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SCIENCE DAY 2021

QUANTIFICATION OF THE REGIONAL ACCELERATORY PHENOMENON USING DEEP LEARNING

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INTRODUCTION

BIOLOGICAL MODIFICATION IN BONE

- ***Biological modifications are known to happen in bone after an injury***
- ***RAP first described in 1983 by HM frost***
  - ***Scientific foundation behind modern accelerated orthodontics and other procedures***
  - ***Sequence of events, including increased bone turnover, in response to noxious stimulus to the bone***
  - ***Wilcko & al. (2001) used it to accelerate orthodontic movement***
  - ***Dibart (2009) described a minimally invasive version of this technique using a piezoelectric knife***
  - ***No studies so far compared the intensity of the bone modifications induced by bur vs piezo***

“[…] ACCELERATES THE LOCAL BONE TURNOVER 10 TO 50 FOLD ABOVE NORMAL FOR MORE THAN A YEAR “

HM FROST, 1983

RESEARCH QUESTION

WHAT WE WANTED TO KNOW

- ***Yaffe (1994) demonstrated on the rat model that reflection of a flap alone gave place to a phenomenon consistent with the RAP***
  - ***We included a group where the tissues were reflected without decortication (sham)***
- ***PICO Question: Is there is a difference in the bone biomodifications induced by decortication with a piezoelectric knife or a rotary bur compared with a sham procedure or intact bone on the rat model?***
- ***Hypothesis: Different surgical methods induces distinct biological modifications in bone***

STUDY DESIGN

WHAT WE WANTED TO SEE

- ***Animal study on the rat tibia***
- ***Procedures tested:***
    - ***Selective cortical penetration with a Piezoelectric knife,***
    - ***Selective cortical penetration with a Rotary bur,***
    - ***Soft tissue reflection***
    - ***Intact bone as a control***
- ***Timepoints:***
    - ***Post-operative day 7 and 14***

MATERIALS & METHODS

SURGICAL ARMAMENTARIUM

- ***Piezoelectric knife***
  - ***BS1 insert of Piezotome***
- ***Bur Group***
  - ***Template for a 0.5 carbide bur in order to make a defect that is comparable in size with the defect from the BS1 insert***

METHODS

SURGICAL PROCEDURE

The BS1 insert of the piezotome

Visualization of the knee through the skin

Osseous defect created (Shown with piezoelectric knife)

Immediate post-op after sutures

After 1 week of healing, at time of sacrifice

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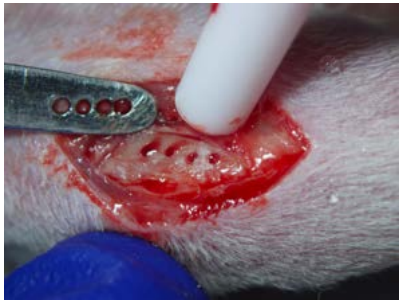
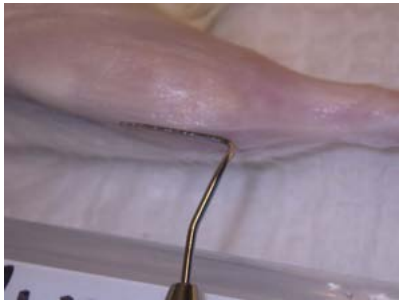
METHODS

EXPERIMENTAL GROUPS

PIEZOELECTRIC KNIFE	ROTARY BUR	SHAM	CONTROL
4x Day 7	4x Day 7	3x Day 7	3x Day 7
4x Day 14	4x Day 14	3x Day 14	3x Day 14



