MRI Safety of Magnetically Controlled Growing Rods in an *in-vivo* Animal Model

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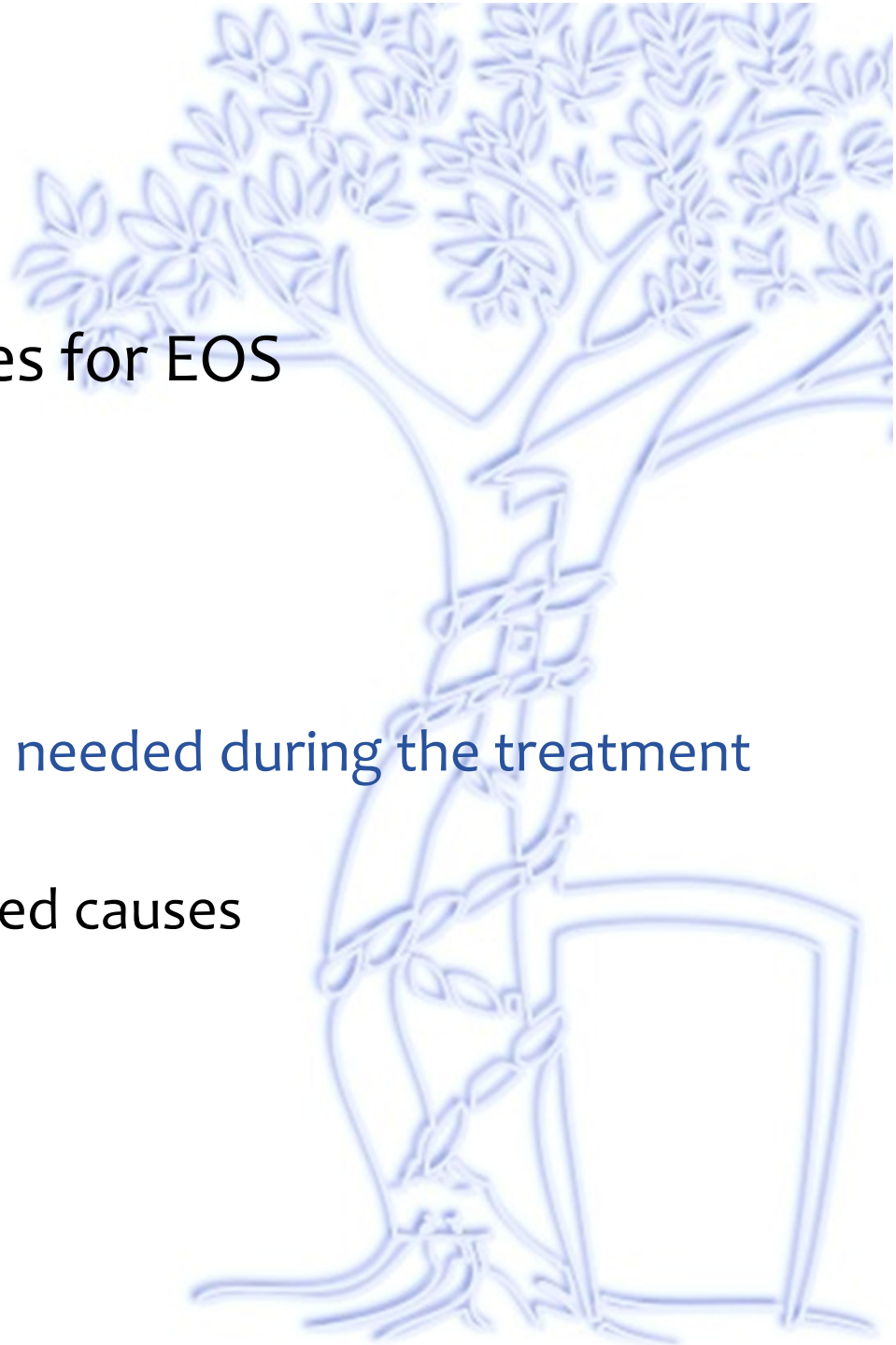
Introduction

