ACTIVITIES AT IMID 2021-2025

Lukáš Odehnal

Biotribology Research Group
Institute of Machine and Industrial Design
Faculty of Mechanical Engineering
Brno University of Technology

Brno, 16th April 2025

INSTITUTE OF **MACHINE**
AND **INDUSTRIAL DESIGN**

PhD study and research

2021

Tribologie bioimplantátů vyrobených technologií Selective Laser Melting (SLM)

Školitel:
prof. Ing. Martin Vrbka, Ph.D

Školitel specialista:
Ing. Matúš Ranuša, Ph.D

Tření a mazání implantátů malých kloubů vyráběných aditivní technologií 3D tisku kovů

Období řešení: **1.1.2022 — 31.12.2024**

ZDROJE FINANCOVÁNÍ **Grantová agentura České republiky** - Standardní projekty

GAČR

O PROJEKTU

Artróza není doménou jen velkých kloubů člověka jako je kyčel a koleno, ale také často postihuje malé klouby na ruce a noze. Jednou z možností léčby těžkých forem artrózy je aplikace implantátu, který zajistí požadovanou artikulaci a uleví pacientovi od bolesti. V poslední době výrobci implantátů diskutují možnosti výroby náhrad malých kloubů nekonvenčními technologiemi jako je 3D tisk z titanových prášků. Výhodou takto aditivně vyráběné náhrady je zjednodušení její konstrukce a výroba na míru pro konkrétního pacienta. Předkládaný projekt se zaměří na hodnocení tribologických vlastností kontaktních povrchů konvenčně a aditivně vyráběných náhrad malých kloubů, které budou analyzovány pomocí simulátoru kloubu a fluorescenční mikroskopie. Navržená metodika umožní posoudit vývoj tloušťky mazacího filmu a současně měřit součinitel smykového tření v kontaktu. Výsledky projektu přinesou jasné závěry z hlediska funkce kontaktních povrchů aditivně vyráběných implantátů a výrazně tak přispějí k dalšímu pokroku v oblasti návrhu a vývoje náhrad malých kloubů.

PhD study and research

2021

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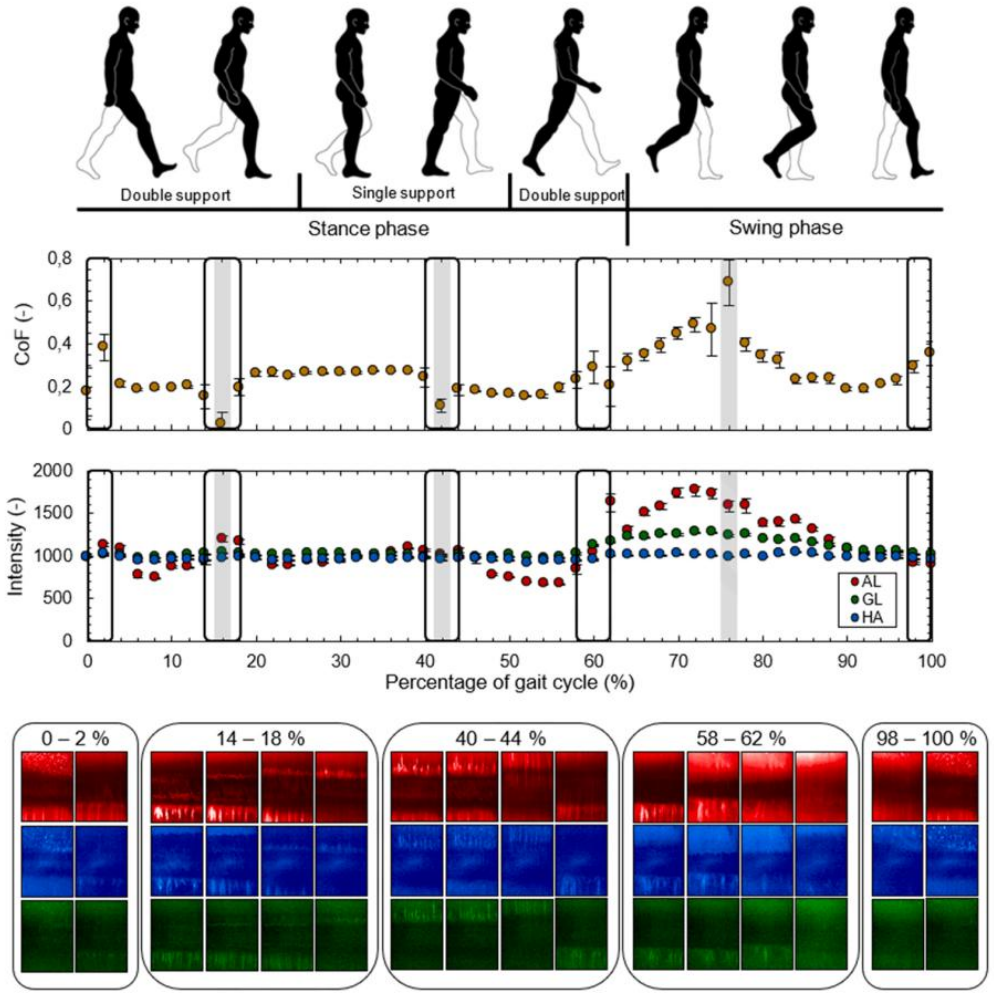

