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Bioactive and magnetic apatitic bone cement for Bone Regeneration

CNR ISSMC
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INSTM

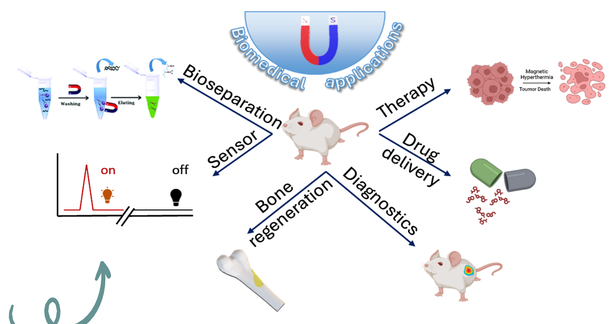
INTRODUCTION & AIM

Injectable apatitic bone cement:

CPC are promising candidates for the **regeneration** of **complex-shape bone defects**, and they can provide a **physical guide** to bone cells to promote bone regeneration. In addition, CPCs can **release drugs** along **controlled** and sustained time kinetics profiles.

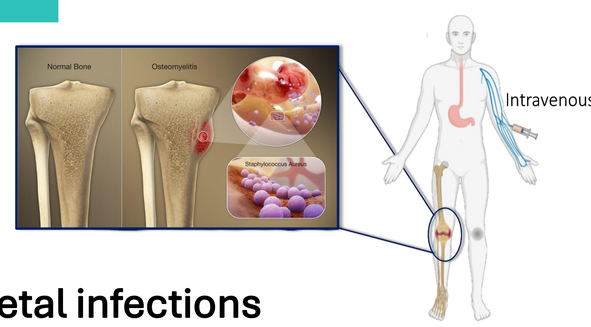
Magnetic-responsive scaffold:

4D-scaffold that posses dynamic and **stimuli-responsive properties** that **enhance their functionality** and adaptability.



Guided bone tissue regeenration

Bacterial infection: bone lesions destroy bone tissue → **Can lead to implant failure**.



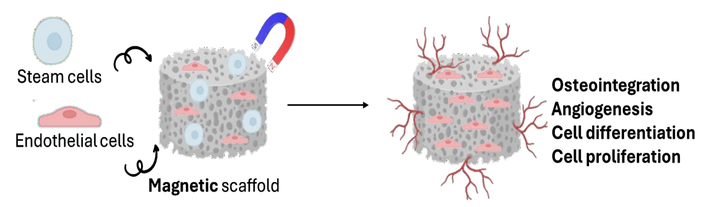
Staphylococcus aureus (gram +)
- responsible for **two-thirds of skeletal infections**
- can form **biofilm**

Common treatment:
1. Surgical removal of affected bone
2. Systemic administration of high dose of antibiotics

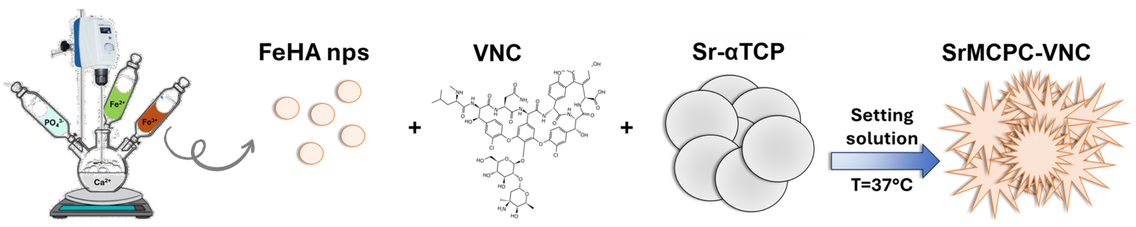
→

Clinical need:

Regeneration of affected **bone tissue** and the **local delivery** of antibiotics (as **Vancomycin**, VNC)



