Rehabilitation for Nerve & Tendon Transfers after SCI

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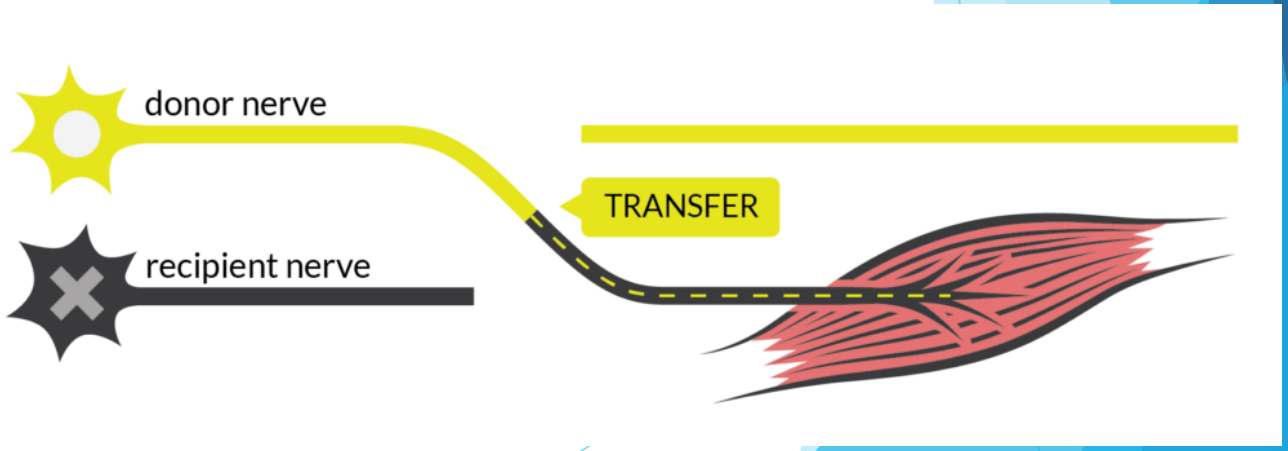
Topics

- Nerve transfers after SCI
  - Phases of Rehabilitation (Pre & Post Surgery)
- Case Example
- Biofeedback
- Tendon Transfers after SCI

Goals of surgery (nerve or tendon transfers)

- Restore hand function and increase independence
  - Hand function is typically the most desired improved function after SCI
- Improve quality of life
- Both nerve and tendon transfers require an expendable donor with normal function that is innervated above the level of the SCI
  - This donor is used to restore an

