A biodegradable Cu/Sr co-doped hydroxyapatite composite for femoral bone defect reconstruction

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1. Introduction:

Clinical Challenge:

Bone defect repair in ischemic conditions, such as early-stage osteonecrosis of the femoral head (ONFH), remains a major challenge.

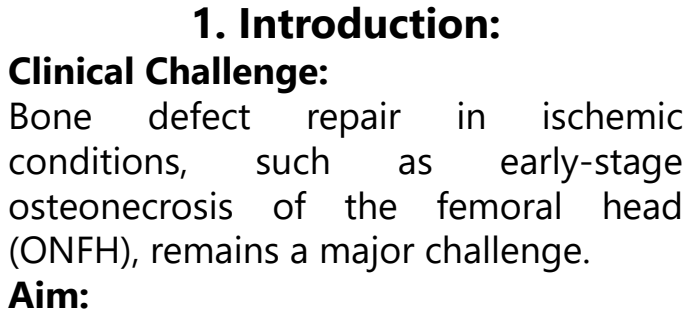
Aim:

Establish a biomimetic, injectable, and degradable composite that targets a synchronized angiogenic and osteogenic response.

2. Methodology:

HA hydrothermal synthesis:

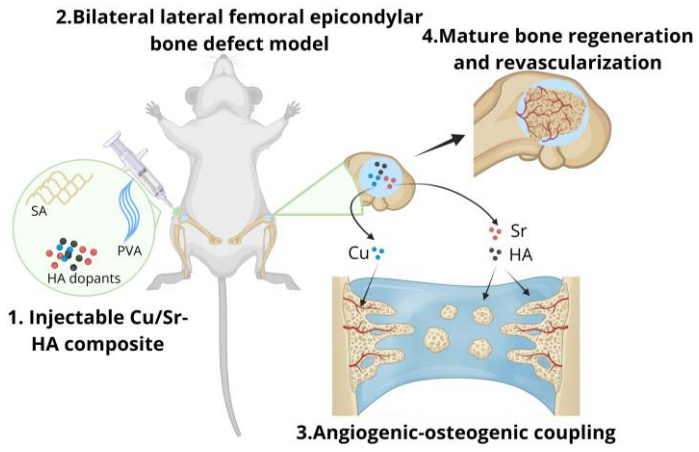
Hydrothermal synthesis of copper (Cu)/strontium (Sr) co-doped hydroxyapatite (HA) (120°C for optimal crystallinity). Incorporated into an injectable dual-network polyvinyl alcohol (PVA) and sodium alginate (SA) hydrogel.



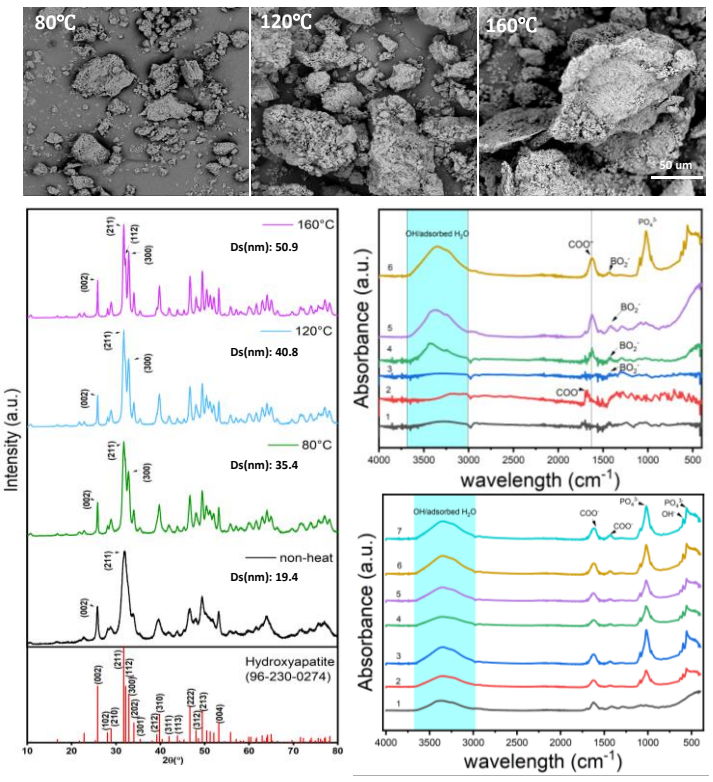
In vitro evaluation:

