Biomedicina Spaziale: a Call to Action

Agenzia Spaziale Italiana

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From wound healing to tissue regeneration in Space

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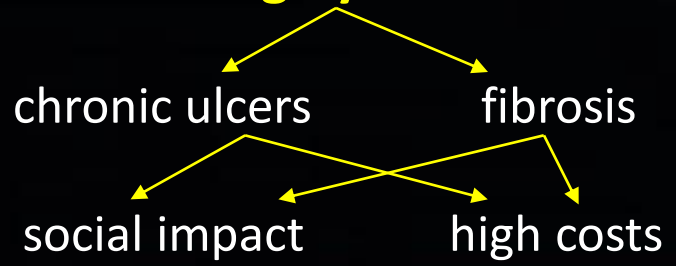
Wound Healing on Earth

Healing dysfunction



Knowledge gaps

Role of mechanical factors.

Mechanisms for switching from imperfect healing into full regeneration.

Phenotypic plasticity of fibroblasts.

Crosstalk among the cell populations involved in wound healing.

Wound Healing in Space

***In vitro* models**

Microgravity-induced changes in mechanisms underlying tissue repair: alterations in inflammation markers as well as in fibroblast, keratinocytes and endothelial cell function, changes in ECM production and dysregulation in apoptosis.

In animal models

The most part evidenced delayed and defective healing.

In humans

Alterations that could affect the body's response to injury: immune dysfunction, chronic inflammation and insulin-resistance, changes in hemorrhage progression and bacterial flora behavior. Astronauts refer delayed healing.

Wound Healing and Tissue Regeneration in Space

- In future space exploration missions, the risk of serious injuries and surgical emergencies will increase.
- Medical evacuation to Earth will be precluded and the patient will have to be treated and managed on board vehicles/stations/space bases.
- Wound Healing in Space is almost completely unknown.

⬇

To prepare for future interplanetary missions:

- ➢ Wound Healing has been included among the crucial aspects to be studied (Drudi 2012).
- ➢ 3D bioprinting and tissue culture have been included among the enabling techniques (Ghidini 2018).

⬇

Space Agencies have begun funding studies on wound healing and tissue regeneration in Space.

- Drudi L, Ball CG, Kirkpatrick AW, Saary J and Grenon SM. Surgery in space: where are we now ? Acta Astronaut 2012, 79:61-66.

- Ghidini. T Regenerative medicine and 3D bioprinting for human space exploration and planet colonisation. *J Thorac Dis* 2018;10(Suppl 20):2363-2375. doi: 10.21037/jtd.2018.03.19

OUR PROJECTS

Project RITMI–Tissue Repair in Microgravity, funded by ASI

SUTURE in SPACE – “Wound healing and sutures in unloading conditions”, selected by ESA to be performed on the ISS (ESA-ILSRA 2014), launched with SpX-26, and supported by ESA and ASI

ESA Topical Team on “Tissue Healing in Space: Techniques for promoting and monitoring tissue repair and regeneration”.

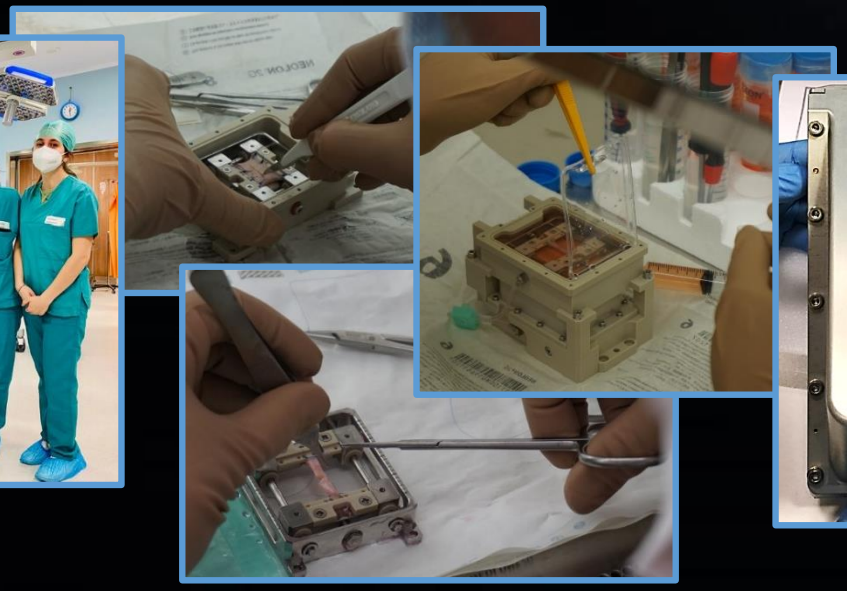
ESA-MAP-WHISPER - Wound Healing In Space: problems and PErspectives for tissue Regeneration and engineering, funded by ESA)