absent and more useful function



Nerve Transfers

Nerve Transfer Phases of Rehabilitation

1 - Pre-operative Phase

2 - Protection Phase

3 - Silent Phase

4 - Re-Education Phase

5 - Strengthening Phase

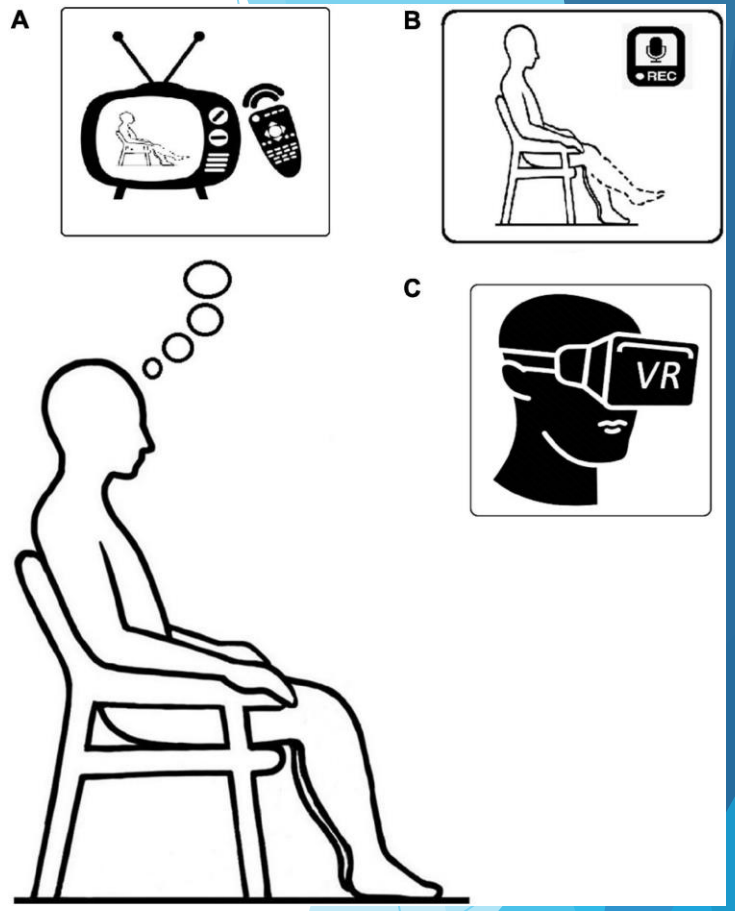
6 - Endurance Phase

1) Pre-operative phase

- Maximize PROM of affected joints and address contractures / tightness / deformities via splinting
- Strengthen the donor nerve/muscle and other functioning muscles
- Could start visualization exercises
- Desensitization, sensory re-education

Visualization / Motor Imagery

- E.g. mental practice, mental imagery, motor imagery
- Consciously and repeatedly IMAGINE performing the movement without actually moving your body
  - Observing & imagining the action
  - Virtual Reality (not as commonly used)
  - Mirror therapy (not as applicable with SCI patients)
- Evidence from high-quality studies has shown that visualization used in combination with physical therapy has positive effects on muscle movement



Medical Research Council (MRC) Muscle Power grading

Grade	Muscle State
0	No contraction
1	Flicker or trace of contraction
2	Active movement with gravity eliminated
3	Active movement against gravity
4	Active movement against gravity and resistance
5	Normal power

2) Protective Phase (initial 3 weeks post surgery)

Grade	Muscle State
0	No contraction

Protect nerve transfer

- Avoid excessive tension on repaired nerve. May consider splint and/or shoulder sling.

Careful ROM exercises to maintain mobility

- e.g. nerve transfers around the shoulder joint: occasionally we immobilize the shoulder for 3 weeks and would then complete ROM to elbow/wrist/hand
- Isometric donor contraction

Visualization / motor imagery

Edema management

- Lymphatic drainage or retrograde massage, compression sleeves/gloves, positioning

Desensitization (as needed)

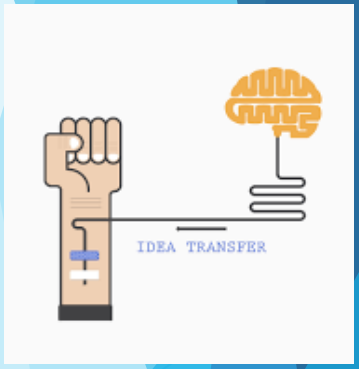
3) Silent/Corrective Phase (MRC 0 – 1)

Grade	Muscle State
0	No contraction
1	Flicker or trace of contraction

The beginning of early reinnervation; no observable muscle contraction

Regaining cortical representation in the denervated muscle

- Patient education important
- Visualization / Motor imagery
  - **Nerve activation exercises** while visualizing donor and recipient action (see video next slide)
  - e.g. axillary to triceps: abduct shoulder while visualizing elbow extension
- Mirror therapy: bilateral nerve co-activation exercises (donor + recipient)



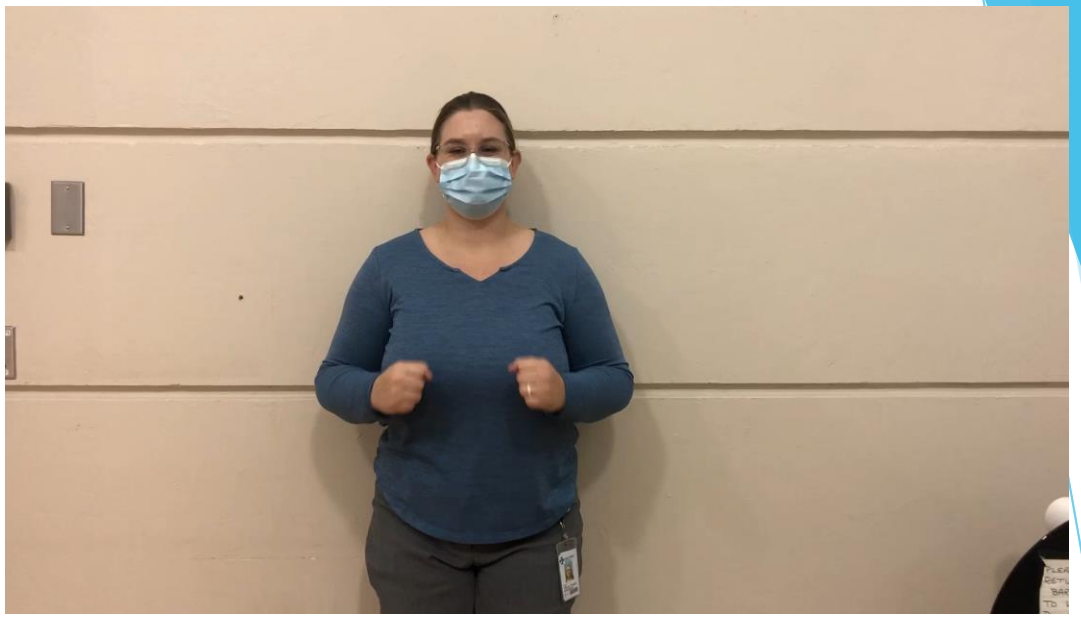
Maintain PROM / address contractures & tightness