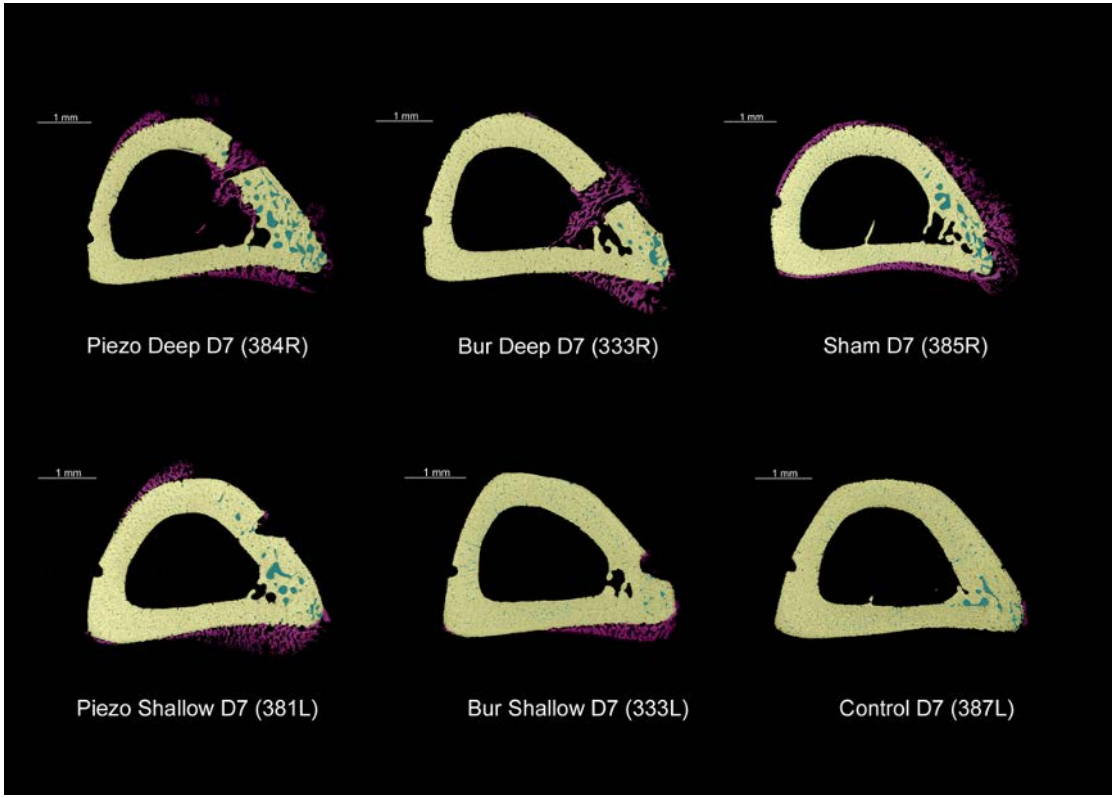
Timeline: Day 0: Experiment → Day 7: Sacrifice of 7D group → Day 14: Sacrifice of 14D group → Data analysis

METRICS & ANALYSIS

HOW WE MEASURED THE RESULTS

- ***Cortical porosity of the bone on micro-CT analysis (Xradia Versa 520) was used to evaluate the intensity of the bone modifications***
  - ***Cortical porosity has been shown to be linked to bone turnover***
  - ***Can be quantified and compared***
- ***Deep learning was used to segment images***
  - ***Subset of machine learning, allows to obtain precise segmentation of 3D images without doing it manually***
  - ***Full scan = 1000+ slices, Only have to segment 6-8 manually per scan***

SEGMENTATION RESULTS



Cortical Bone

Reactive Bone (Callus)