- Growth-friendly techniques for EOS
  - Long standing process
- EOS population
  - Significant comorbidities
  - MRI investigation might be needed during the treatment period
    - Spine or non-spine related causes

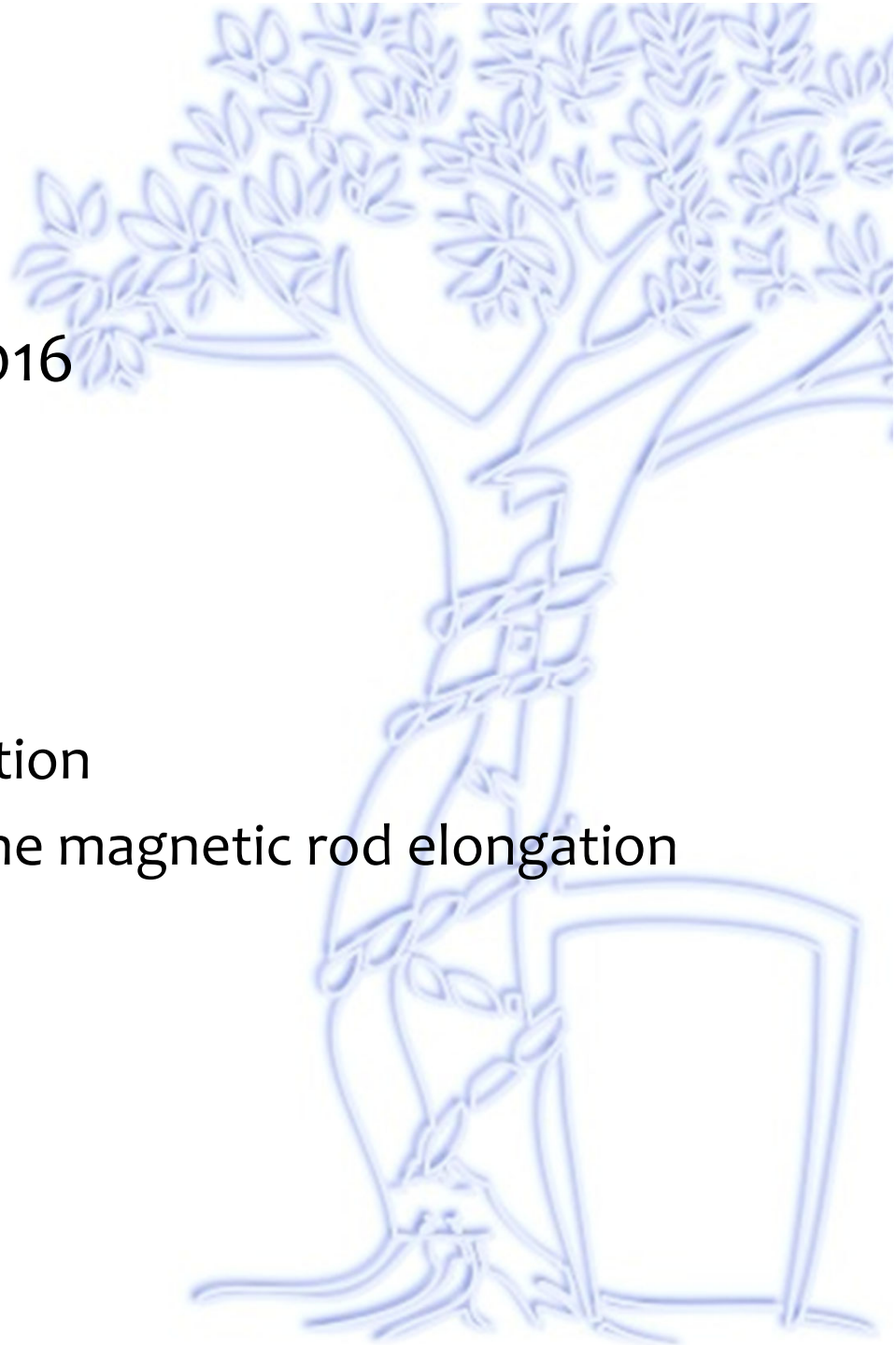


MRI-MCGR

- MRI-MCGR interaction
  - Unknown
  - Not suggested by manufacturer
- Potential complications
  - Uncontrolled change in the length
  - Heating due to radiofrequency fields leading to tissue damage
  - Displacement of the rod due to torque occurring with the motion of a ferromagnetic material
  - Deactivation of magnet preventing further lengthening