Strengthen functioning muscles

Scar management

e.g. Nerve activation exercise + mirror therapy

axillary to triceps: abduct shoulder while visualizing elbow extension (shd flex + elbow extension would also be appropriate)



4) Re-education Phase (MRC 1-2)

Grade	Muscle State
1	Flicker or trace of contraction
2	Active movement with gravity eliminated

Recipient muscle starting to contract and produce movement

Nerve activation exercises

- Continue bilateral nerve co-activation exercises (donor + recipient)
- e.g. axillary to triceps: shoulder abduction + elbow extension

Start AROM in mid-range and in a gravity eliminated position

- Limb positioning is important

RESPECT FATIGUE: Short sessions, multiples times per day

Use biofeedback unit (EMG) if available

5) Strengthening Phase (MRC 2-3)

Grade	Muscle State
2	Active movement with gravity eliminated
3	Active movement against gravity

Transition gravity eliminated AROM → to AROM against gravity, with a focus on functional movements important to the patient

- e.g. axillary to triceps: focus on functional reaching

Donor deactivation

- Facilitate selective activation of isolated donor nerve, and of isolated recipient nerve
- e.g. supinator to PIN: when bringing food to mouth forearm will supinate but you want to keep hand closed
- Can use biofeedback to decrease donor nerve output

Watch for and correct for compensatory movements

Biofeedback unit: can progress from EMG to ETS (electrical triggered stimulation using biofeedback)

6) Endurance Phase (MRC ≥ 3)

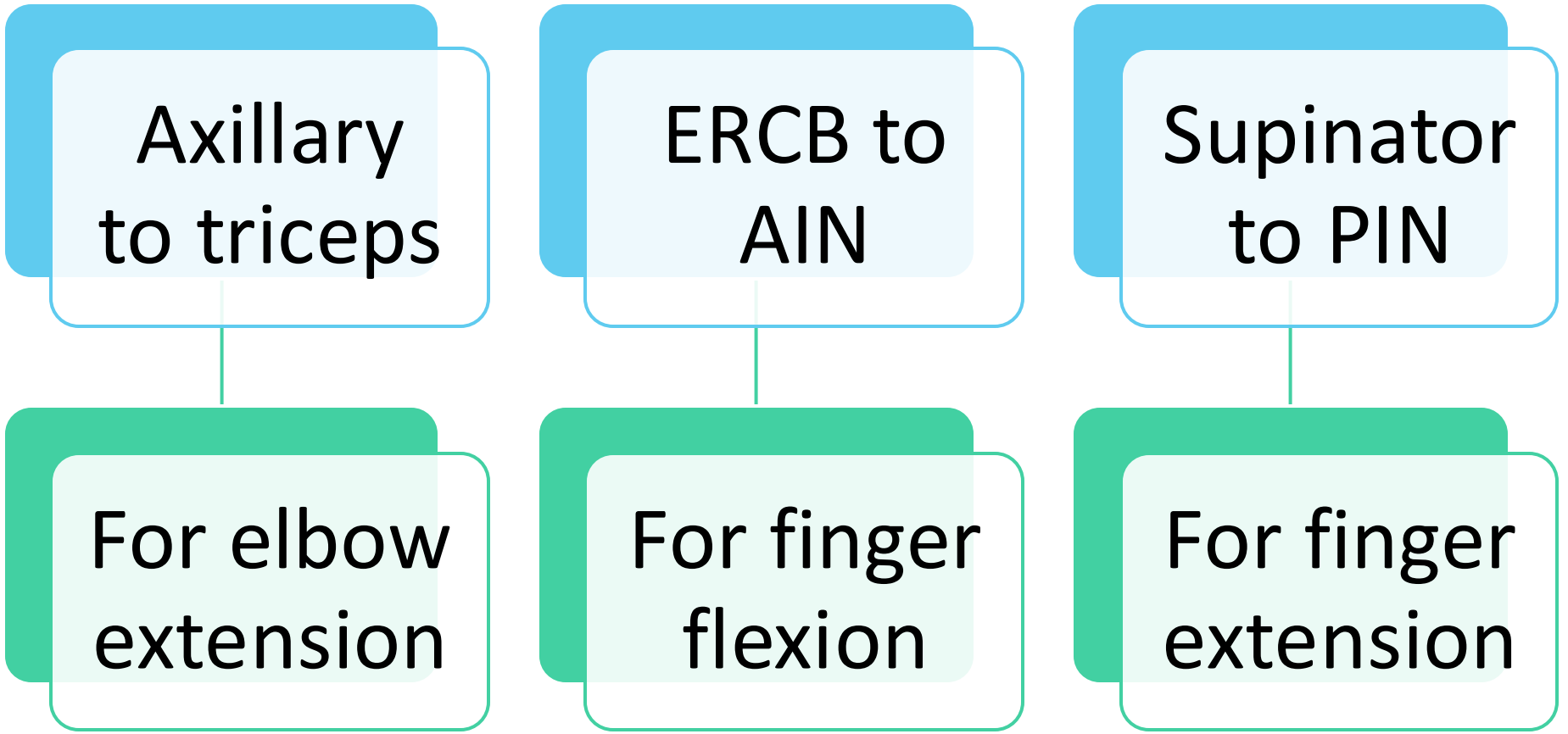
Grade	Muscle State
3	Active movement against gravity
4	Active movement against gravity and resistance
5	Normal power

