3rd Meeting of the International Consensus Meeting
8-10 of May, 2025 Istanbul

B11 – How should antimicrobial properties of an orthopaedic titanium implant be evaluated in animal and clinical studies?

Assoc. Prof. Margarita Trobos

Department of Biomaterials, Institute of Clinical Sciences, Sahlgrenska Academy,
University of Gothenburg, Sweden

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Alexander W Burns
Australia

Humberto González-Ugalde
Mexico

Noreen J Hickok
USA

Liliana A Morales-Laverde
Sweden

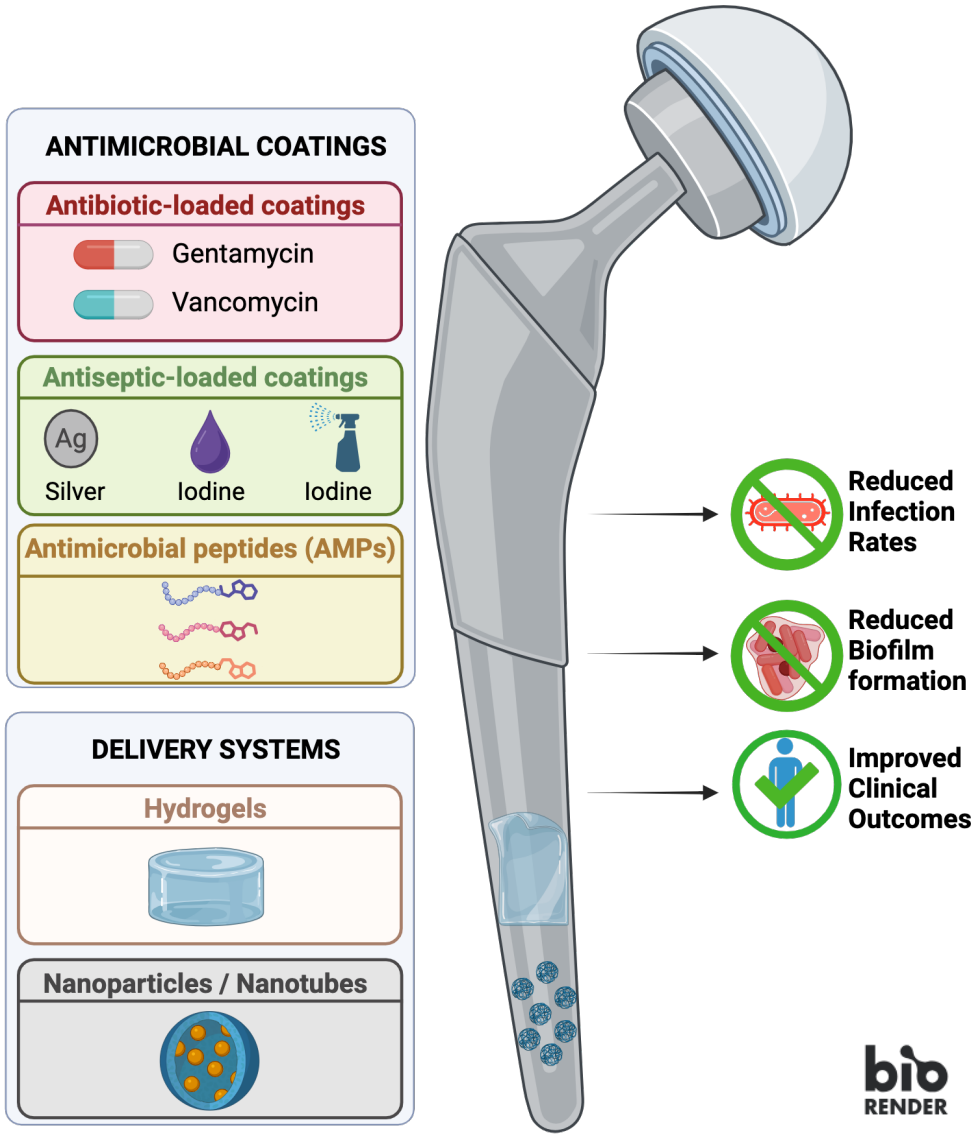
Ebru Oral
USA

Claudia Siverino
Switzerland

2747	287	51
Number of articles retrieved	**Full text review/Screening**	**Final number of publications**

- Systematic review of studies **from 2015 to 2024**, focusing on **animal (n=42)** and **human (n=9) studies** involving **antimicrobial titanium implants**

Antimicrobial Strategies for Orthopaedic Ti implants



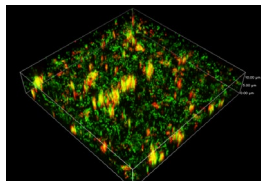
Background & Aim:

- **Implant-associated infections** are a major complication in orthopaedic surgery
- Novel titanium **implants with antimicrobial properties** are being developed
- **Lack of standardization** in evaluating their efficacy *in vivo*
- **Aim:** Identify **key criteria** to evaluate such implants, focusing on animal and clinical studies
- Most studies reported **reduced infection rates and improved clinical outcomes** with antimicrobial coatings