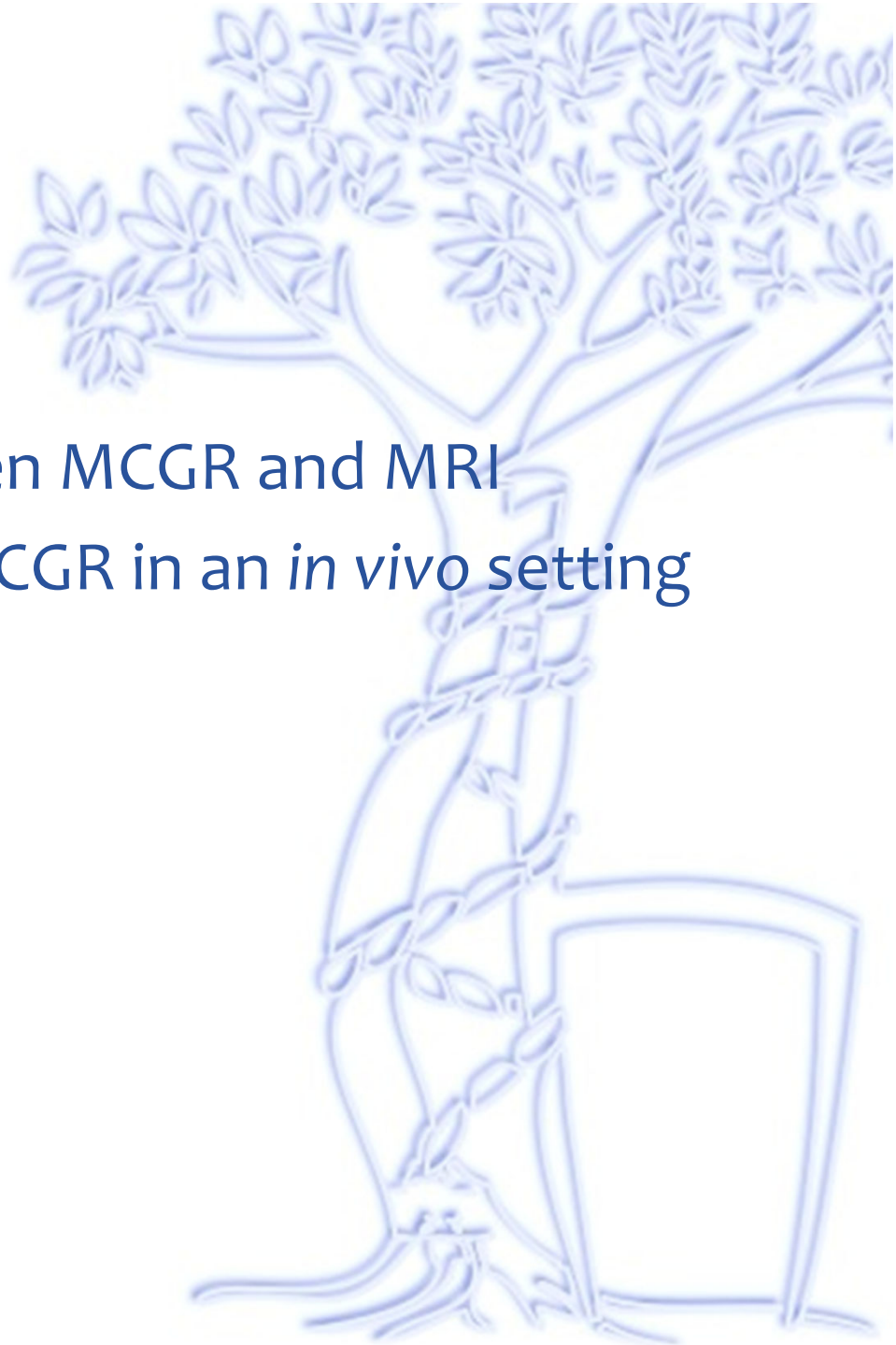
Background

- Budd et. al., Eur Spine J 2016
  - In-vitro study
  - Phantom model
  - 1.5 T
    - Significant image distortion
    - No negative effect on the magnetic rod elongation mechanism