- Transition AROM from against gravity → to against light/moderate resistance
- Increase resistance & endurance
- Recipient muscle is not fully innervated and still easily fatigued
- Biofeedback unit: Could transition from ETS to NMES
- Return to functional activities
- Continue donor deactivation

	Phase	Timeframe	Objectives
Pre-innervation	Protective	0-3 weeks post op	• Protect nerve coaptation • Control edema
	Silent/Corrective	MRC 0-1	• Address contractures / tightness • Maintain PROM • Strengthen functioning muscles • Stimulate cortical awareness
Post-innervation	Re-Education	MRC 1-2	• Establish donor-recipient nerve co-activation • Start AROM in GE position • Stimulate functional use of new motion
	Strengthening	MRC 2-3	• Perform AROM AG • Increase functional use of new motion • Donor de-activation
	Endurance	MRC >3	• Perform AROM against light/moderate resistance • Increase resistance & endurance

Bateman et al (2023)

Our most common nerve transfers



Outcomes

Nerve transfer	Movement restored	Months to visible contraction	Months to functional movement	% patients achieving useful function
Brachialis to AIN	Finger flexion	10	18	65
Supinator to PIN	Digit extension	9	12	75
AIN to ulnar	Ulnar n intrinsics	9	18	65

From Hill et al. 2019

With SCI patients the timelines to contraction / function WILL BE LONGER

Case Example

- **Diagnosis:** C4 SCI injury
- **HPI:** Dirt biking injury Nov 2023
- **Surgery:** Bilateral upper extremity nerve transfers, DOS May 6 2024
  - Axillary nerve branch to posterior deltoid transferred to radial nerve branch to lateral head of triceps
  - Brachialis to anterior interosseous nerve (AIN) and flexor digitorum superficialis (FDS)
  - Supinator to posterior interosseous nerve (PIN)

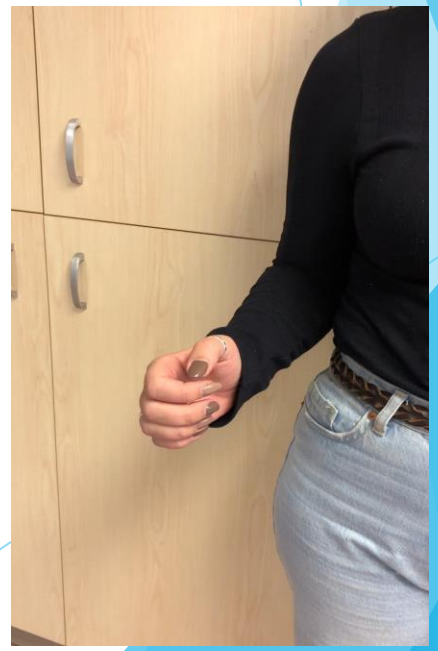
Case Example: Overall Therapy Plan

- When referred for therapy, was in the **Re-Education Phase (MRC grade 1-2)**
  - Recipient muscle starting to contract and produce movement
- Treatment included:
  - Taught bilateral **nerve activation exercises** (see next slide)
  - Start AROM in mid-range and in a gravity eliminated position
  - RESPECT FATIGUE: Short sessions, multiples times per day
  - Use **biofeedback unit** if available
  - Strengthen existing functioning muscles (biceps)
- Recommend 1-2 visits per month for peripheral nerve re-training exercises, with a focus on home program