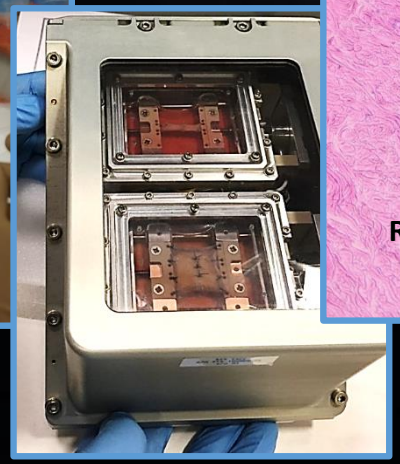
GROWS - “Wound Healing and Skin Reconstruction in Unloading Conditions” selected by ESA and CMSA - China Manned *Space* Agency in the frame of the “Joint Call for Proposals for Integrated Projects utilizing the Space Environment on ISS and CSS, supported by ESA and CMSA”.

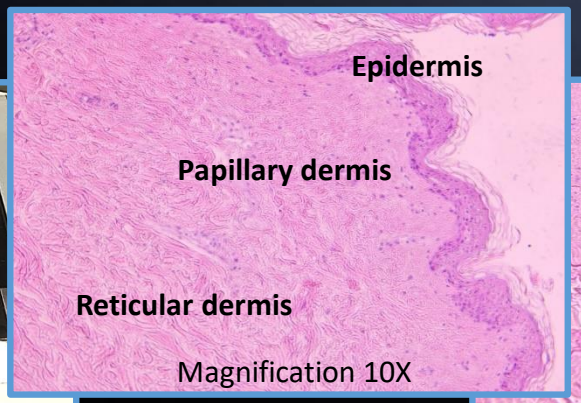
Special Issue Wound Management and Healing in Space, Monici M., van Loon J.W.A., Choukér A., Iorio C.S. Eds., Front. Bioeng. Biotechnol., Sec. Tissue Engineering and Regenerative Medicine, Volume 10 - 2022 , https://doi.org/10.3389/fbioe.2022.1078986

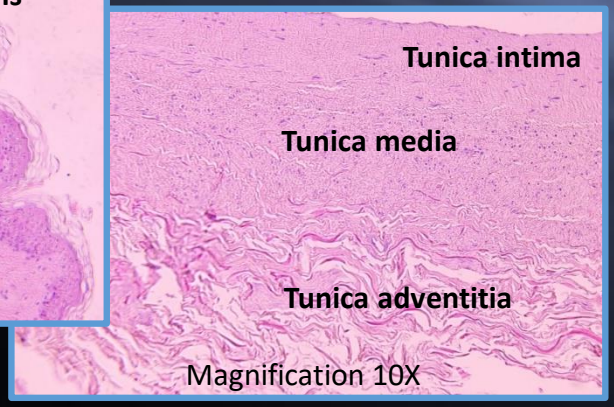
SUTURE IN SPACE

The experiment, launched with SpX-26 and performed on board the ISS from 28th November to 7th December, studies the behavior and healing of *ex vivo* sutured wound models in weightlessness.









International Journal of *Molecular Sciences*

MDPI

Article

Optimization of an Ex-Vivo Human Skin/Vein Model for Long-Term Wound Healing Studies. Ground Preparatory Activities for the 'Suture in Space' Experiment Onboard the International Space Station

