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Are we ready for minimally invasive *in situ* 3D printing? - *A scoping review*

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Introduction

We define the term minimally invasive *in situ* 3D printing (MI3DP) as the deposition of biomaterials on the intended anatomical location in the living body through small surgical incisions. MI3DP has certain advantages as opposed to conventional implants:

- ability to tackle natural defects with irregular topographies
- increased depositioning precision
- improved interaction between native tissue and implant
- reduced healing time, contamination and scars

SYSTEM REQUIREMENTS

- **Miniaturization**
- **Preoperative defect imaging**
- **Printing on uneven surfaces**
- **Multi-axial printing**
- **Continuous *in situ* scanning**
- **Bioinks and biomaterials**

SAFETY CONSIDERATIONS

- **Radiation**
- **Cytotoxicity**
- **Temperature**

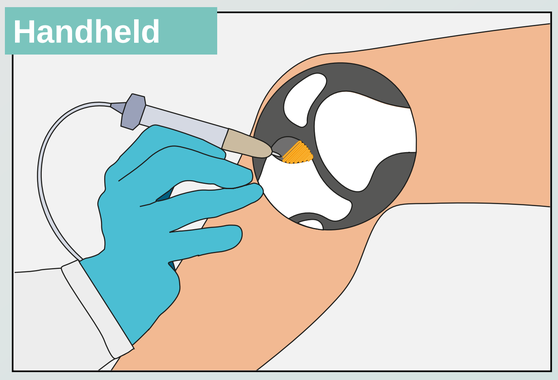
3D PRINTING MODALITIES

- **Extrusion**
- **Inkjet**
- **Laser**

Methods

We performed a scoping review to provide an overview of the current state of the technology and discuss the current challenges of MI3DP.

Handheld

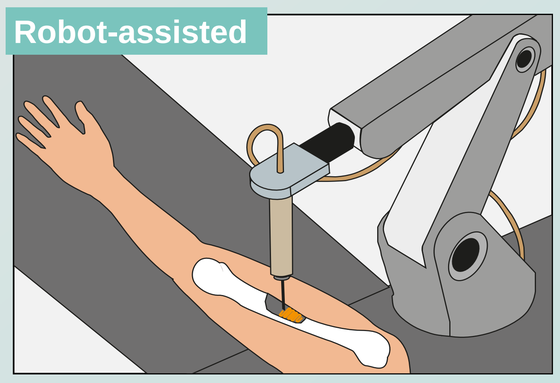


Advantages
- Fast operation
- Small and intuitive device
- Lower initial cost
- Easy to sterilize

Disadvantages
- Not suitable for complex structures
- Hard to reach deep locations

Studies: [1-5]

Robot-assisted

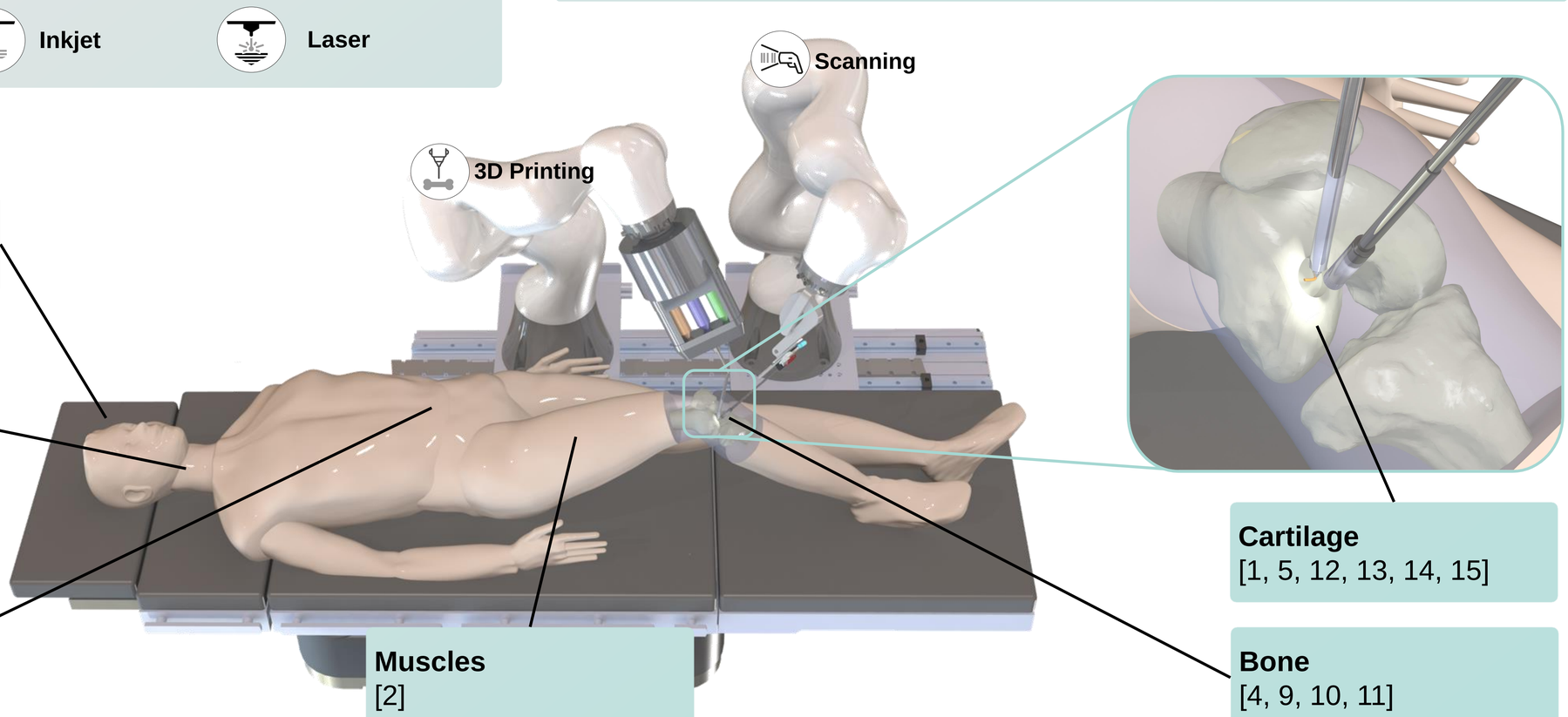


Advantages
- Precise printing
- Ability to print complex structures

More suitable for minimally invasive *in situ* printing

Disadvantages
- Imaging and planning needed
- Higher initial cost

Studies: [6-15]



Results

- No published research on MI3DP system performance for bone/cartilage regeneration in minimally invasive settings.
- Some research groups developed MI3DP for abdominal organs, evaluating them in minimally invasive contexts ([6*, 7*, 8*]).
- Miniaturization is a challenge in MI3DP and affects the choice of printing modality; mainly extrusion-based printing was selected so far.

Conclusion

MI3DP holds promise for diverse medical applications despite miniaturization challenges. Further research and development could lead to personalized surgery, lowering complications and recovery duration.

References

tinyurl.com/MI3DPrint

Websites:

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biromed.dbe.unibas.ch

Swiss MAM
dbe.unibas.ch/en/swiss-mam/

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