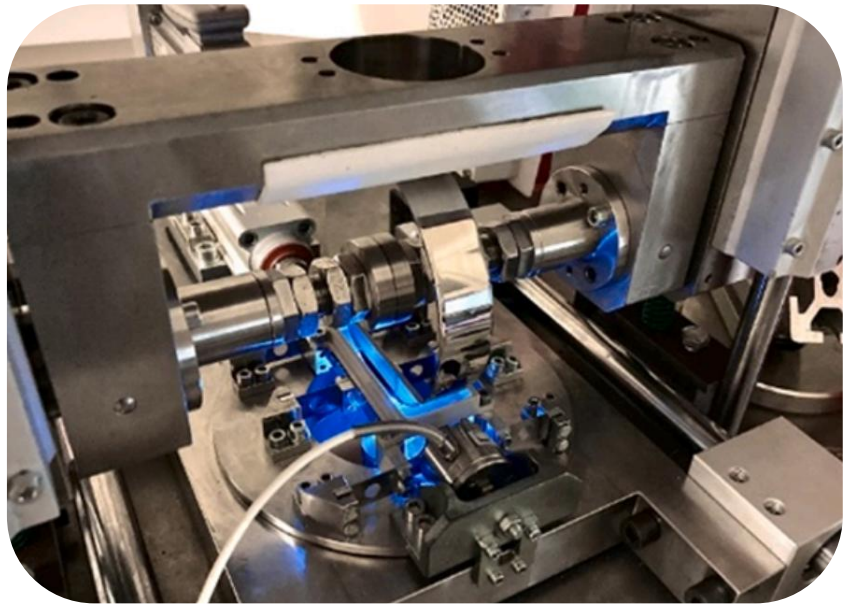

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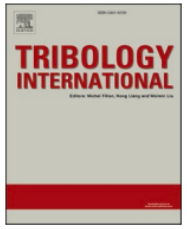
2021

Contents lists available at ScienceDirect

Tribology International

journal homepage: www.elsevier.com/locate/triboint



Development of lubrication film and influence on friction in a total knee replacement during a gait cycle

Lukáš Odehnal [a,*], Matúš Ranuša [a], Markus A. Wimmer [b], Martin Vrbka [a], Ivan Křupka [a]

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[b] Department of Orthopedic Surgery, College of Medicine, Rush University Medical Center, Chicago, USA

ARTICLE INFO

Keywords:
Total knee replacement
Friction coefficient
Lubrication film development
Fluorescent microscopy

