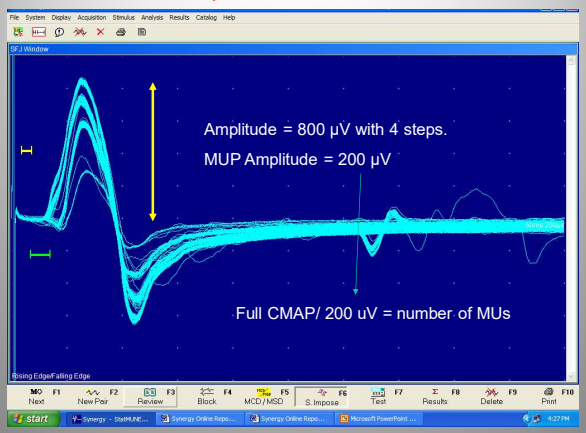
   or CMAP area / MUP area

   or CMAP "descriptor"/ MUP "descriptor" (MUNIX)

Motor unit number estimation, MUNE

- Incremental stimulation (McComas)
  - automatic subtraction (Ballantyne, Stålberg)
- Multiple point stimulation (Kadrie)
- F-response (Doherty, Stashuk)
- Spike-triggered averaging (Brown, Stålberg)
- Statistical method (Daube)
- MUNIX (Nandedkar-Barkhaus-Stålberg)
- Clustering index (Sonoo et al)
- Form Factor (Nandedkar et al)
- CMAP Scan (Block, Bostoc et al)
- Stepix, Ampix (Nandedkar et al, submitted)

Step 2: Incremental stimulation.



McComas et al

Motor Unit Number Index (MUNIX)

Developed by Nandedkar, Barkhaus & Stålberg

Three step process

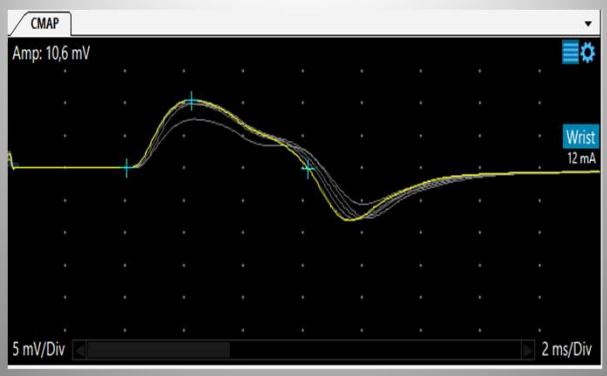
1 - Record CMAP

2- Record surface EMG at various force levels

3- Compute the MUNIX using a a special statistical method

This method gives an 'index' related to the number of motor units. Individual MUPs are not identified.

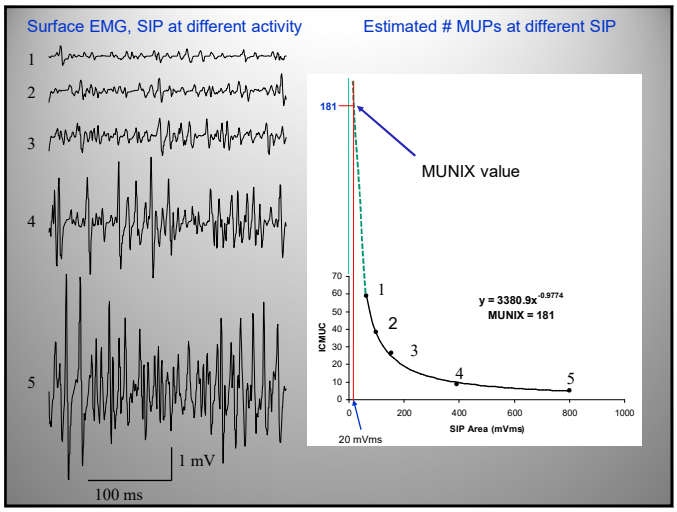
Step 1: Record highest CMAP



Step 2: Record Surface EMG, SIP

Step 3, estimation of # MUPs for various degree of activation (SIP)