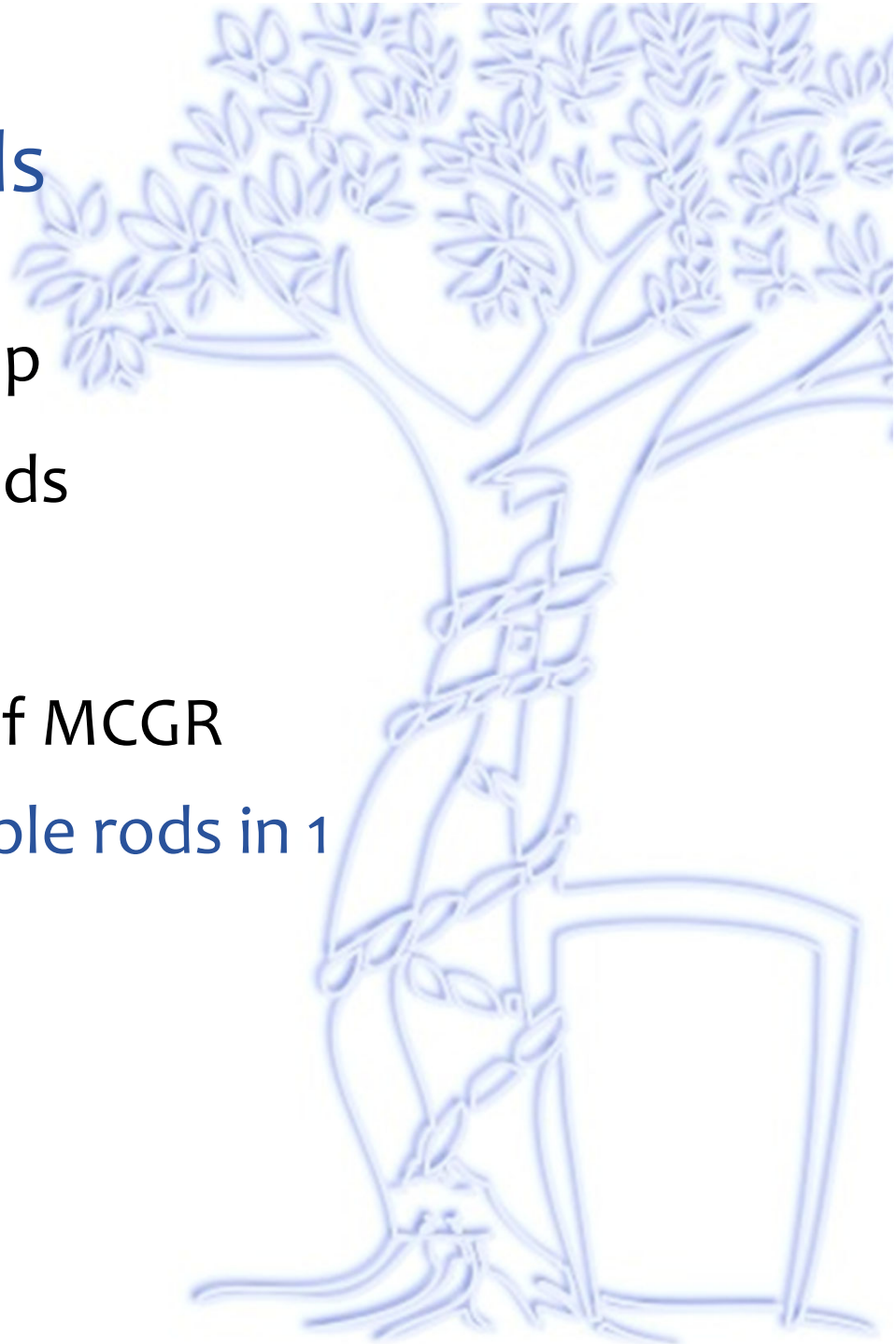
Purpose

- To investigate
  - The interaction between MCGR and MRI
  - MRI compatibility of MCGR in an *in vivo* setting



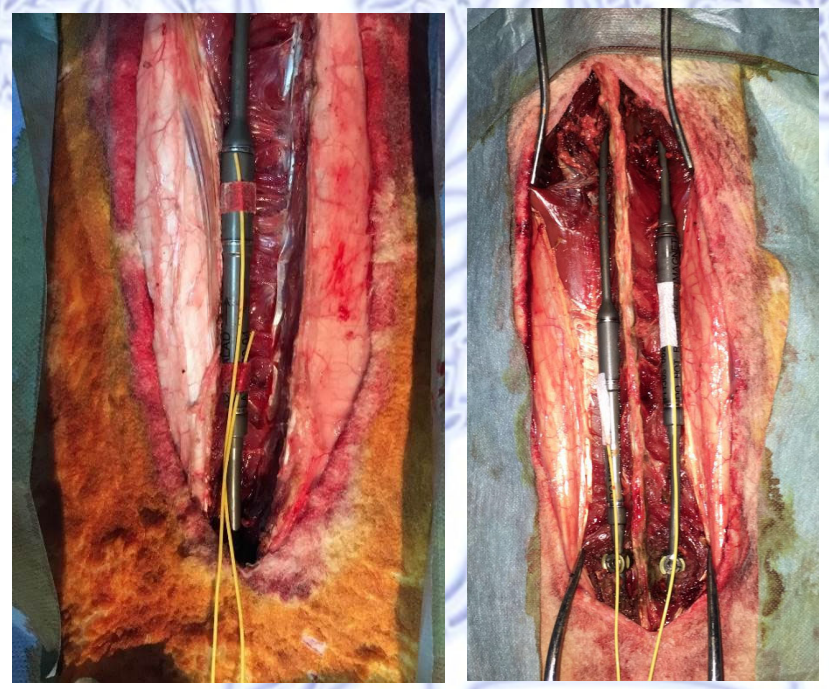
Materials and Methods

- 3 male Merino breed sheep
- Pedicle screws @ both ends
- T6-12 instrumentation
- Submuscular placement of MCGR
  - Single rod in 2 and double rods in 1



Materials and Methods

- Rod length was measured and recorded preoperatively
- MRI compatible T1 Neoptix Reflex fiberoptic temperature sensors
  - Attached over the magnets
- Multilayered closure

