Advances in SCI Rehabilitation
Indego Exoskeleton and more

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<table>
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<th>Role of stem cells in clinical medicine</th>
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**Stem cells as therapy**
- replace cell lines that have been lost or destroyed
- modify the behavior of other cells

**Stem cells as targets of drug therapy**

**Stem cells to generate differentiated tissue for in vitro study of disease models for drug development**
Signature characteristics of stem cells

Stem cell

Self-renewal

Stem cell

Differentiation

Differentiated cells
development to stem cell type

- Fertilization
- Totipotent cells
- Blastocyst
  - Inner cell mass
  - Pluripotent cells
    - "Embryonic" stem (ES) cells and cell lines
  - Multipotent cells
    - "Adult" stem cells
- Fetal tissues
- Adult tissues
Reprogramming adult cells to become pluripotent cells

Introduction of reprogramming genes, transcripts or small molecules

Somatic cells → Early intermediates → Late intermediates → “Immature” iPSCs → “Mature” iPSCs

- Inhibition of somatic regulators
- Activation of pluripotency loci
- Acquisition of factor independence
- Complete reprogramming (telomeres, X chromosome, memory erasure)
- Induction of proliferation
- Inhibition of senescence and apoptosis pathways
- Immortalization
replacement therapy

Patient

Lymphocyte  Reprogramming  Fibroblast

iPS

Correction of diseased gene

Differentiation

Other cell types  Pancreatic  Neuronal  Hematopoietic

Autologous transplantation
Transplantation of human ES-derived oligodendrocyte progenitor cells into adult rats, seven days after the induction of a spinal cord injury, was shown to enhance remyelination and promote improved motor function.
Human embryonic stem cell-derived oligodendrocyte progenitor cell transplants remyelinate and restore locomotion after spinal cord injury.


Stemcell Inc. – Pathway study – STOPPED

Neuralstem Inc. – Neural Stem Cells – RECRUITING PATIENTS

Combination therapy: (Stem Cells +) InVivo Scaffold – HUMAN TRIAL SUSPENDED (CHRONIC SCI) – ACUTE SCI study: temporarily HALTED)
<table>
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<tr>
<th>Stem Cells Study</th>
<th>Country</th>
<th>Phase</th>
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<tr>
<td>Nose Cells and Nerve Graft – Pr Raisman (UK) and Dr. Tobakow (PL)</td>
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<td>RECRUITING</td>
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<td>Schwann Cells and combinations – Miami Project</td>
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<td>RECRUITING</td>
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<tr>
<td>Dr. Wise Young- Umbilical Cord Blood Stem Cells + combinations</td>
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<td>Slovenia</td>
<td>Phase– Slovenia</td>
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Bone Marrow Stem Cells Intrathecal Injection - Dr. Vaquero Phase II clinical trial (Spain) – Phase II trial completed.

Neuroplast (The Netherlands) – Autologous BoneMarrow-derived Stem-Cells – Clinical trial in preparation for both chronic and acute SCI

BioArctic – SC0806 (biodegradable device+ FGF1) – clinical trials approved, recruiting patients- Sweden – Slovenia
Scar appears a few days or weeks after the injury prevents any axon from growing away from the lesion area.

One of the key scar reduction strategies: Chondroitinase enzyme
ReNetX Bio – NOGO TRAP
intradiscal delivery of the NoGo Trap protein

CHASE IT: Chondroitinase and gene therapy for chronic SCI
bacterial enzyme called chondroitinase, has repeatedly
been proven to degrade the scar, to promote growth and
to improve recovery in animal experiments
VR can “trick” the brain into believing that it is physically performing the actions being simulated in the VR environment.

In healthy people, this can produce feelings of vertigo in VR settings featuring sheer cliffs or drops.

In people with traumatic brain injuries, this can encourage the brain to stimulate neurological pathways that have been “turned off” following an injury.
Virtual Reality
Neuro-stimulation is the process of using gentle electrical currents to stimulate the spinal cord below the point of injury, enabling nerve circuits in the spinal cord to ‘hear’ and act upon messages coming from the brain.

Based on various studies, those techniques seem to generate light functional return as well as some improvement of the patient’s autonomic function.
Epidural Stimulation: Dr. Harkema University of Louisville, Kentucky

Epidural Stimulation Study in Minnesota

Transcutaneous e-stim

Project Edge – Neuromodulation – Dr. Reggie Edgerton, Spinal Cure Australia

Dr. Gregoire Courtine, EPFL Zwitserland/ GTX Medical

Transcranial Magnetic Stimulation (TMS) or Deep Cranial Stimulation
Stem Cell and REPAIR

Virtual Reality

Neuromodulation

Brain-Computer Interfaces

Wearable Robots
Powered exoskeletons did not start as assistive devices. The first patent for a powered exoskeleton, filed by a Russian inventor named Nicholas Yagn, was approved on January 28, 1890.
In 1965, funded by U.S. military, General Electric started developing Hardiman, Human Augmentation Research and Development Investigation” and “MANipulator.”, Called HardiMan

The machine was huge—once built, it would weigh 1,500 pounds.
Exoskeletons
Belgrade 1970, for paralysis patients. Miomir Vukabratovic partial active exoskeleton. far lighter, just 26 pounds no power source integrated into the device
2000 Defense Advanced Research Projects Agency Berkeley Lower-Extremity Skeleton, or BLEEX. University of California, Berkeley,
Exoskeletons

Fig 6. From left-right, Vanderbilt Exoskeleton, eLEGS, ReWalk and Rex
Lightweight

At just 26 pounds
no exposed cables
No upper-body apparatus
No backpack mounted components
Intuitive Controls
Mirroring natural human movement, lean forward to initiate standing or walking and lean backward to stop and sit.
Wireless Operation
Mobile app allows user to control operation, change settings, and capture data without the need for tethered controls.
Compatible
A slim profile is compatible with standard mobility aids and can be worn while seated in a wheelchair.
Quick Setup and Fit
A single-hand strapping and retention system allows Indego to be put on, taken off and adjusted to fit without assistance.
Versatile Indego allows over ground training or personal mobility on a variety of surfaces both indoors and outdoors.
Extended Power

With up to four hours of use and easy-to-change, fast charging batteries, Indego’s power source allows for extended use in therapy and at home.
Uniquely Personal

well suited for use in the clinical setting and allows for an easy transition to use at home.
Function Electric Stimulation

Coming soon…
Exoskeletons

Intuitive
Versatile
Lots of hope for SCI patients, some here already, some on the way…
Indego Exoskeletons