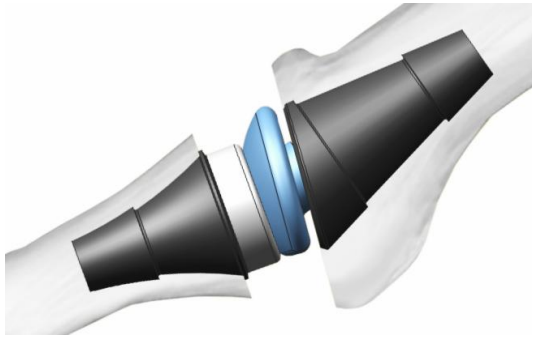
ABSTRACT

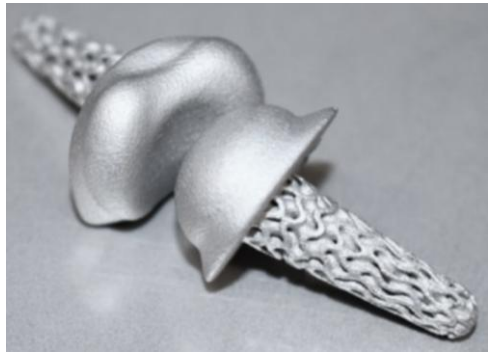
The presented study dealt with the experimental analysis of friction and lubrication mechanism observed with fluorescent microscopy in total knee replacement represented by CoCrMo wheel and PMMA plate. Model synovial fluid with marked constituents was used as test lubricant. The experiments investigated three main parameters. Slide-roll-ratio (SRR) showed the greatest influence on lubrication film formation. Friction coefficient was mostly influenced by axial load; its increase led to a decrease in friction. Relative speed was manifested for SRR 1.25 and higher where its increase caused a decrease in friction. The complex experiment showed a development of friction coefficient and lubrication film along the whole gait cycle. The results of this experiment correspond with the initial results concerning the influences of parameters.

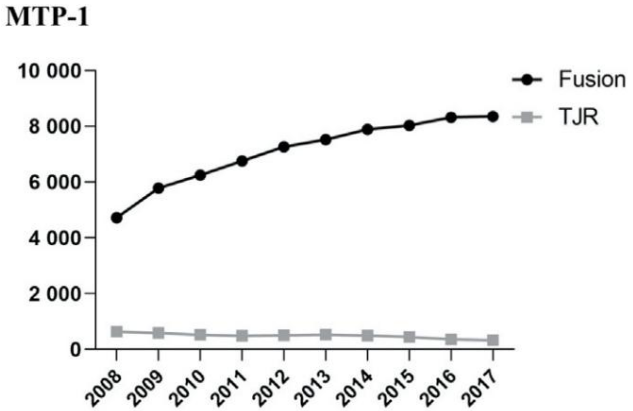
PhD study and research

2022

<u>Téma:</u> Tribologické procesy v kontaktu 3D tištěného malého kloubního implantátu