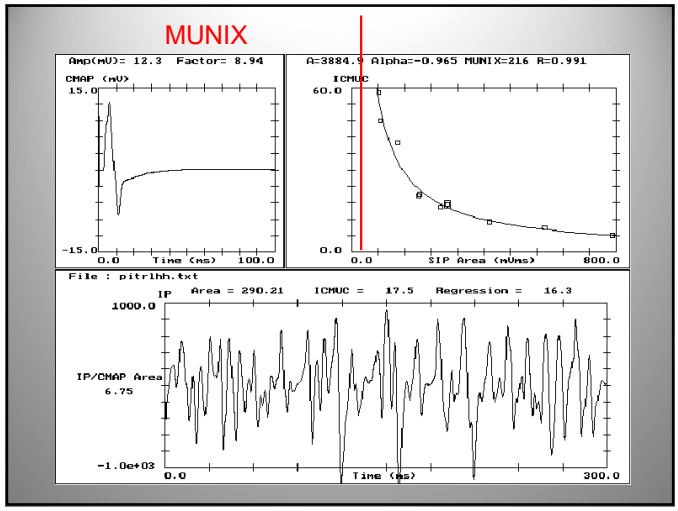
$$\left(\frac{\text{CMAP power}}{\text{CMAP area}}\right) / \left(\frac{\text{SIP power}}{\text{SIP area}}\right) = \text{“N” for a given surface EMG (SIP)}$$



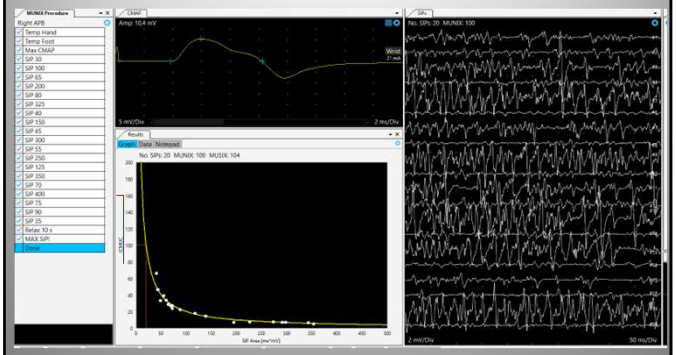
Extrapolation from summation pattern to "single MUP pattern"

- With increasing activation there is an increasing summation. If summation signal is used for calculation, erroneously low MUNIX value is obtained.
- Therefore, calculation is made at various degree of activity and extrapolation is made to expected value at very low activity.
- MUNIX value is the value extrapolated to activity = 20 mVms

Practical examples

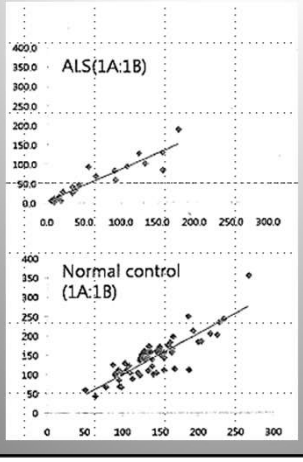


MUNIX, Sierra (Cadwell)