Cytotoxicity and proliferation were monitored with hMSCs using viability assays and Live/Dead staining. Angiogenic capacity was evaluated through HUVECs scratch migration and tube formation assays. Osteogenic performance was confirmed by evaluating calcium nodule deposition via Alizarin Red staining and qRT-PCR.

In vivo evaluation:

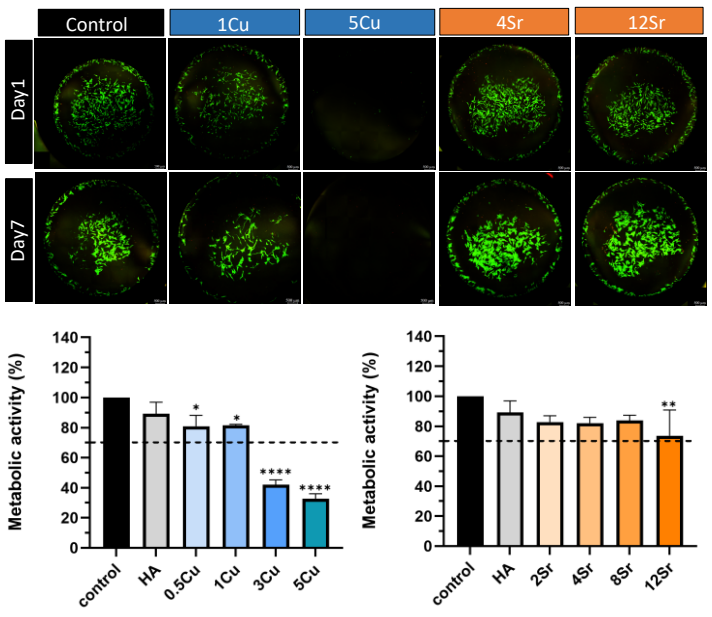


3. Characterization results

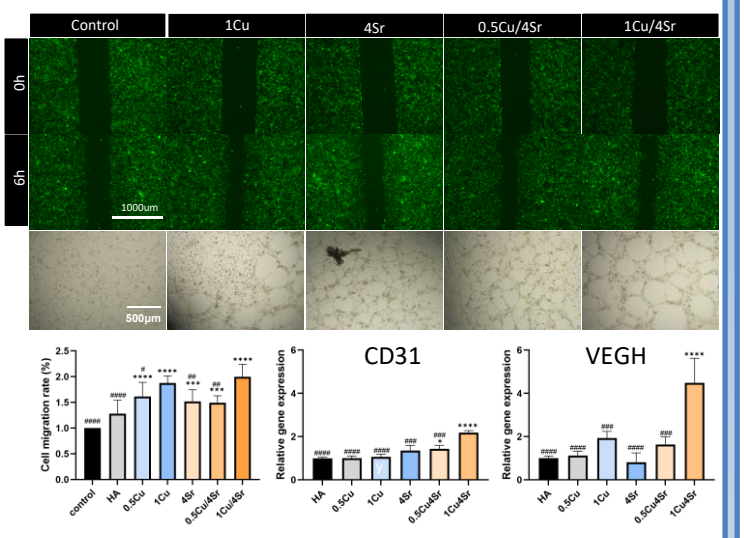


4. In vitro synergistic effect results

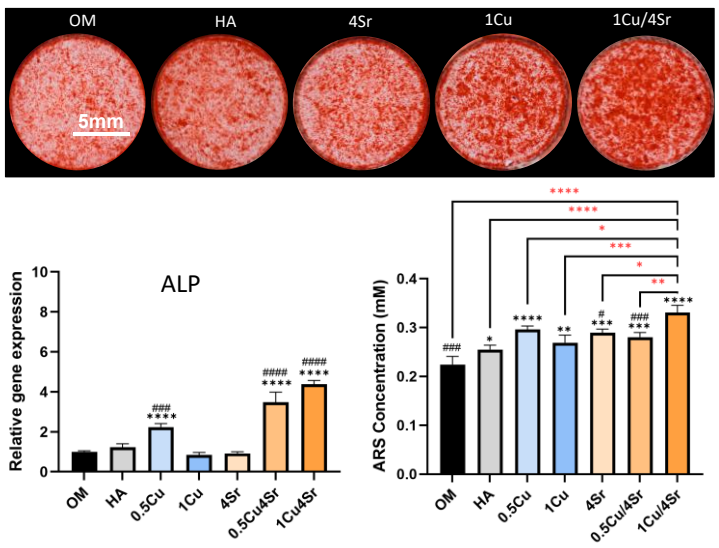
Cytotoxicity



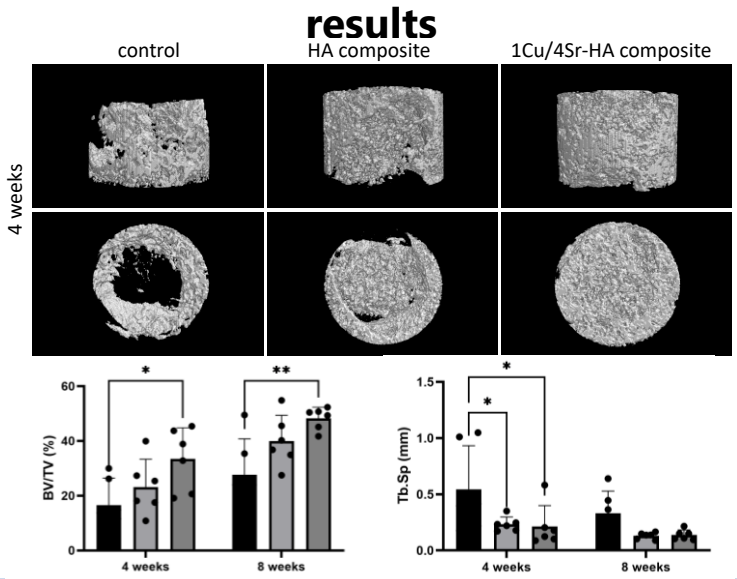