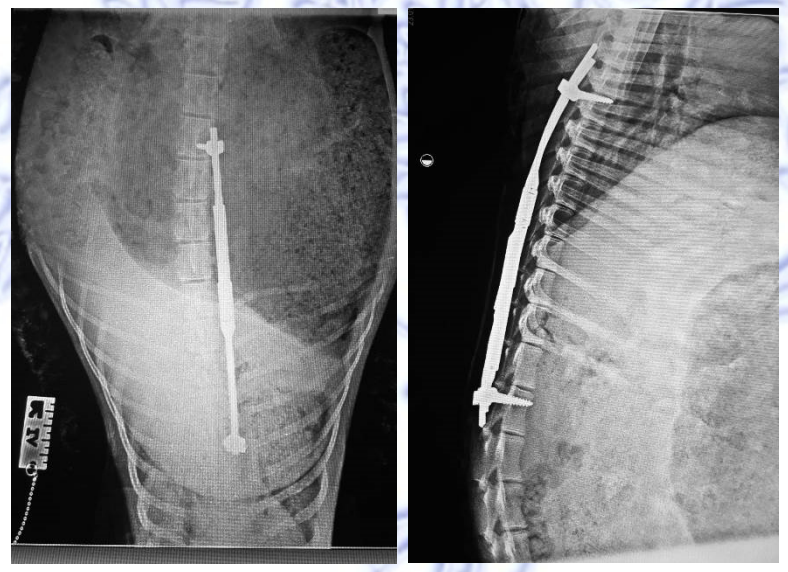


Materials and Methods

- Thoracic and lumbar MRI
  - 0.3 T vertical field open MRI unit (Hitachi)
  - MR waves were applied 45 minutes
  - Temperature changes were recorded every 3 minutes
    - Neoptix reflex four-channel signal conditioner