Case Example: Nerve activation

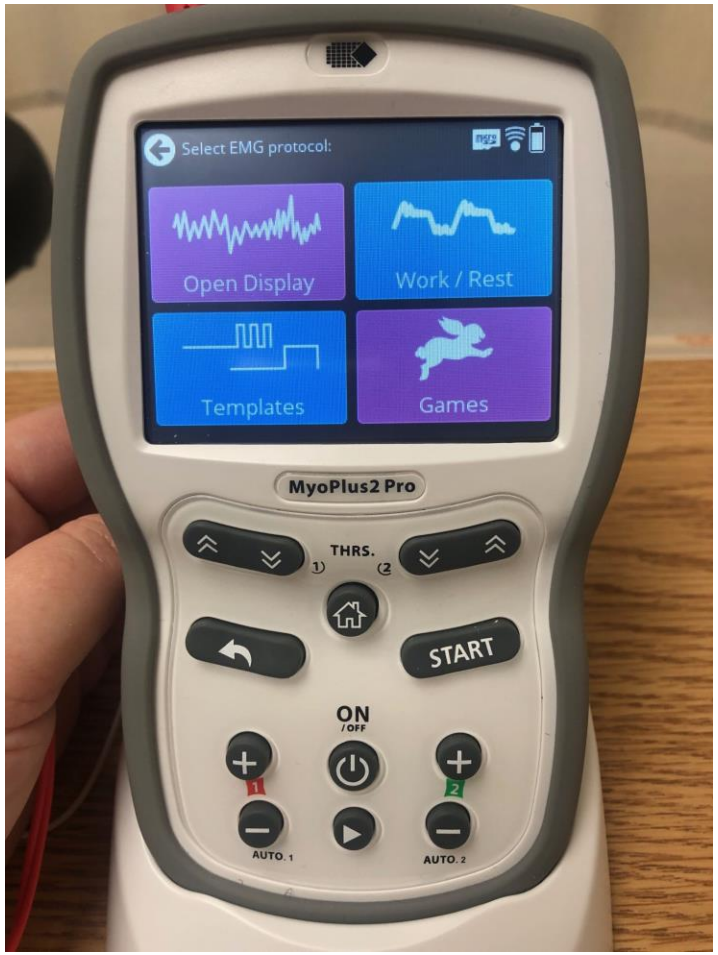
(donor + recipient)

Axillary to triceps	Shoulder abduction + elbow extension
Brachialis to AIN & FDS	Elbow flexion + tight fist
Supinator to PIN	Supination + extend fingers/wrist/thumb