Cortical Porosity

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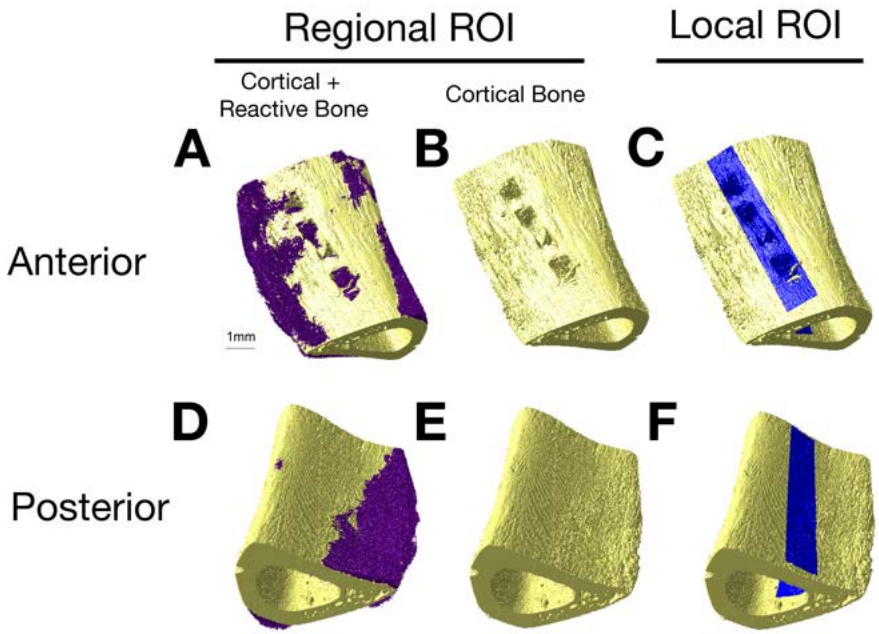
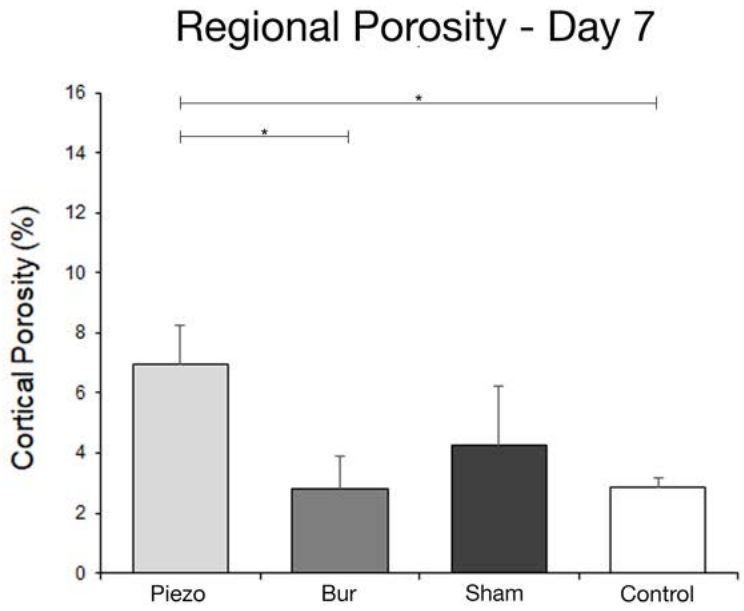
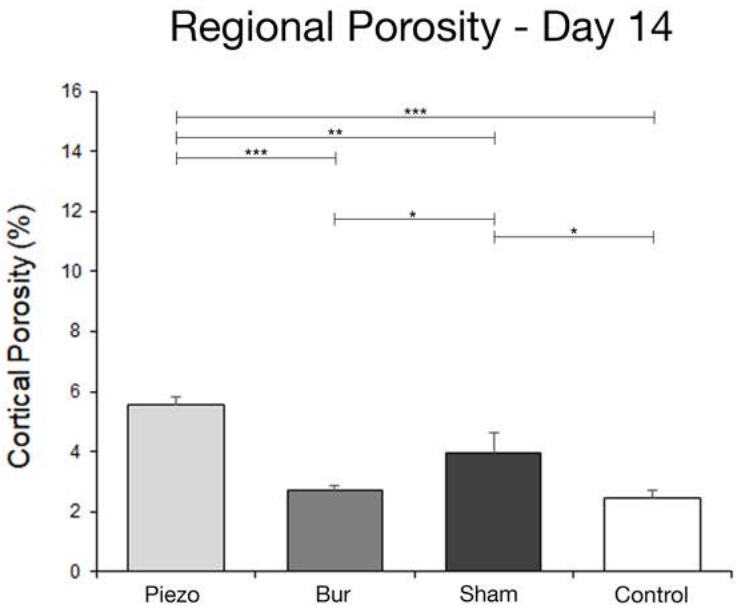
RESULTS

