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.

Amplitude = 800 µV with 4 steps.

MUP Amplitude = 200 µV

Full CMAP/ 200 uV = number of MUs
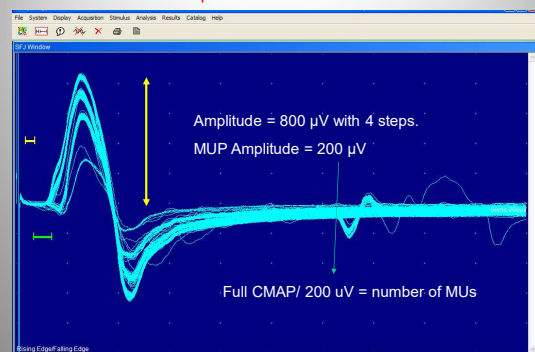
McComas et al

Motor Unit Number Index (MUNIX)
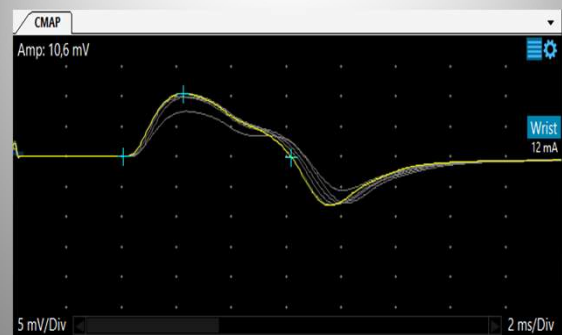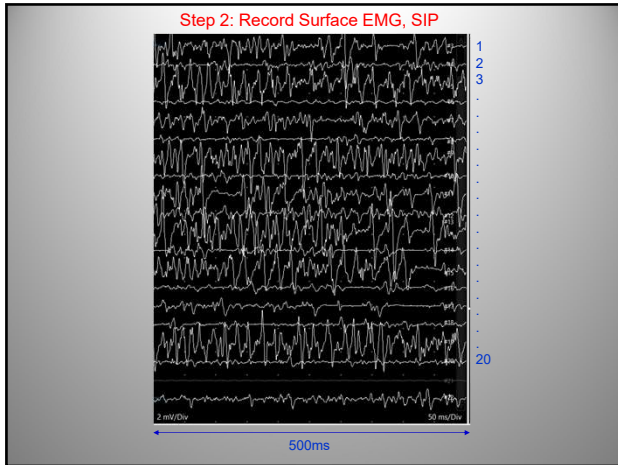
Developed by Nandedkar, Barkhaus & Stålberg

Three step process

    1 - Record CMAP

    2- Record surface EMG at various force levels

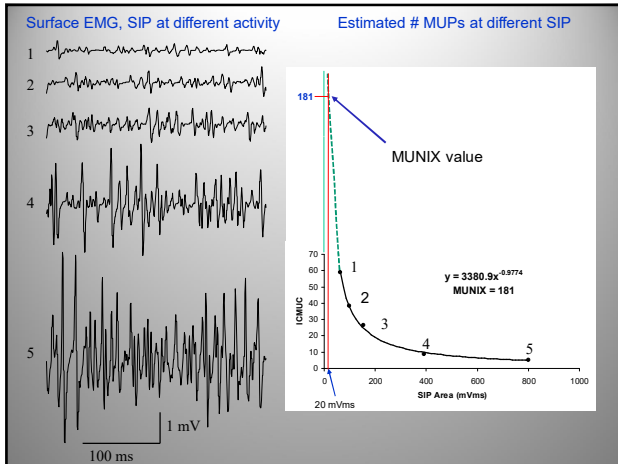   3- Compute the MUNIX using a a special statistical method

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

1
2
3
.
.
.
.
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.
.
.
.
.
.
.
.
20

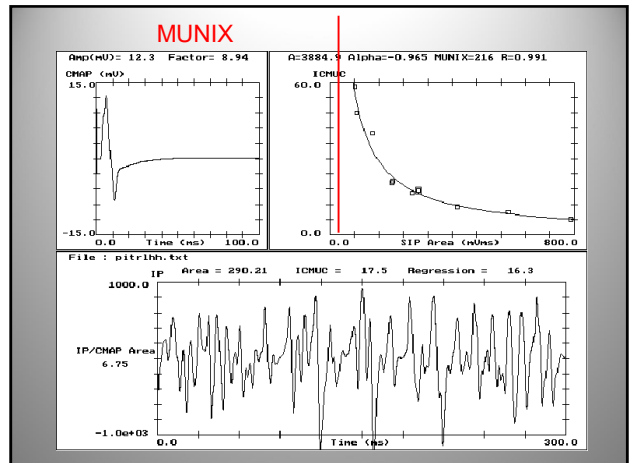2 mV/Div   50 ms/Div

500ms

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

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

Surface EMG, SIP at different activity   Estimated # MUPs at different SIP

1
2
3
4
5

181

MUNIX value

y = 3380.9x$^{-0.9774}$
MUNIX = 181

ICMUC

70
60
50
40
30
20
10
0
0   200   400   600   800   1000
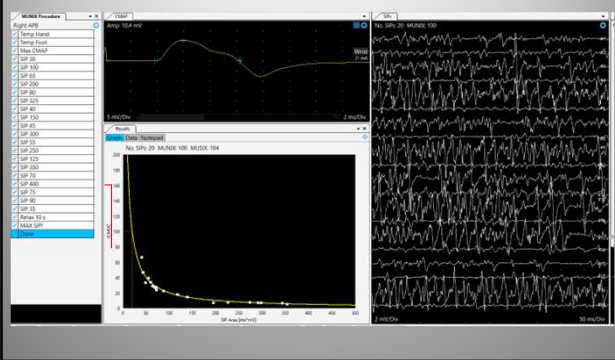SIP Area (mVms)

