“CAROL DAVILA” UNIVERSITY OF MEDICINE AND PHARMACY, BUCHAREST

FACULTY OF MEDICINE

BIONIC VERSUS NEUROSENSORY EXOPROSTHESIS FOLLOWING FOREARM AMPUTATIONS

DOCTORAL THESIS SUMMARY

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Thesis Overview

The doctoral thesis entitled *"Bionic vs Neurosensory Exoprosthesis After Forearm Amputation"* is a complex and innovative work in the field of medicine and bioengineering. It aims to compare two modern technologies for upper limb prosthetics: myoelectric bionic exoprostheses and neural-commanded exoprostheses, with or without sensory feedback (neurosensory).

1. Context and Motivation

Forearm amputation is a devastating medical and psychological event, severely affecting a patient's quality of life. The human hand, as an extension of the motor cortex, is essential for autonomy, work, and social identity.
Statistics show an alarming increase in amputees: over 450,000 in the U.S. (2010), and 55,000 in Romania. The thesis addresses this reality and focuses on two main directions in prosthetics: bionic and neurosensory exoprostheses.

2. Research Objectives

- Comparative analysis of the two prosthetic technologies.
- Highlighting their advantages and limitations.
- Proposing innovative solutions to improve prosthesis functionality and quality of life.

Specific objectives include:

- Detailed study of forearm functional anatomy and nerve endings for interfacing with prosthetics.
- Analysis of various prosthesis types: mechanical, myoelectric, neural, neurosensory.
- Development and testing of bidirectional neural implant interfaces.
- Testing on animal models and clinical evaluation on human patients.

3. Types of Prostheses Analyzed

- **Myoelectric prostheses:** Use EMG signals from stump muscles. They are accessible but limited in motion and require long training. Lacks sensory feedback and causes quick muscle fatigue.
- **Neural prostheses:** Use signals directly from residual nerves (median, ulnar). Enable more natural control but require electrode implantation.
- **Neurosensory prostheses:** Most advanced. Provide both motor control and sensory feedback (pressure, texture, temperature). Use implanted electrodes and electronics to send signals to the brain’s sensory cortex.

4. Anatomical and Surgical Considerations

Includes a thorough analysis of forearm muscles and nerves with:

- Fascicular mapping of median and ulnar nerves.
- Motor bundle–digital movement correlation.
- Optimal electrode implantation locations.

Supports surgical procedures required in neurosensory prosthesis implantation.

5. Neural Interface Technologies

Describes components of an implantable neural interface:

- **Electrodes (cuff/intrafascicular):** For precise recording/stimulation.
- **Processing modules:** Amplify and decode signals.
- **Power systems:** Implantable batteries, wireless RF or inductive coupling.
- **Tactile sensors:** Mounted on fingers to transmit signals to sensory nerves.

Animal experiments (rats, pigs) showed functional feasibility of the systems. Methods for performance testing and nervous system integration are detailed.

6. Surgery and Rehabilitation

Multidisciplinary approach:

- **Stump preparation:** Vascularization, muscle balance, tissue closure.
- **Prosthesis selection:** Based on stump type and patient profile.
- **Patient adaptation:** Motor training, occupational therapy, psychotherapy, neurofeedback.

Highlights importance of forming new “neural maps” in the brain for efficient prosthesis control.

7. Experimental and Clinical Results

Tests revealed:

- Higher motor and sensory integration with neurosensory prostheses.
- Significant reduction in phantom limb pain.
- Improved fine movement execution.
- Increased patient satisfaction and self-confidence.

Results validate the superiority of neural interface systems over traditional myoelectric prostheses.

8. Rehabilitation and Neuroplasticity

Patients need to develop new "neural maps" to control the prosthesis. Emphasizes the essential role of multidisciplinary teams and psychological support in both functional and emotional recovery.

9. Conclusions

Neurosensory exoprostheses offer the greatest benefits in functionality, natural control, and social reintegration. However, technological, ethical, and financial challenges remain. Collaboration among researchers, clinicians, and authorities is essential to make this technology widely accessible.

The thesis proposes a viable model for the future of upper limb prosthetics in Romania, focusing on high-performance yet accessible solutions that closely replicate natural hand functionality and enable full social integration.

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LIST OF PUBLICATIONS RELATED TO THE DOCTORAL THESIS TOPIC

1. D Prisecaru, D Besnea, S Lazarescu, F Istudor, O lonescu, S Zaoutsos, C Niculae- **Design and Development of 3D-Printed Models for Limb Joi11t Motion Simulation, ROMANJAN JOURNAL OF INFORMATION SCIENCE AND TECHNOLOGY**
2. S Lazarescu, F Istudor, O Ionescu, D Dragomir,M lon, L Szekely, S Olasz, I Tiizes, G lonescu, S Zaoutsos, C Niculae - **New method for develop personalized movement algorithms for neural forearm prostheses equipped with Al module, ROMANIAN JOURNAL OF INFORMATION SCIENCE AND TECHNOLOGY**
3. S Lazarescu, F Istudor, D Prisecaru - **CONTROL YSTEM WITH SENSORY INTERFACE FOR A NEURAL FOREARM PROSTHESIS, UPB Scientific Bulletin**