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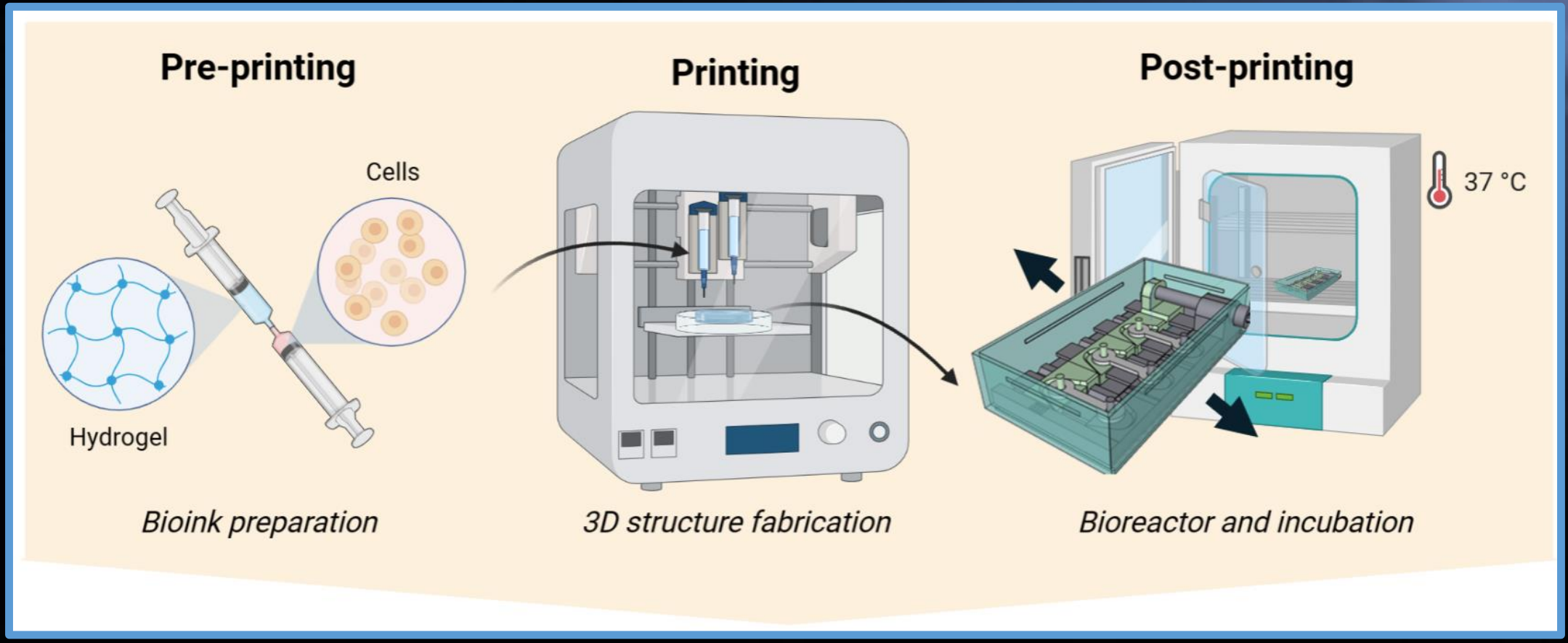
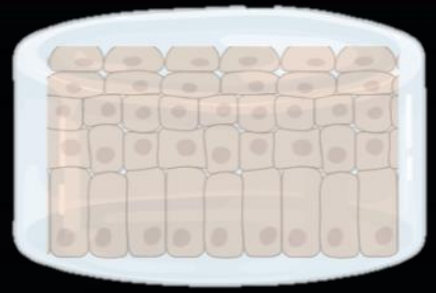
esa ASI

3D bioprinting, culture and maturation of biological tissue analogues under conditions of altered gravity





Final mature tissue

OBJECTIVES

General objectives:

- Understand the mechanisms of tissue repair/regeneration in Space.
- Develop analogues of biological tissues (skin, muscle, blood vessels, kidney) in altered gravity conditions.

Specific objectives:

1. Understand the role of mechanical/gravitational factors in the regulation of the cellular and molecular mechanisms underlying tissue repair/regeneration.
2. Know the behavior of wounds and sutures in Space, in terms of healing progression and quality of the scar.
3. Help understand the mechanisms that switch scarring into true tissue regeneration.
4. Define requirements for monitoring tissue repair/regeneration.
5. Help implement regenerative medicine strategies (including 3D bioprinting and tissue construct culturing in Space).
6. Help develop strategies (drugs, biochemicals, devices, protocols, and techniques) that promote tissue repair/regeneration in Space.

TEAM and COLLABORATIONS

Multidisciplinarity: experts in biology and molecular biology, histology, biochemistry, pharmacology, bioengineering and 3D bioprinting, plastic and cardiovascular surgery, trauma surgery and emergency medicine, biophysics and mechanobiology, biomaterials.

Facilities: simulation of altered gravity conditions; laboratories equipped for cell and tissue culture, histology, molecular biology, 3D bioprinting; bioreactors; sea-horse; optical-, fluorescence- and electron-microscopy; lasers; access to operating rooms, etc.

Industries:

Smith & Nephew

Kayser Italia

Steve Jones

Lizofarm

Human Brain Waves

RIGENERA Micrografting Technology

FRA PRODUCTION S.p.A.

REVĚE

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EXPLOITATION OF RESULTS

Space benefits

A better knowledge of tissue repair/regeneration mechanisms and the development of techniques of regenerative medicine are crucial issues for the future programs of deep space exploration.

Earth benefits

The opportunity to understand the role of gravity and mechanical factors in repair/regeneration and to identify the mechanisms that induce imperfect healing rather than true regeneration can help developing strategies to promote healing in patients affected by wound healing dysfunctions on Earth.
Impaired wound healing has very high socio-economic costs, therefore there is a strong need to develop new therapeutic strategies.

Thanks for your attention