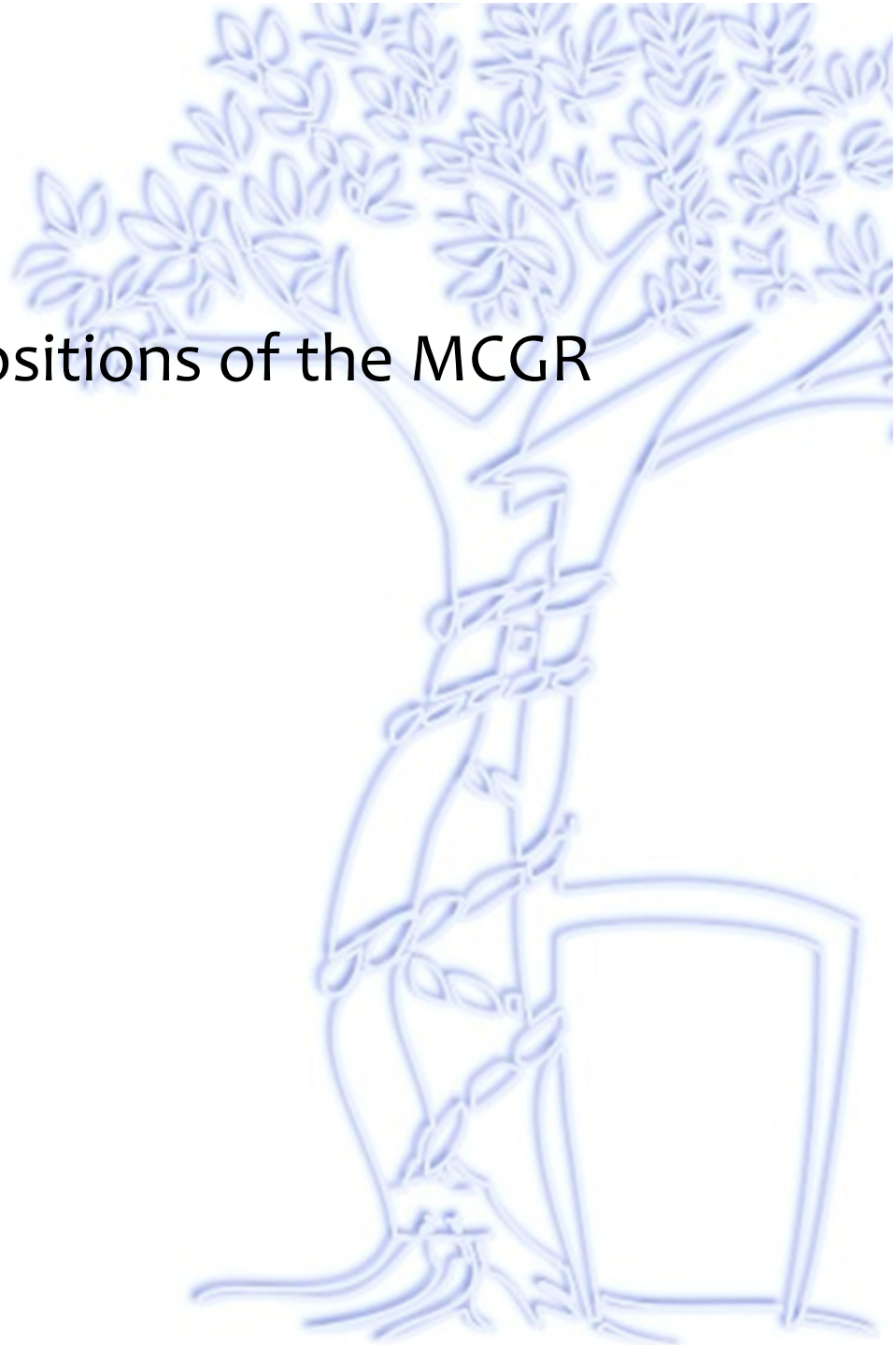
Materials and Methods

- Postoperatively
  - AP and lateral X-rays
- After euthanasia
  - Implant removal
    - Length measurement