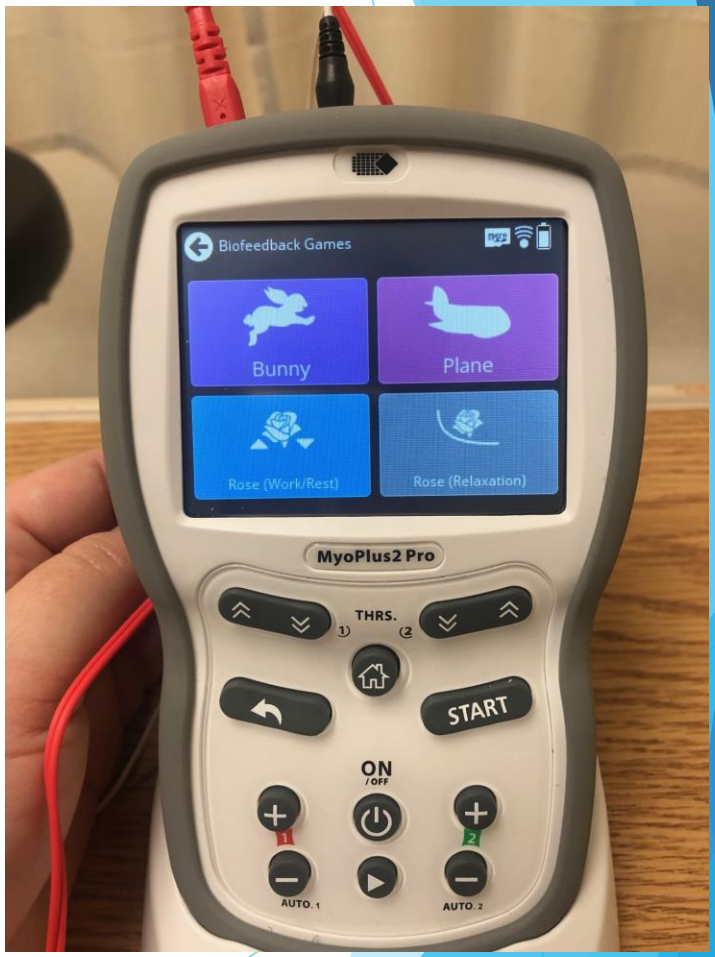


Biofeedback Unit

Main Screen



EMG Screen



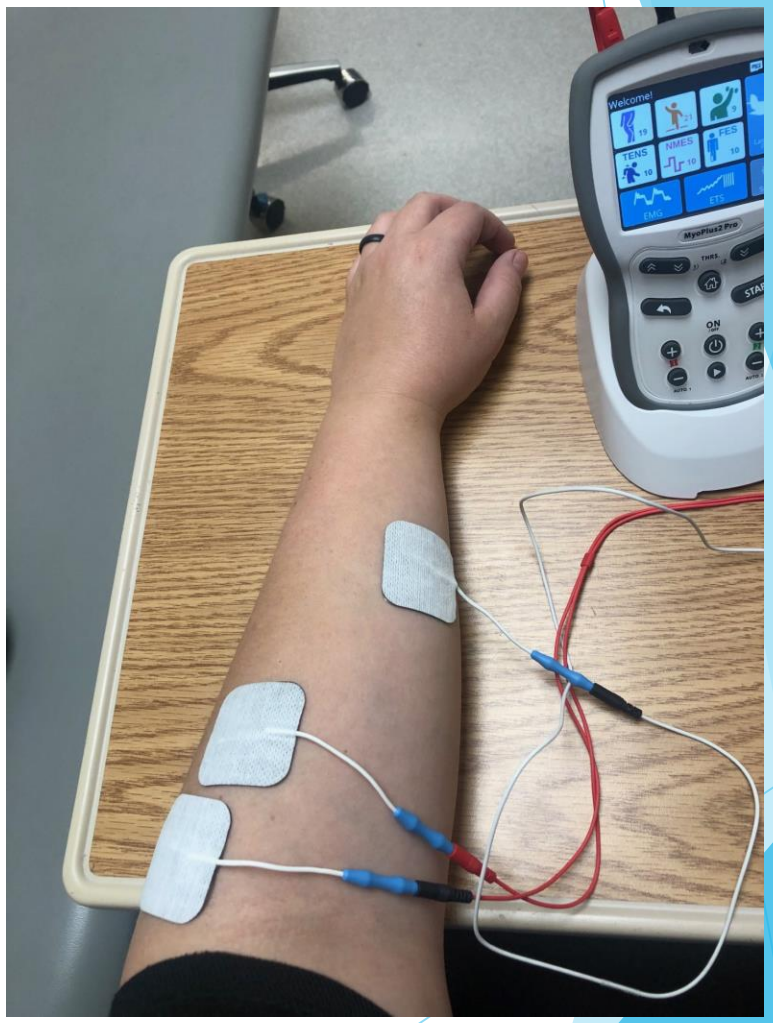
EMG Games Screen

Biofeedback Tips

- Will start biofeedback training when motor units confirmed on needle EMG, or MRC grade 1-2
- Electrodes will be placed on the **recipient** muscle
- Reference electrode: can go anywhere on the body
- Negative **Black –ve** electrode: place near upper insertion or top of the muscle
- Positive **Red +ve** electrode: place on the motor point of the muscle (usually located at the center of the muscle mass where the motor nerve enters the muscle)
  - Find the best position by slightly moving the +ve electrode around
  - Your objective is to find the spot where the minimum amount of electrical stimulation will easily excite the greatest muscular contraction without causing pain.