Synergistic angiogenesis



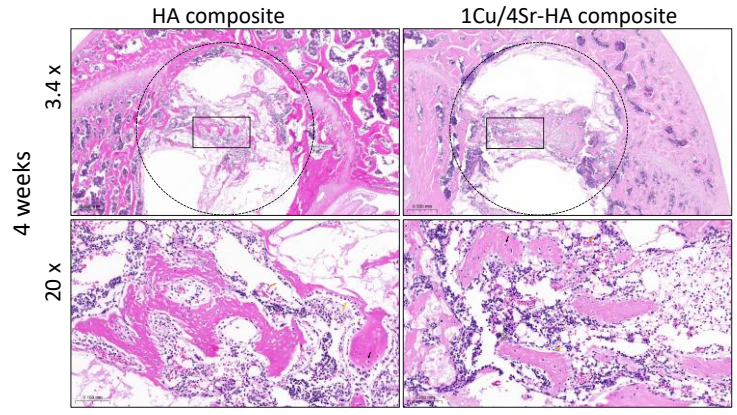
Synergistic osteogenesis



5. In vivo 3D bone reconstruction results



6. In vivo histology results



7. Conclusion

- 3% Cu induces cytotoxicity, underscoring that precise ion tuning is critical for biocompatibility.
- The composite acts as a dual-action void filler that actively promotes angiogenesis and osteogenesis.
- The composite uniquely promotes both "bridge-like" host bone integration and "island-like" de novo bone foci.
- The system drives both osteoconduction and osteoinduction.