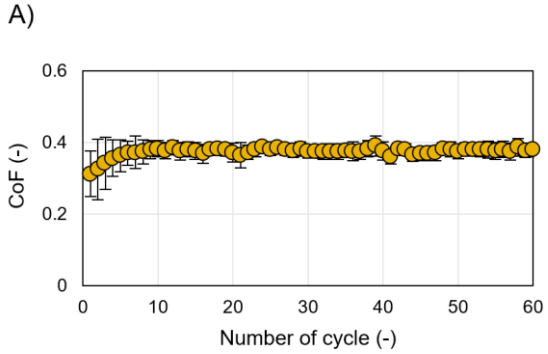


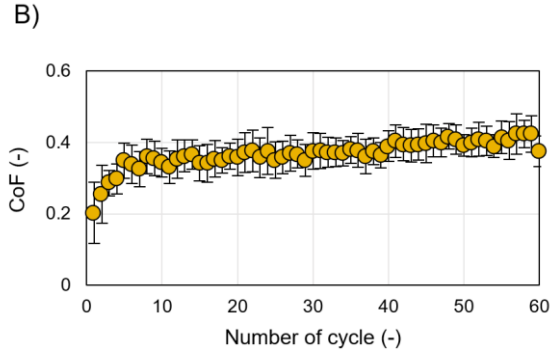


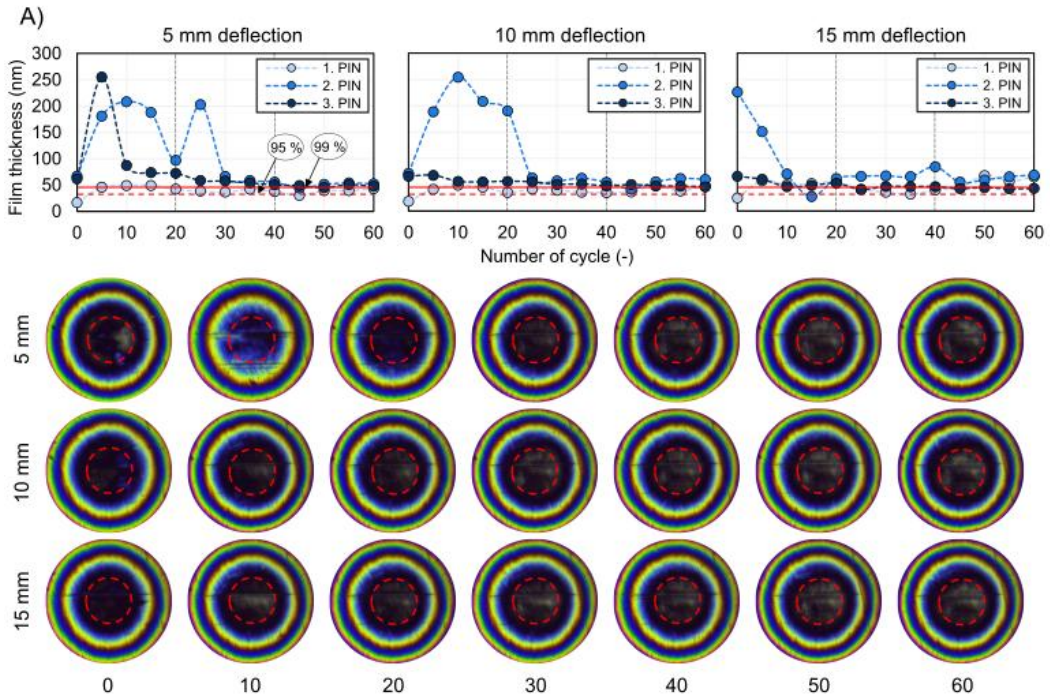
Number of interventions

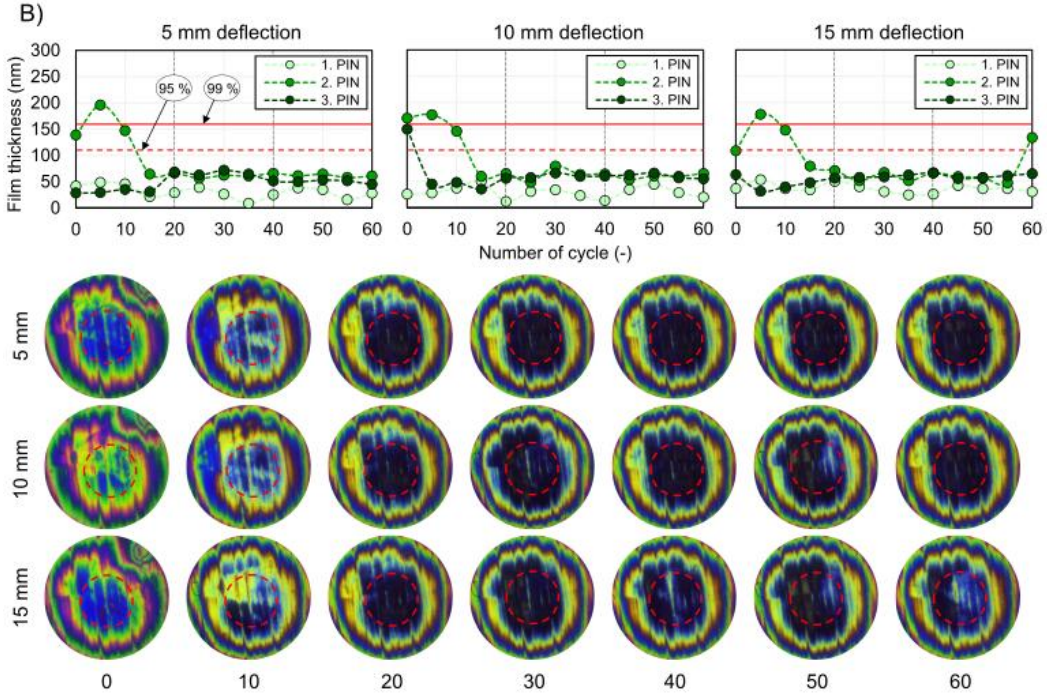
PhD study and research – Initial experiments (conventional alloys)

2023









PhD study and research – Initial experiments (conventional alloys)