    - Checking integrity of elongation system by ERC



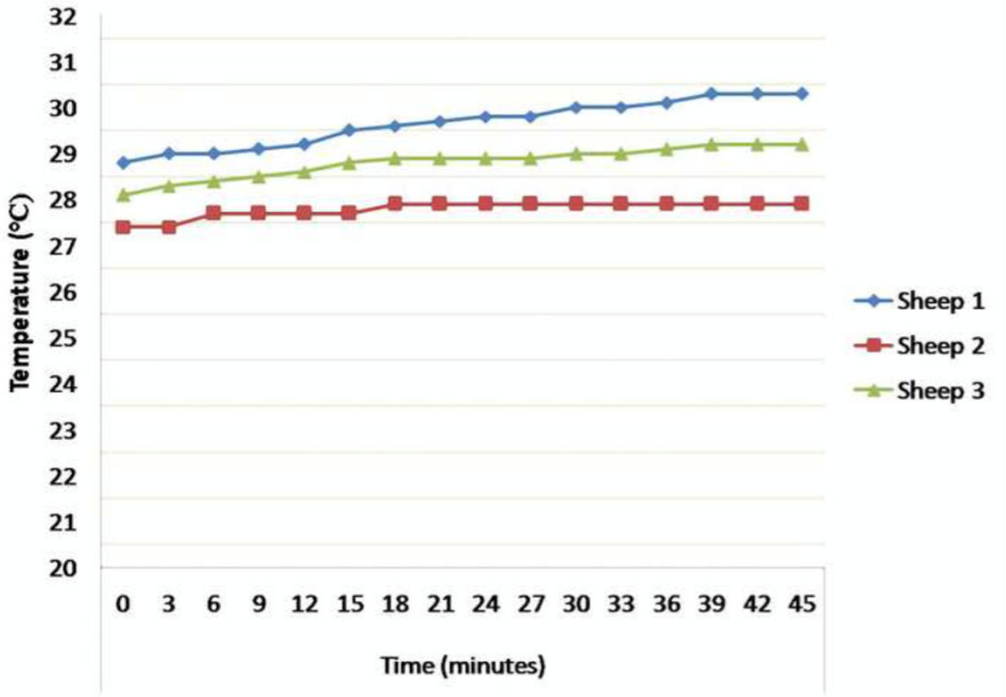
Results

- No displacement in the positions of the MCGR
- Length of MCGR
  - No change
- Ability to elongate
  - It works