- ***Regional** vs **Local ROIs***
- ***Presence of reactive bone***
- ***Local analysis: Regions of Interest (ROIs) in blue have a dimension of 6 x 1 x 1 mm***
- ***Regional analysis: Based on whole scan (approx 7mm)***



RESULTS





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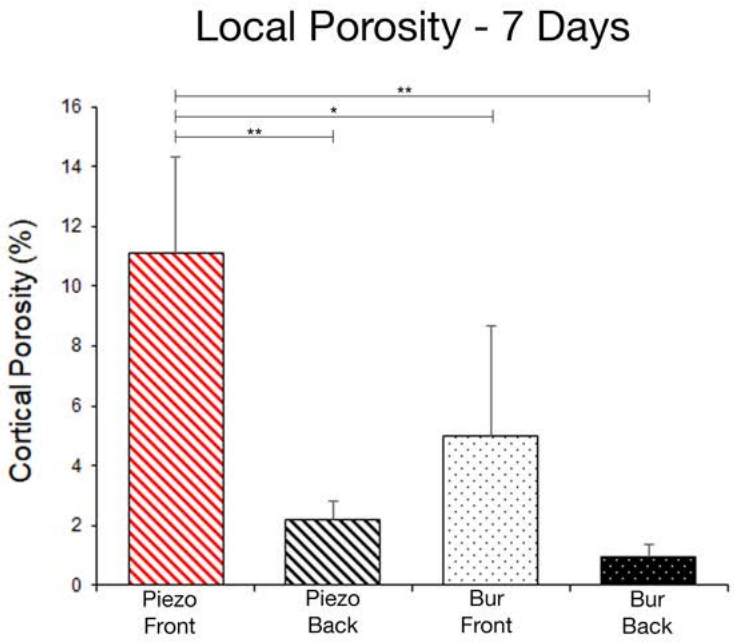
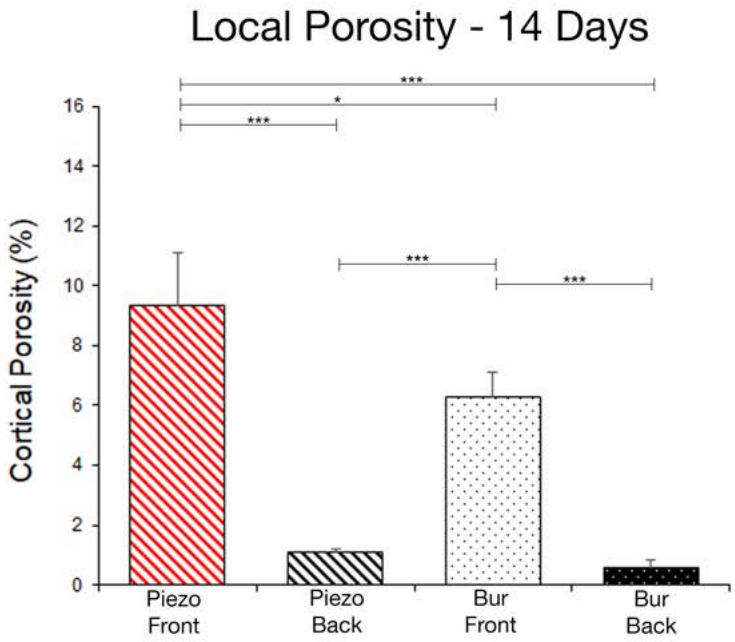
RESULTS





