MAKING ISOGRAFTS FROM XENOGRAFTS ONE KIDNEY AT A TIME EN BLOC WITH HELP OF ARTIFICIAL INTELLIGENCE

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THE ORGAN SHORTAGE

Global organ shortage remains a critical unmet need in transplantation medicine.

Xenotransplantation offers a potential bridge, yet immune rejection and long-term graft intolerance persist as major barriers.

100,000+
US TRANSPLANT WAITLIST

~13 PTS/DAY
DIE WAITING

CLINICAL CHALLENGE: FRAILTY

High-frailty transplant recipients represent a growing, underserved population:

- ↑ Post-operative complication rates
- ↓ Tolerance for immunosuppressive regimens
- ↑ Graft rejection risk due to immune dysregulation
- Limited benefit from standard xenograft protocols

OBJECTIVES

1. Propose an AI-assisted conceptual framework for personalized xenograft adaptation
2. Integrate patient immunologic and frailty profiles into scaffold design
3. Bridge laboratory innovation with patient-centred clinical translation

CONCEPTUAL FRAMEWORK

PATIENT PROFILE
- IMMUNOLOGIC HLA
- FRAILTY SCORE
- COMORBIDITIES
- BIOMARKERS

→

AI ENGINE
- ML IMMUNE PREDICTION
- BIOMECH. MODELING
- SCAFFOLD OPTIMIZATION
- RISK STRATIFICATION

→

XENOSCAFFOLD
KIDNEY MATRIX PORCINE DERIVED

STEP 1: SCAFFOLD CONDITIONING
DECELLULARIZATION & ECM TUNING PER PATIENT BIOMECHANICS

STEP 2: CELLULAR REPOPULATION
PATIENT-DERIVED IPSC SEEDING; VASCULAR & TUBULAR RECELLULARIZATION

STEP 3: IMMUNO-MODULATION
TAILORED CYTOKINE MILIEU; TOLERANCE-INDUCING CELL CO-CULTURE

PERSONALIZED ISOGRAFT-LIKE XENOGRAFT → MINIMAL IMMUNOSUPPRESSION · LONG-TERM TOLERANCE · PATIENT-CENTRED OUTCOME

AI INTEGRATION

Multi-omic Integration
HLA typing, proteomics & transcriptomic profiles feed patient-specific immune tolerance predictors

Biomechanical Modeling
FEA-based scaffold stiffness, porosity & perfusion optimization per recipient anatomy

Reinforcement Learning
Iterative scaffold parameter refinement guided by in silico immune simulation outcomes

FRAILTY & CLINICAL TRANSLATION

- Reduced immunosuppression burden
- Lower infection & toxicity risk
- Scaffold-mediated self-tolerance induction
- Improved quality of life & survival outcomes

DISCUSSION

Strengths:
- Patient-centred, scalable conceptual model integrating cutting-edge AI with regenerative engineering

Limitations & Future Work:
- Requires experimental validation, bioethical review of porcine xenograft sources, and regulatory pathway development (EMA/FDA)

CONCLUSIONS

✦ AI-guided personalization redefines xenografts as dynamic, patient-matched substrates

✦ Framework minimises immunosuppression, benefiting high-frailty populations

✦ Bridges laboratory innovation with patient-centred clinical translation