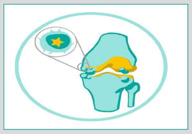
NanoSTARS Imaging for Stem Cell Therapy for Arthritic Joints

Niamh Duffy[1], Declan Byrnes[1], Georgina Shaw[1], Mary Murphy[1], Frank Barry[1], VJ Raghavan[2], Martin Leahy[2]

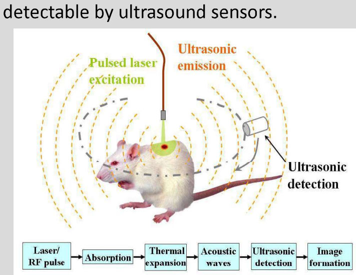
Background



Mesenchymal stem/stromal cells (MSCs) present potential for cell-mediated therapy in many diseases such as osteoarthritis (OA). However, a major challenge to clinical translation is a lack of understanding about engraftment of delivered cells and their biological activity *in situ*. STARSTEM, an EU horizon 2020 project aims to develop a novel nanotechnology-enhanced optoacoustic imaging (OAI) platform for MSCs.

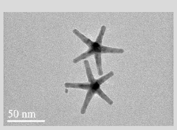
Optoacoustic Imaging (OAI)

The underlying principle of optoacoustic imaging is the photoacoustic effect: the conversion of light energy into acoustic waves. The tissue of interest is illuminated with nanosecond laser light pulses. Chromophores in the tissue absorb the light energy, converting it to heat and causing a thermoelastic expansion of the tissue. This generates acoustic waves, which are then detectable by ultrasound sensors.

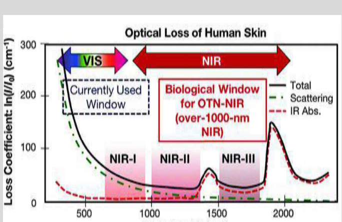


Gold Nanostars (AuNS)

The contrast medium of choice, a gold nanoparticle, shaped like a star (the nanostar), amplifies the signal response in OAI. Nanostars absorb light at around



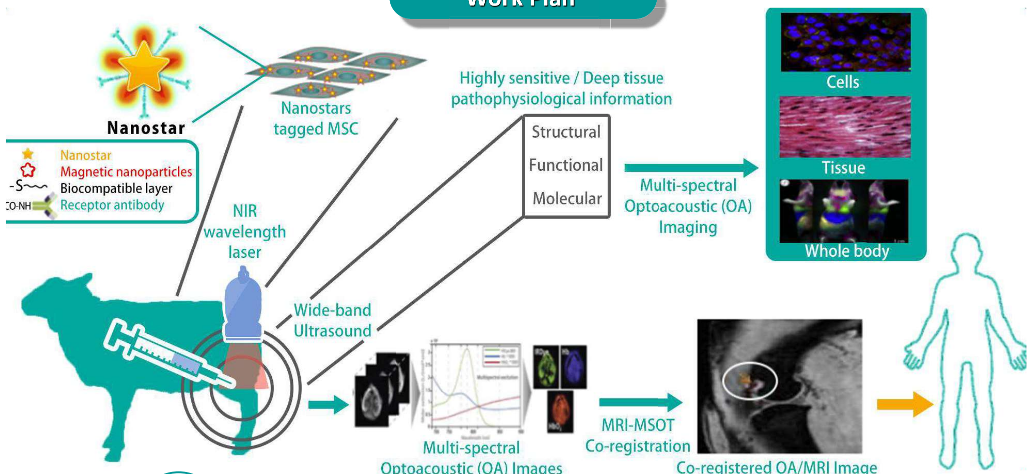
1100nm, which is within the near-infrared II biological window (NIR-II), also known as the optical window, as there is minimal absorption by tissue chromophores such as haemoglobin, melanin and fat (Smith et al., 2009).

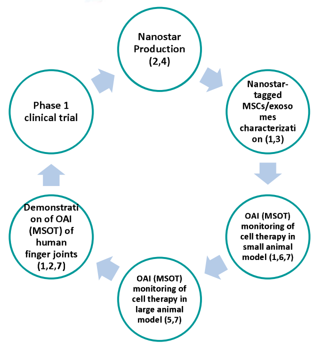


Smith et al., 2009

The STARSTEM platform will be capable of tracking MSCs and MSC-derived exosomes, labelled with nanostars, at unprecedented depth and sensitivity.

Work Plan





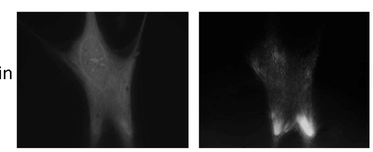
Partners

1. Regenerative Medicine Institute (REMEDI), National University of Ireland Galway, Galway, Ireland
2. Tissue Optics & Microcirculation Imaging (TOMI), National University of Ireland Galway, Galway, Ireland
3. Università degli Studi di Genova, Genoa, Italy
4. The Institute of Photonic Sciences, Barcelona, Spain
5. University of Cambridge, Cambridge, UK
6. Technical University of Munich, Munich, Germany
7. iThera Medical GmbH, Munich, Germany

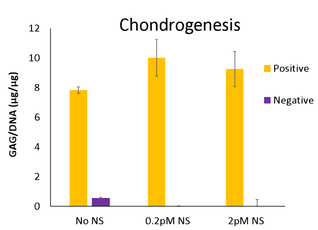
NS-loaded MSC Characterization

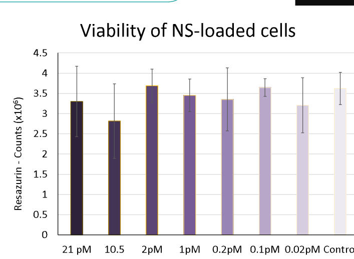
MSCs have been successfully loaded with nanostars as can be seen with dark field microscopy. Uptake of nanostars has not altered the cell phenotype in terms of viability, surface marker expression and tri-lineage differentiation capacity.

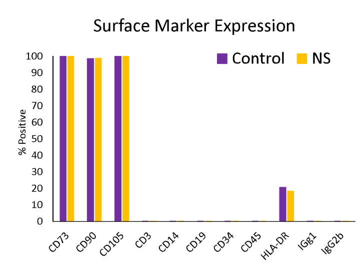
Phalloidin

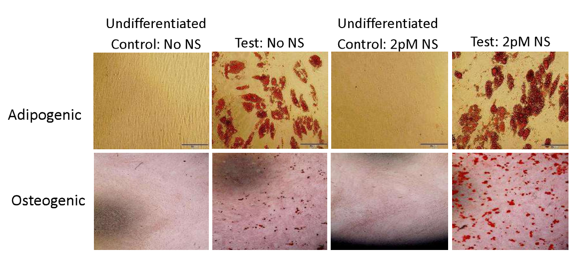


Dark Field









Future Work

Current work focuses on conjugation of superparamagnetic iron oxide particles (SPIONs) to the nanostar surface to allow for multi-modal imaging with MRI. MSCs will be characterized once more with these new nanoparticles. Small animal experiments will then begin to track MSC/exosomes in the joint.

REMEDI · Technical University of Munich · Pintail · Università degli Studi di Genova · ICFO The Institute of Photonic Sciences · TOMI Tissue optics & microcirculation imaging · iTheraMedical · University of Cambridge

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 761214. The materials presented and the views expressed are the responsibility of the authors only. The EU Commission takes no responsibility for any use made of the information sent out.