NEW DEVELOPMENTS IN FES TECHNOLOGY FOR SCI REHABILITATION:
A CRITICAL EVALUATION
Arthur Prochazka
Centre for Neuroscience,
University of Alberta
the wish list

Kimberley Anderson. 2004
Hand function
Bladder control
FES surface stimulators

- Medtronic Respond
- Neuromove EMG-triggered
- Empi Focus
- U of A Bionic Glove
- Bioness H200
Multicentre trial: 48 SCI subjects, 7 centres
- Significant improvements in grasp-release scores
- ~50% kept using for >6 months

Popovic study 1999:
- “daily use increased power of grasp & ROM”
- “Most manual tasks improved significantly”
- “significantly improved independence in C5-C7 SCI if initial FIM and QIF scores were 20%-50% of max.”
Ness Handmaster (Bioness H200)

7 C5-6 SCI subjects

Significant improvements in:

• grip strength (0.6N to 16.5N)
• finger linear motion (0cm to 8.4cm)
• Fugl-Meyer scores

Alon & McBride 2003
FES-assisted exercise therapy

Milos R. Popovic, Toronto Rehab Institute

22 sub-acute SCI subjects (13 treatment, 9 controls)
12 weeks, 45 mins daily

push button
Popovic results

Daily FES-assisted exercise produces results
BUT
How can it realistically be delivered?
Need to:
1. improve device design
2. daily exercise training
3. quantify outcomes
1. Improve device design

Vibration sensor & transmitter

Prochazka US 6,961,623 (2005), Licensed to Bioness Inc.
Prochazka, Broughton, Kowalczewski, Chong 2007
Implanted neuroprostheses

Neurocontrol Freehand

Loeb r.f. Bion

Advanced Bionics battery Bion
stim router: implanted lead only

Gan et al 2006
Stim Router wristlet (est. 2008)
• minimally invasive, affordable
• control 2 or 3 muscles independently

Prochazka 2004
2. Daily exercise training

_Gritsenko et al. 2004_
“Autocite” constraint-induced therapy system

Lum et al. 2006
Telerehab Joystick
(ReJoyce)

Kowalczewski et al. US pending
Rejoyce aims:

• Affordable
• Multi-task
• No loose parts
Rejoyce ADL games
tele-rehab
Replacing hand function
Simple alternative:
toothclick headmouse
3. Quantify outcomes

ARAT Hand function test
Rejoyce hand function test

hold the handle with your bad hand, move it as far up, and then as far down, as you can.
Bladder control
dyssynergia
Spinal root stimulation

Medtronic extradural sacral root stimulator for stress incontinence

Brindley Finetech intradural sacral ventral root stimulator for SCI (1982)
Intraspinal microstimulation (ISMS)

Nashold et al. 1971

1960's: pilot study in spinal cats
Good bladder contractions
Sphincterotomies needed
Stim spread to leg and pelvic floor MNs
Multi-electrode ISMS

Prochazka, Gaunt, Mushahwar 2002-2005
Problems
- invasive
- small targets
- selective activation
- unwanted reflexes
- electrode migration
- adaptation
Pudendal nerve stim for stress incontinence

Several successful clinical studies 2002-2006
New concept: stim router activates pudendal nerve, maintaining continence

low-freq stim

Skin

nerve

urethra

sphincter

Gaunt et al 2007
Hi-freq stim via router inhibits pudendal nerve, allowing voiding

Gaunt et al 2007

Intraurethral Pressure (mmHg) vs. Time (s)
Concept: wireless control of voiding (2009?)

EUS

pud nerve

EUS
Bladder control conclusions

- Stim in and around spinal cord problematic
- Pudendal nerve stim by 2009
Summary

• FES telerehab for hand function
• Stim router: novel neuroprosthesis
• Pudendal nerve stim for bladder control
• Jan Kowalczewski
• Valeriya Gritsenko
• Robert Gaunt
• Liu Shi Gan
• Tyler Simpson
• Michel Gauthier
• Al Denington
• Su Ling Chong
• Peter Ellaway
• Colin Broughton

• Canadian Institutes of Health Research
• Alberta Heritage Foundation for Medical Research
• NIH
• International Spinal Research Trust
• Alberta Paraplegic Foundation