Reference material

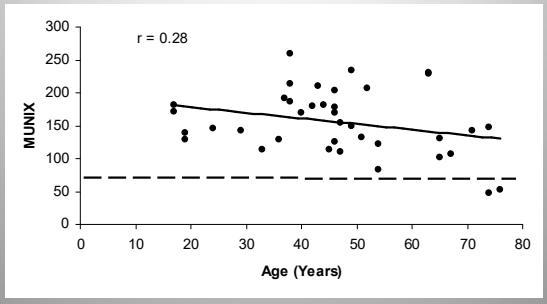
Intra-observer test-retest



15-20% reproducibility for healthy
20-25% " in pathology

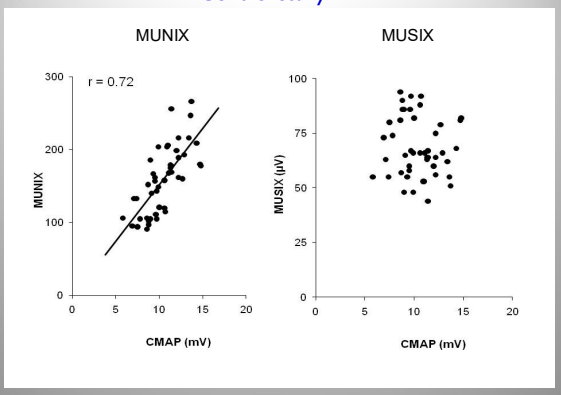
Suk-Won Ahn et al
Muscle Nerve 2010

Reference values
MUNIX vs age



MUSIX (motor unit size index) = CMAP Amplitude / MUNIX

Control study

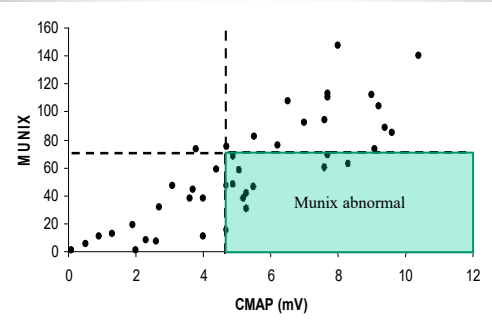


MUNIX is correlated to CMAP ampl
MUSIX is not correlated to CMAP ampl

Nandedar,Barkhaus, Stålberg

Patients

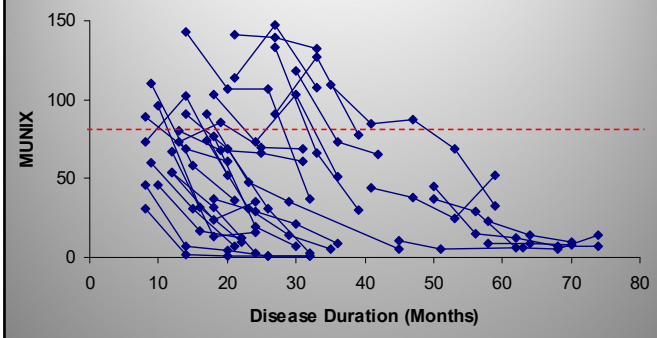
Motor unit number index "MUNIX" in ALS



A general correlation between MUNIX and CMAP, BUT not always.
Some have normal CMAP amplitudes but low MUNIX (reinnervation)

modified from
Nandedkar,BarkhausStålberg 2003

Serial MUNIX Measurements in ALS : Hypothenar



Nandedkar, Barkhaus

What can affect MUNIX & How?

- Submaximal nerve stimulation (technical or physiologic)
- Stimulus artifact
- Baseline shift in SIP
- Non homogenous SIP (gives lower Munix)
- Tremor (gives lower Munix)
- Patient unable to offer full resistance
- Volume conduction (Bimodal amplitude in SIP) (may give too high Munix)
- E1 electrode position is suboptimal giving smaller CMAP
- Temperature (> 29 degrees Celsius on the dorsum of hands and > 27 degrees Celsius on the dorsum of the feet
- Degree of training important

MUNIX findings, Summary

- MUNIX values vary among different normal muscles
- Reduced with age
- Reduced in patients with neurogenic disease
- Useful to follow disease progression

The MUNIX method

Pros

- Fast : Less than 5 minutes
- Non-invasive
- Minimal stimulation
- Reproducible
- Can be used to monitor changes in #MUs over time

Cons

- Requires voluntary muscle activation. Difficult in very weak muscles.
- Volume conduction from other muscles may affect to SIP
- Mathematical model is not intuitive

Indications

MUNIX was developed to follow axonal loss (ALS, polio, SMA)

NOT effective in

Myopathy (primary muscle diseases)

Facial muscles

Literature hints

Neuwirth C, Nandedkar S, Stålberg E, Weber M. Motor unit number index (MUNIX):
A **novel technique** to follow disease progression in amyotrophic lateral sclerosis. Muscle Nerve 2010;42:379–84.

Nandedkar SD, Barkhaus PE, Stalberg EV, Neuwirth C, Weber M. Motor unit number index: **Guidelines** for recording signals and their analysis. Muscle Nerve 2018;58(3):374-380.