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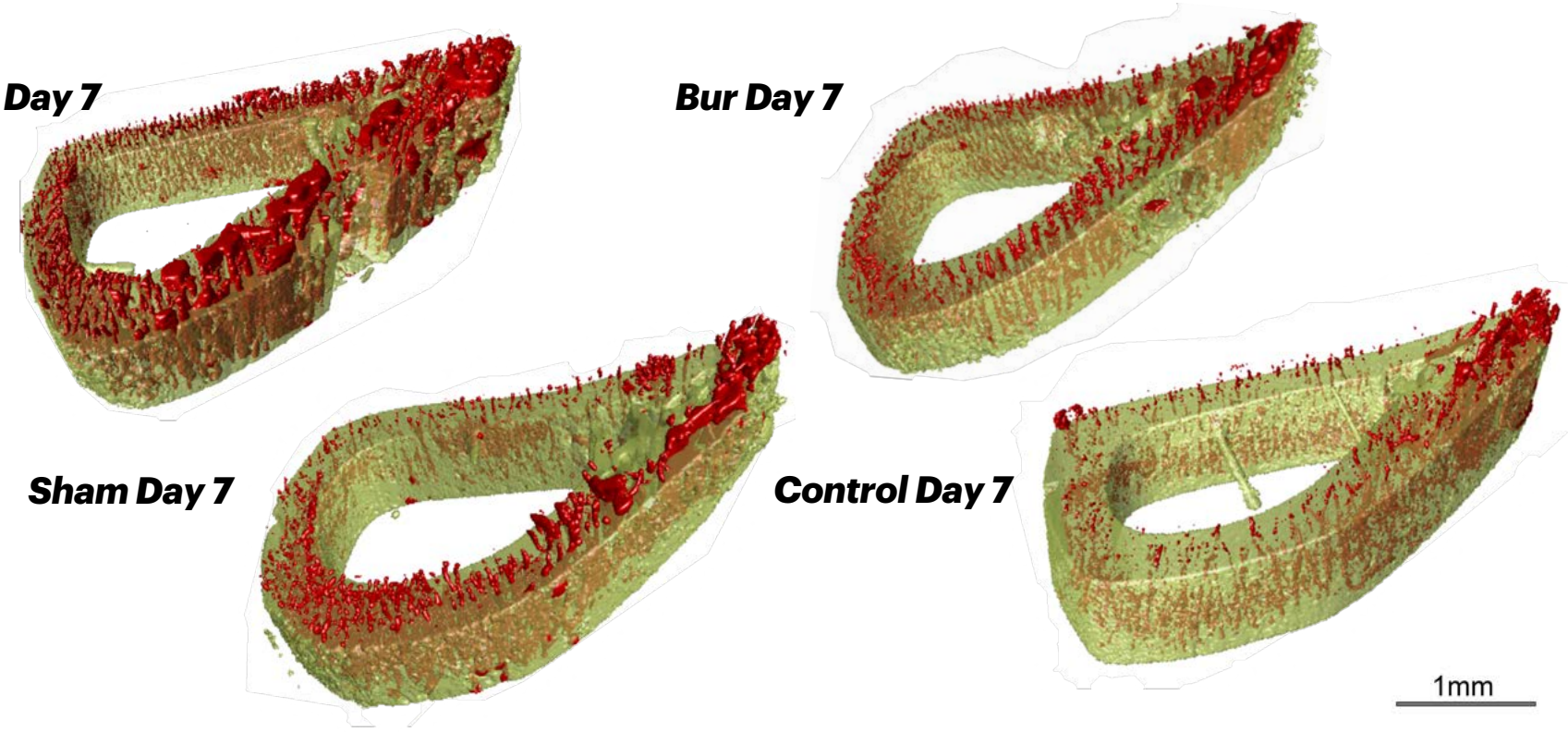
3D RECONSTRUCTIONS



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DISCUSSION / CONCLUSION

WHAT THIS DATA TELLS US

- ***According to our results, piezoelectric surgery induces a phenomenon consistent with the RAP that is significantly more pronounced that the one induced by a rotary bur or reflection of tissues alone***
- ***Local analyses also suggest that the piezoelectric knife induces more bone modifications, but also that said modifications are localized.***
- ***What is the origin of these porosities?***
  - ***Original paper by Frost mentioned that they observed "a secondary Haversian system"***
  - ***3D rendering of the porosity shows a vascular net-like arrangement***