2023

Tribology Letters (2023) 71:125
https://doi.org/10.1007/s11249-023-01795-4

ORIGINAL PAPER

Tribological Behaviour of Ti6Al4V Alloy: An Application in Small Joint Implants

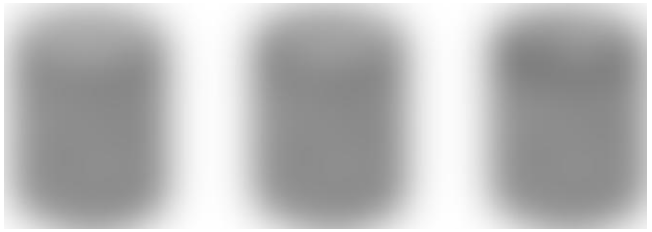
Lukáš Odehnal[1] · Matúš Ranuša[1] · Martin Vrbka[1] · Ivan Křupka[1] · Martin Hartl[1]

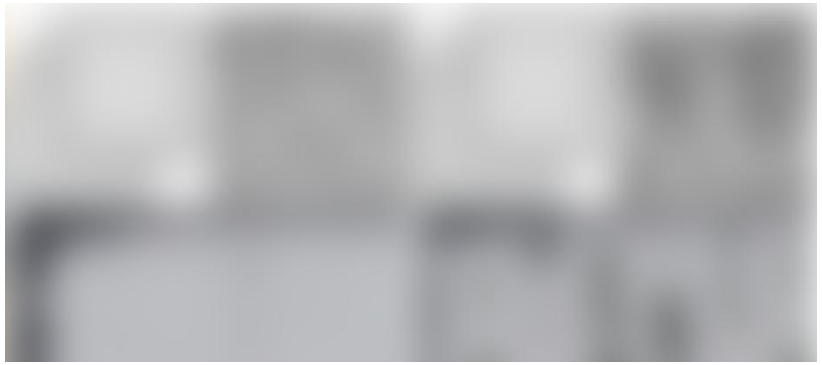
Received: 15 June 2023 / Accepted: 4 October 2023 / Published online: 8 November 2023

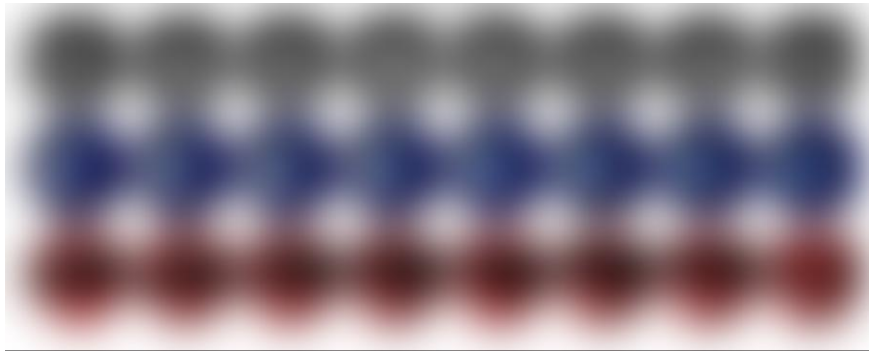
Abstract
The presented study deals with the analysis of the tribological behaviour of the Ti6Al4V alloy manufactured conventionally. The study aimed to verify whether the titanium alloy is suitable for use as a contact material in small joint implants, as additive manufacturing of this alloy can in the future provide certain benefits, such as individualization and simplification of the implant construction, or controlled porosity. The tested pair consisted of a pin and a glass plate lubricated with model synovial fluid. The contact area was observed with colorimetric interferometry. Alongside film thickness, friction, and wear scars were measured. From the designed experimental conditions, the titanium alloy was not able to create a sufficiently thick lubrication film to overcome its surface roughness and damage to contact surfaces occurred. Friction was comparable for all the tested configurations. The application of conventionally manufactured titanium alloy as a contact surface in small joint implants seems to not be suitable since its performance fell short when compared to conventional cobaltous alloy. Nevertheless, there are various alternative methods available, such as unconventional manufacturing, polishing, surface texturing, and coating.

