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From Percutaneous to Transcutaneous Hearing Implants: Surgical Techniques, Osseointegration, and Microbiological Insights

Akademisk avhandling

Som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin, Göteborgs universitet kommer att offentligen försvaras i hörsal Arvid Carlsson, Medicinaregatan 3, den 23 oktober 2025, klockan 13.00.

av Marsel Ganeyev

Fakultetsopponent:

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Avhandlingen baseras på följande delarbeten

I. **Ganeyev, M**., Ben Amara, H., Monksfield, P., Hol, M., Stokroos, R., Hultcrantz, M., Savage Jones, H., Trobos, M., Thomsen, P., Palmquist, A., Johansson, M.L. Pain and infection are the primary reasons for elective retrieval of bone-anchored implants. Submitted manuscript.

II. **Ganeyev, M.**, Morales-Laverde, L., Hoffman, M., Hultcrantz, M., Palmquist, A., Thomsen, P., Johansson, M.L., Trobos, M. Staphylococcal persistence and biofilm resistance in bone-anchored hearing systems: Clinical impact. Submitted manuscript.

III. **Ganeyev, M.**, Shah, F.A., Thomsen, P., Palmquist, A., Johansson, M.L. Mechanical and thermal efficiency of a single drill system for bone-anchored hearing implants. *PLOS ONE* 2025; 20(5): e0311026.

IV. **Ganeyev, M.**, Pollaers, K., Monksfield, P., Emanuelsson, L., Ben Amara, H., Thomsen, P., Palmquist, A., Johansson, M.L. Comparative evaluation of machined and laser-ablated transcutaneous implants with recessed and non-recessed placement in a sheep model.

SAHLGRENSKA AKADEMIN
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From Percutaneous to Transcutaneous Hearing Implants: Surgical Techniques, Osseointegration, and Microbiological Insights

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Abstract

From the moment a person decides to change their life and steps into the operating room to (re)gain one of the most vital senses—hearing—through to their return to daily routines, multiple factors shape both the decision-making process and overall experience. Thus, optimising functional outcomes in implantable bone conduction devices (BCD) requires a patient-centred approach that integrates clinical insights with advanced diagnostic, surgical, and analytical methods to examine the interplay between biological responses, surgical execution, and the microbiome. This thesis explores these aspects in four studies. Paper I analyses retrieved percutaneous implants, linking clinical symptoms with structural, histological, and microbiological findings. Paper II investigates the peri-abutment microbiome, showing how staphylococcal colonisation, biofilms, and antibiotic resistance drive soft tissue complications. Paper III evaluates the mechanical and thermal effects of different drilling protocols on bone trauma. Lastly, Paper IV introduces a surface-modified transcutaneous implant and a less invasive implantation alternative with translational potential.

The first two studies expand our understanding of tissue–implant interactions by investigating the role of the colonising microbiome and integrating clinical findings with structural and microbiological analyses. Findings from Paper I revealed that pain and infection are the most common factors affecting implant success and are influenced by both patient-related and microbiological factors. Paper II demonstrated that biofilm formation and antibiotic resistance in staphylococci colonising percutaneous implants are key drivers of adverse soft tissue outcomes. Paper III examined the thermal and mechanical effects of a single-drill system, highlighting its impact on heat generation and bone preservation. Finally, Paper IV identified surgical bone preparation—rather than surface modification—as the determining factor in early new bone formation and fibrous encapsulation, extending research strategies established in percutaneous implants to transcutaneous implants and providing new evidence to guide their future clinical development. Together, these results support evidence-based refinements in BCD practice and guide the development of next-generation implants with greater longevity, fewer complications, and improved patient outcomes.

Keywords: *biomaterials, bone conduction device (BCD), bone-anchored hearing system (BAHS), percutaneous implants, transcutaneous implants, osseointegration, inflammation, pain, infection, Staphylococcus aureus, Staphylococcus epidermidis, biofilm, antimicrobial resistance (AMR), minimally invasive surgery, drilling protocols.*

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