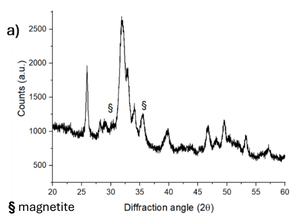
METHODS

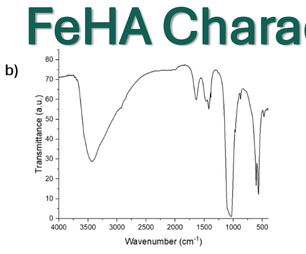


1. Synthesis of **Sr-doped *α*TCP** by solid state chemical reaction at 1400°C.
2. Synthesis of superparamagnetic iron-doped hydroxyapatite nanoparticles (**FeHA**).
3. **FeHA** and **VNC** were mixed with the cement powder phase to develop magnetic bone cement containing vancomycin (**SrMCPC-VNC**)
4. Appropriate amounts of powder and liquid, liquid-to-powder (LP) ratio = 0.6, were mixed to obtain the **SrMCPC** cements

RESULTS & DISCUSSION

FeHA Characterization





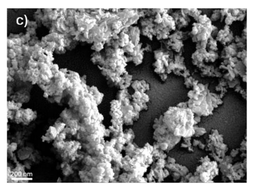
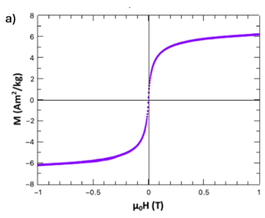


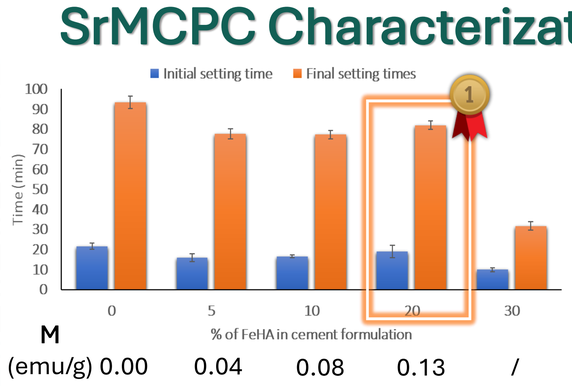
Table 1 ICP-OES, UV-Vis and DLS analysis of FeHA nanoparticles

ICP-OES	**Ca/P**	1.47 ± 0.01
	(Ca + Fe)/P	1.78 ± 0.02
	Fe/(Ca + Fe) mol%	17.47 ± 0.59
	Fe tot wt.%	13.02 ± 1.75
UV-Vis	**Fe^{2+} % (Fe^{2+}/Fe tot)**	5.76
	Fe^{3+} % (Fe^{3+}/Fe tot)	94.24
DLS	**ζ-potential (mV)**	−29.20 ± 0.50
	Z-average (nm)	201 ± 1
	PdI	0.37 ± 0.02