PhD study and research – 3D printed samples with surface structure

2024

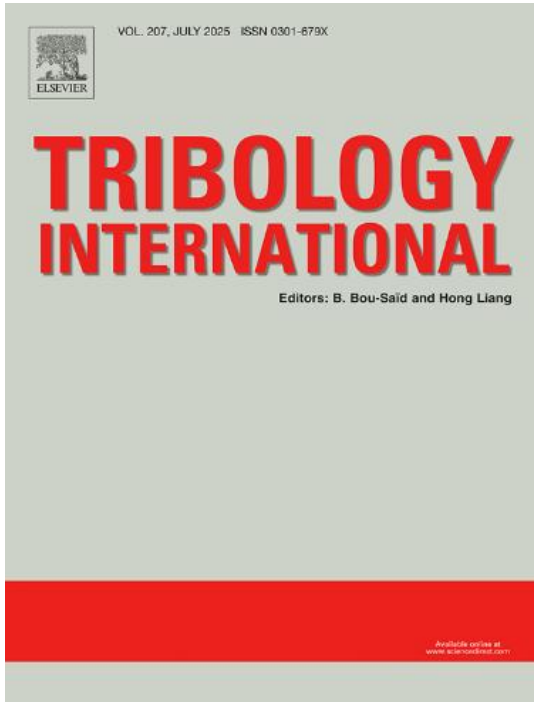






PhD study and research – 3D printed samples with surface structure

2024



Peer review status

[1st revision] Tribological behaviour of additively manufactured Ti6Al4V with controlled surface structure: An application in small joint implants

- Reviews completed: 2+
- Review invitations accepted: 2+
- Review invitations sent: 2+