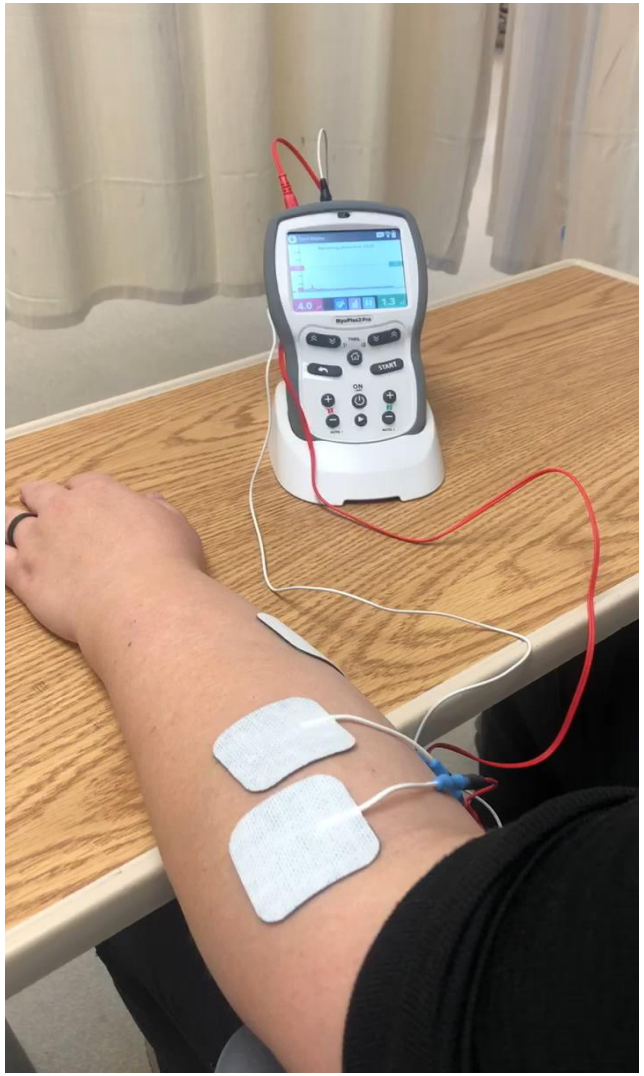
Case Example: Biofeedback

- **Example for Supinator to PIN:**
- Electrodes on recipient muscle
- **Red +ve** electrode: on extensor wad motor point
- **Black –ve** electrode: near the extensor upper insertion
- Reference electrode: anywhere on the body
- Will start biofeedback training when motor units confirmed on needle EMG, or MRC grade 1-2
- **Supinator to PIN:** nerve activation exercise is supination + wrist/finger extension