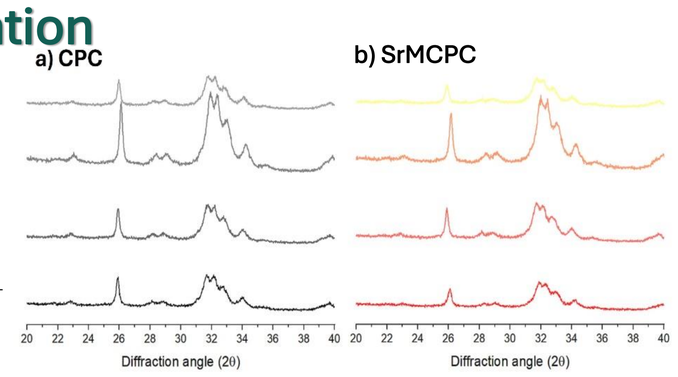


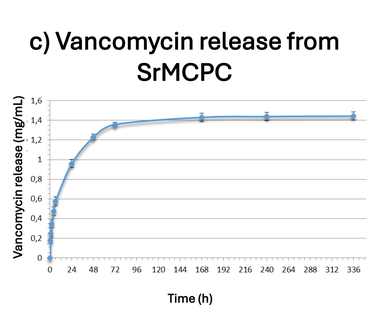
XRD and **FTIR**: typical pattern of **nanocrystalline HA** with **trace** of **magnetite** (§, ≈ 9 wt.%)
Chemical analysis shown **Ca/P < 1.67**
FeHA shows a **good** in fluid media, attested by the quite **dispersibility low ζ-potential** and **small particle size**
FeHA shows **superparamagnetic-like** behaviour, with a **saturation magnetization** of ≈ **6 Am^2/Kg**

SrMCPC Characterization



M (emu/g) 0.00 0.04 0.08 0.13 /



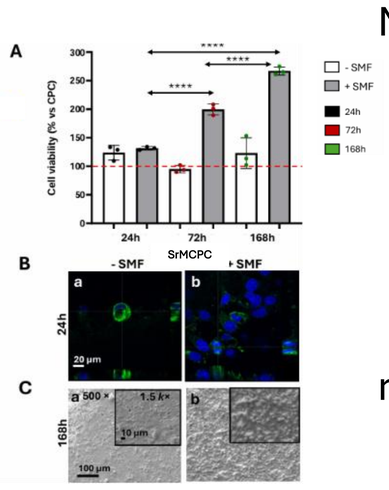


20 wt% of **FeHA** respect to αTCP is **best compromise** in terms of injectability, paste workability, setting times and magnetic behaviour.

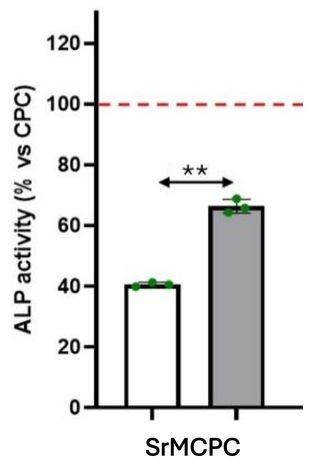
Sustained release of VNC over 1 week

Biological evaluation: SaOs-2 osteoblast-like Cells

All cements formulation supported cell attachment and spread on the surface.
No SMF: cell viability ≈ CPC
SMF: MagCPC20 pronounced increase in viability



Magnetic cements are **biocompatible**, **improve** osteoblast **proliferation under SMF**, and **promote** osteogenic **differentiation** as reflected by increased ALP activity when SFM is applied

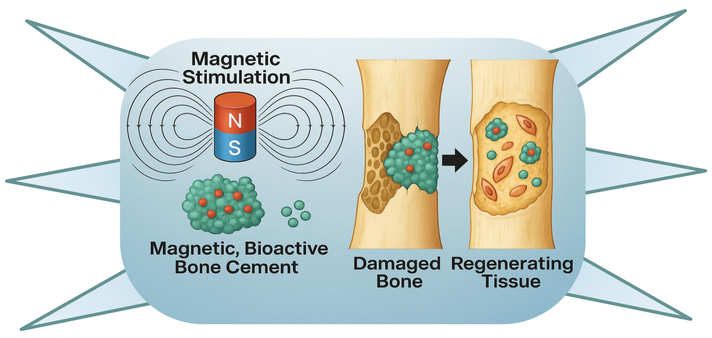


CONCLUSIONS

SrMCPC: **Biocompatible, injectable, and self-hardening within ~20 min**

SrMCPC: **enhance osteoblast proliferation**

Osteogenic differentiation is improved, as indicated by higher alkaline phosphatase (ALP) activity under SMF



FUTURE WORK

***In-Vivo* test**

Optimization of magnetic activation parameter (field intensity, exposure time, …)

VNC release under the application of pulsed **magnetic field**

REFERENCES
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