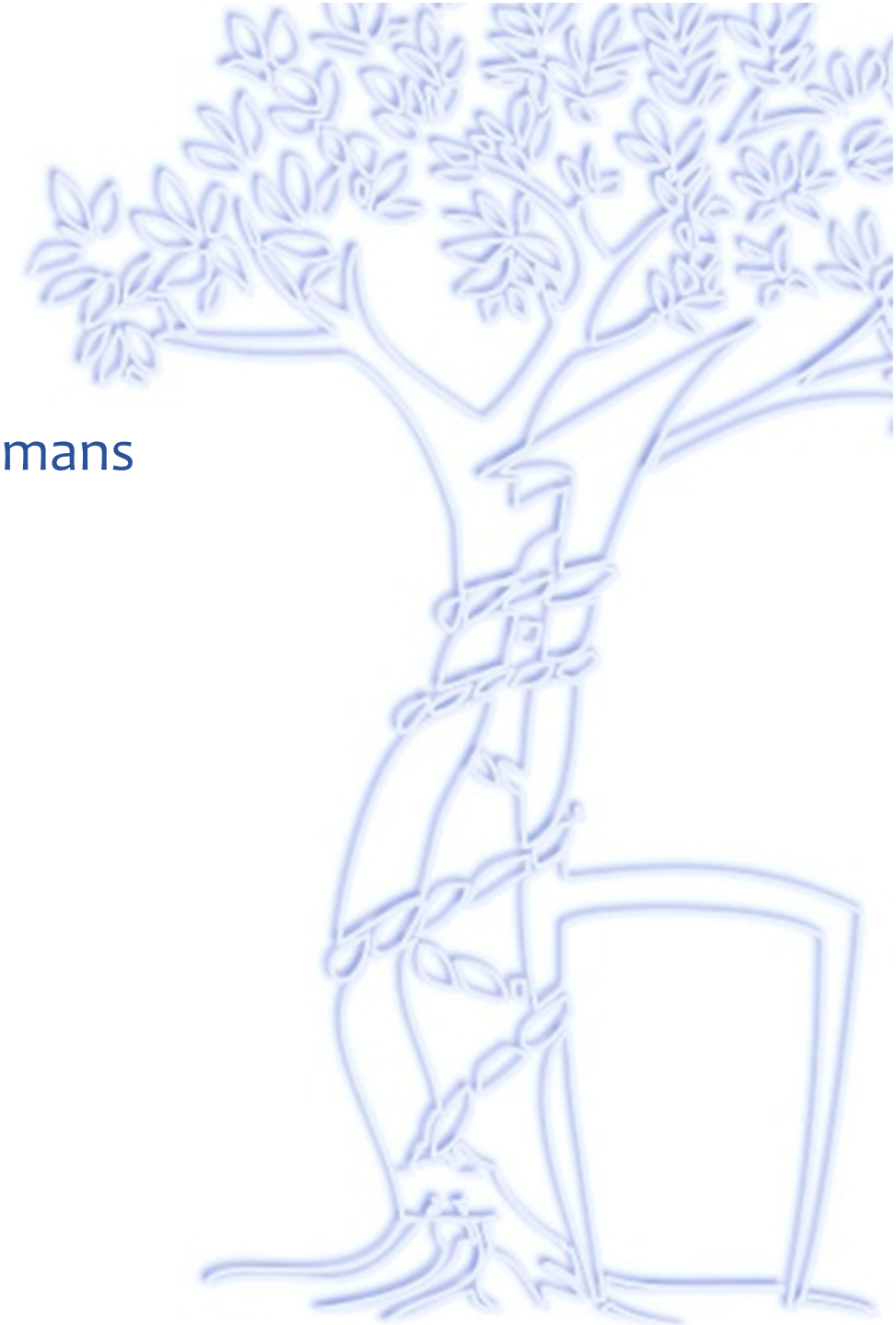
Results

- Heating
  - Mean increase
    - 1.45°C (0.5-2.4)



Drawbacks

- Animal model
  - Cannot extrapolated to humans
- Size of scattering effect
  - Not measured
- Acute setting
  - Long-term effects?
- Weak magnet
  - With stronger magnets?



Conclusion

- Lower magnet MRI is safe in an animal model with MCGR
  - NO
    - displacement of the rod
    - changes in their length
    - significant heating
    - adverse effect on the lengthening mechanism
  - BUT
    - Significant scattering effect on visualization of the surrounding tissues