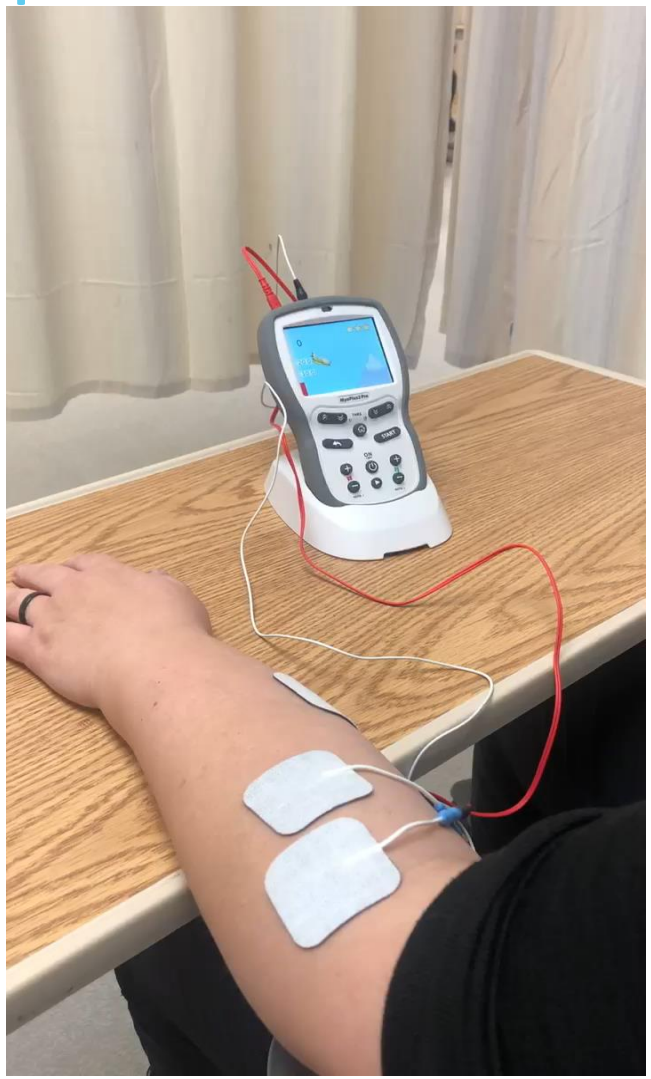


Electrode Placement

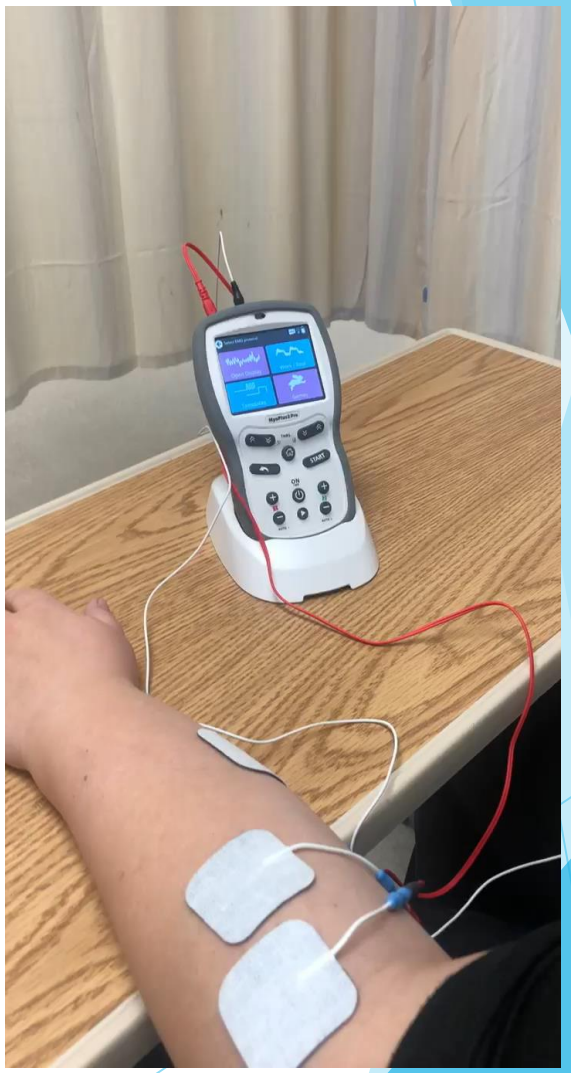
Biofeedback for Supinator to PIN



EMG Open Display



EMG Plane Game



EMG Plane Game Settings

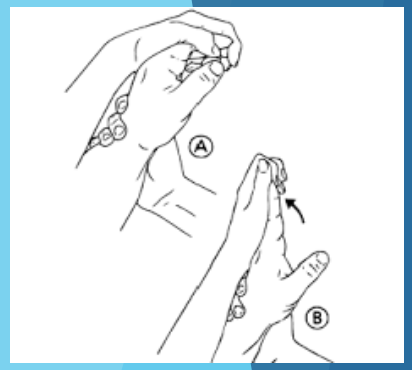
Tendon Transfers

Common Tendon Transfers after SCI

- Purpose: re-route “spare” muscles to compensate for paralyzed ones
- Goal: improve function

Biceps to triceps	Brachioradialis to ECRB with tendon graft	PT / ECRL / or FCR to FPL & FDP	PT to EDC / EPL / AbPL
• Requires functional brachialis and supinator muscles • Improves elbow extension / improves elbow flexion contracture	• Improves wrist extension (elbow must be extended to allow wrist extension)	• Improves hand grasp/close	• Improves hand opening

Tendon Transfer Pre Surgery Guidelines



- Address any joint contractures / stiffness
  - The joint that the tendon transfer will move must have maximum passive ROM prior to surgery
  - A tendon transfer surgery will fail if the joint has become stiff
  - Surgery requires a supple joint before performing a tendon transfer procedure
- Strengthen the donor muscle

Tendon Transfer Post Surgery Guidelines

Immobilization:

- A period of immobilization is required to allow the tendon to heal, typically 4-6 weeks

Gradual ROM:

- Once the immobilization period is over, a gradual range of motion (ROM) program is initiated to restore function. This is also accompanied by a gradual splint wean.

Strengthening:

- As the tendon heals, strengthening exercises are introduced to improve grip strength and functional abilities.

Functional Activities:

- Patients are encouraged to gradually return to functional activities and daily tasks. There is an emphasis on functional movement patterns (e.g. grasp, release, pinch).

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Questions?

I am open to any future case discussions and guidance for your future nerve transfer clients.

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