20 mVms

1 mV
100 ms

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.

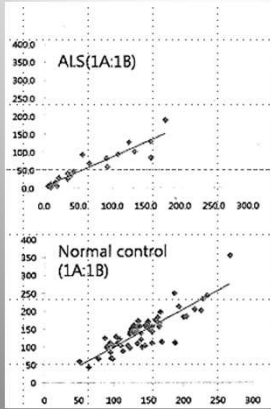- MUNIX value is the value extrapolated to activity = 20 mVms

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Practical examples

MUNIX

Amp(mV)= 12.3   Factor= 8.94
CMAP (mV)
15.0

A=3884.9 Alpha=-0.965 MUNIX=216 R=0.991
ICMUC
60.0

-15.0
0.0   Time (ms)   100.0

0.0
0.0   SIP Area (mVms)   800.0

File : pitrlhh.txt
IP   Area = 290.21   ICMUC =   17.5   Regression =   16.3
1000.0

IP/CMAP Area
6.75

-1.0e+03
0.0   Time (ms)   300.0

MUNIX, Sierra (Cadwell)

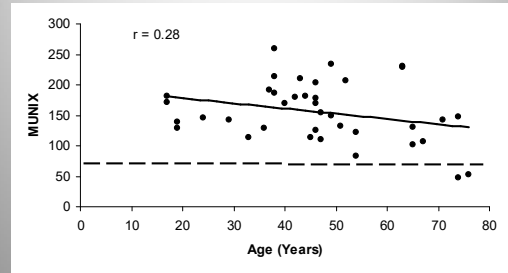## Reference material

Intra-observer test-retest

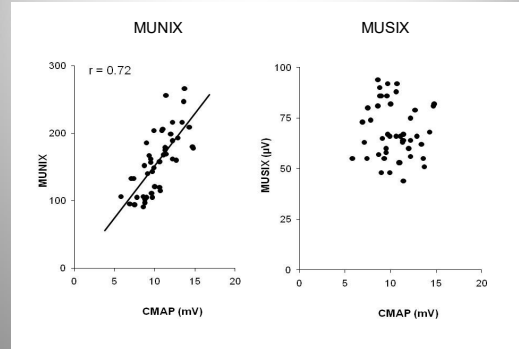15-20% reproducibility for healthy
20-25%   "   in pathology

Suk-Won Ahn et al
Muscle Nerve 2010

Reference values
MUNIX vs age
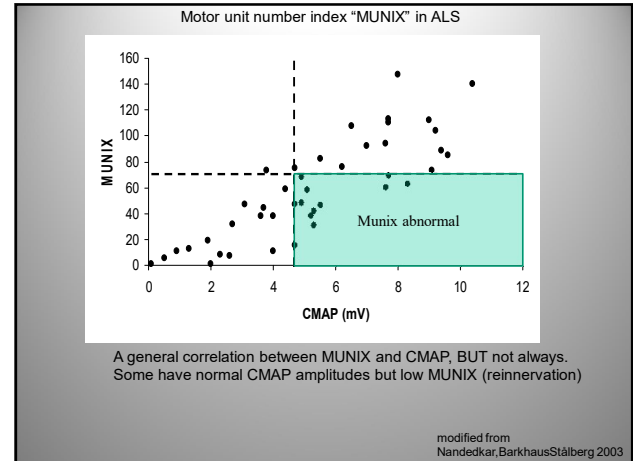

MUSIX (motor unit size index) =
CMAP Amplitude / MUNIX
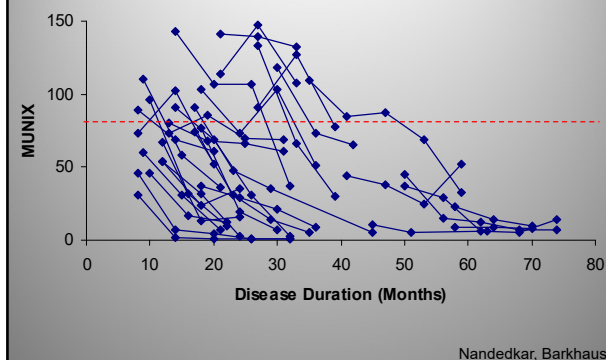
Control study

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

MOTOR UNIT NUMBER INDEX: GUIDELINES FOR

RECORDING SIGNALS AND THEIR ANALYSIS

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Muscle Nerve, sept 2018