Outcome evaluation and analytical techniques:

1. Bacterial Viability

- Live/dead staining

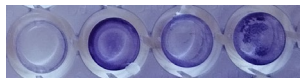


2. Bacterial Adhesion

- CFU counting after detachment
- SEM imaging

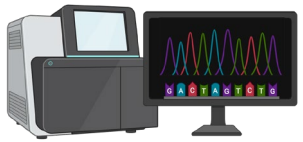
3. Reduction in Biofilm Formation

- Crystal violet staining (biofilm biomass)
- CLSM & SEM imaging
- CFU counting from dispersed biofilm



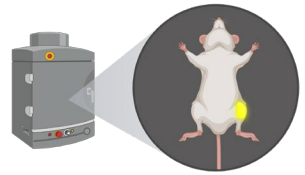
4. Antibiotic Resistance

- MIC testing
- Whole-genome sequencing



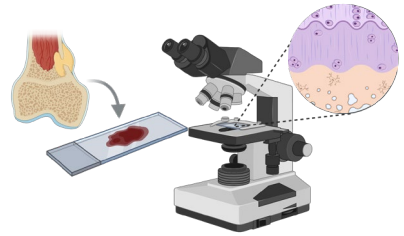
5. Infection Rates

- Microbiological cultures
- Imaging (X-ray, µ-CT, MRI, IVIS bioluminescence)



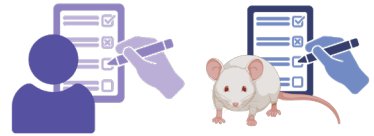
6. Inflammatory Response

- Blood tests
- Histological analysis



7. Clinical Outcomes

- Recovery & complication rates
- Clinical exams, imaging



8. Functional Outcomes

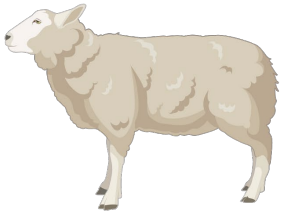
- Mobility tests
- Pain scales
- Functional scoring systems

Models:

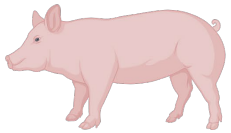
Mice (C57BL/6) (n=5-10)

Rats (Sprague-Dawley) (n=5-10)

Rabbits (New Zealand White) (n=6)

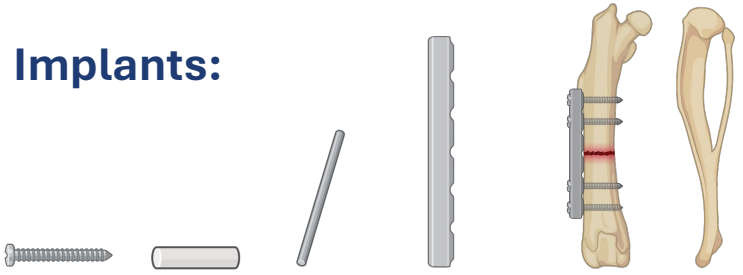


Sheep (n=7)



Minipigs (n=7)

Implants:



In animal studies, key factors include:

- **Choice of model** — rodents, rabbits, or large animals with relevance to human bone healing
- **Bacterial inoculation** — clinically relevant species (*S. aureus, S. epidermidis*) with standardized doses (10^6 to 10^8 CFU) to avoid sepsis or rapid clearance
- **Infection** — acute or chronic infections should reflect the intended clinical scenario
- **Timing** — pre- or post-implantation infection; use of planktonic bacteria or pre-formed biofilm on implant depending on the model
- **Follow-up** — ranges from 1 week to several months
- **Evaluation** — assess bacterial viability, biofilm formation, inflammatory response, infection rates, clinical outcomes
- **Design** — include blinding, controls, power analysis, and ethical compliance

In clinical studies, key factors include:

- **Design** — use prospective RCTs or observational studies
- **Patient population** — high-risk orthopaedic patients (arthroplasty or trauma; n=5–653)
- **Implant types** — prostheses, nails, fixation materials
- **Antimicrobial coatings** — gentamicin, vancomycin, iodine, silver
- **Infection sites** — bone and joint
- **Outcomes** — clinical (recovery & infection rates); functional (mobility & pain)
- **Follow-up** — long-term (months to years; 1 year common)
- **Design** — apply standardised definitions, ensure ethical compliance

Question:

- How should antimicrobial properties of an orthopaedic titanium implant be evaluated in animal and clinical studies?

❖Response:

- The antimicrobial properties of orthopaedic titanium implants should be evaluated using a combination of *in vitro*, animal, and clinical studies to ensure comprehensive assessment of safety and efficacy.
- Animal models provide crucial insights into the biological interactions of implants with host tissues and pathogens, while human studies validate clinical applicability.
- To effectively evaluate the antimicrobial properties of new orthopaedic titanium implants, it is recommended to use a combination of well-established animal models, appropriate bacterial species, standardized inoculation doses, and comprehensive and quantitative analytical techniques.

Level of Evidence: Moderate

❖**Vote:**

Agree n=42; 98%

Disagree 0

Abstain n=1; 2%