1st revision

Review Complete

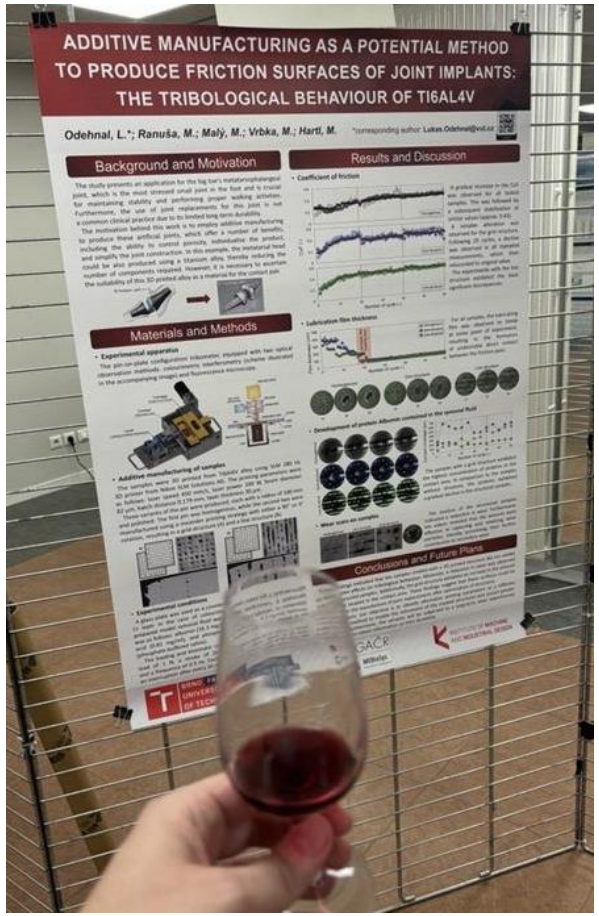
Last review activity: 1st April 2025

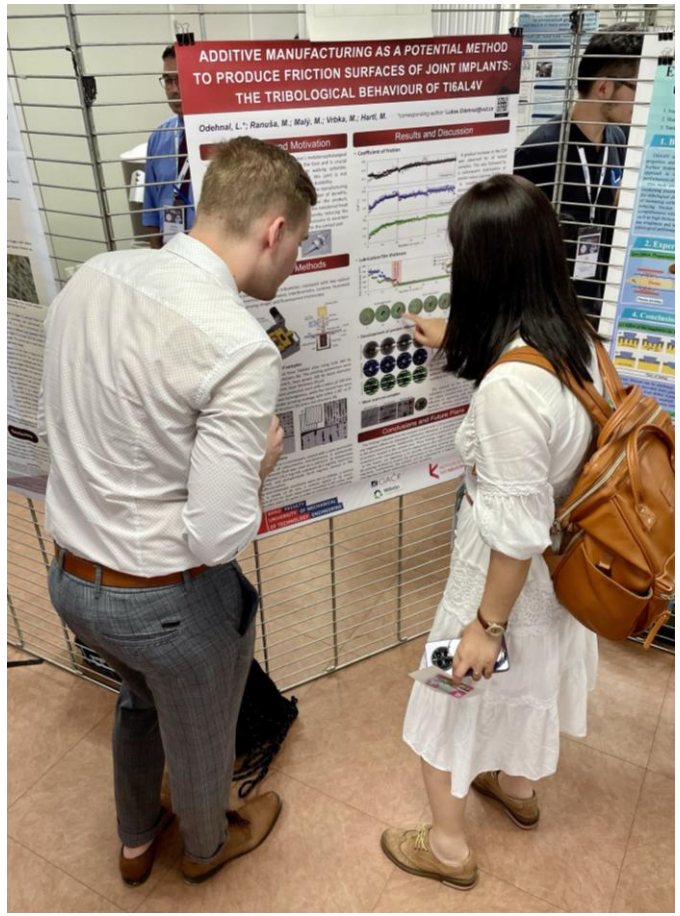
PhD study and research – 3D printed samples with surface structure

2024

PhD study and research – 3D printed samples with surface structure

2024





49th LEEDS LYON SYMPOSIUM ON TRIBOLOGY

PhD study and research

2024

Tribology Letters (2025) 73:15
https://doi.org/10.1007/s11249-024-01950-5

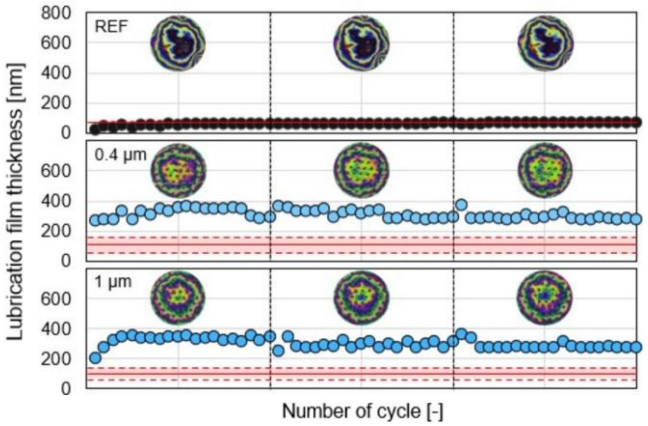
ORIGINAL PAPER

Effect of Surface Texturing on Friction and Lubrication of Ti6Al4V Biomaterials for Joint Implants

Matúš Ranuša[1] · Lukáš Odehnal[1] · Ondřej Kučera[1] · David Nečas[1] · Martin Hartl[1] · Ivan Křupka[1] · Martin Vrbka[1]

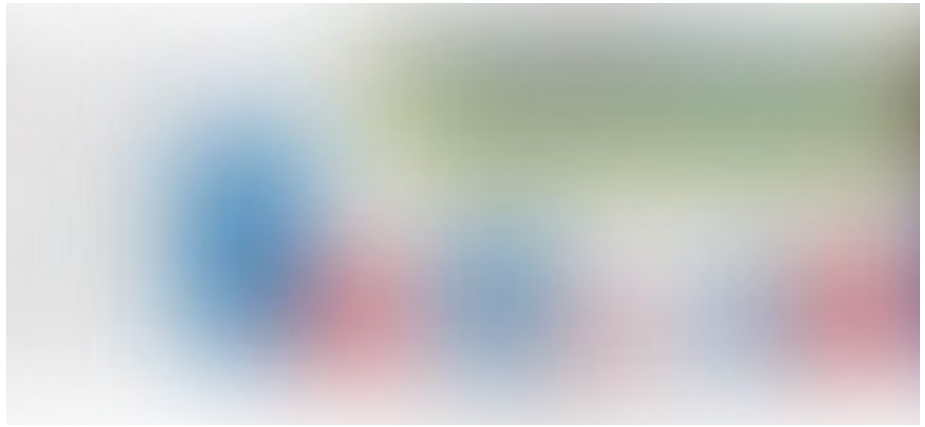
Received: 6 August 2024 / Accepted: 4 December 2024 / Published online: 19 December 2024

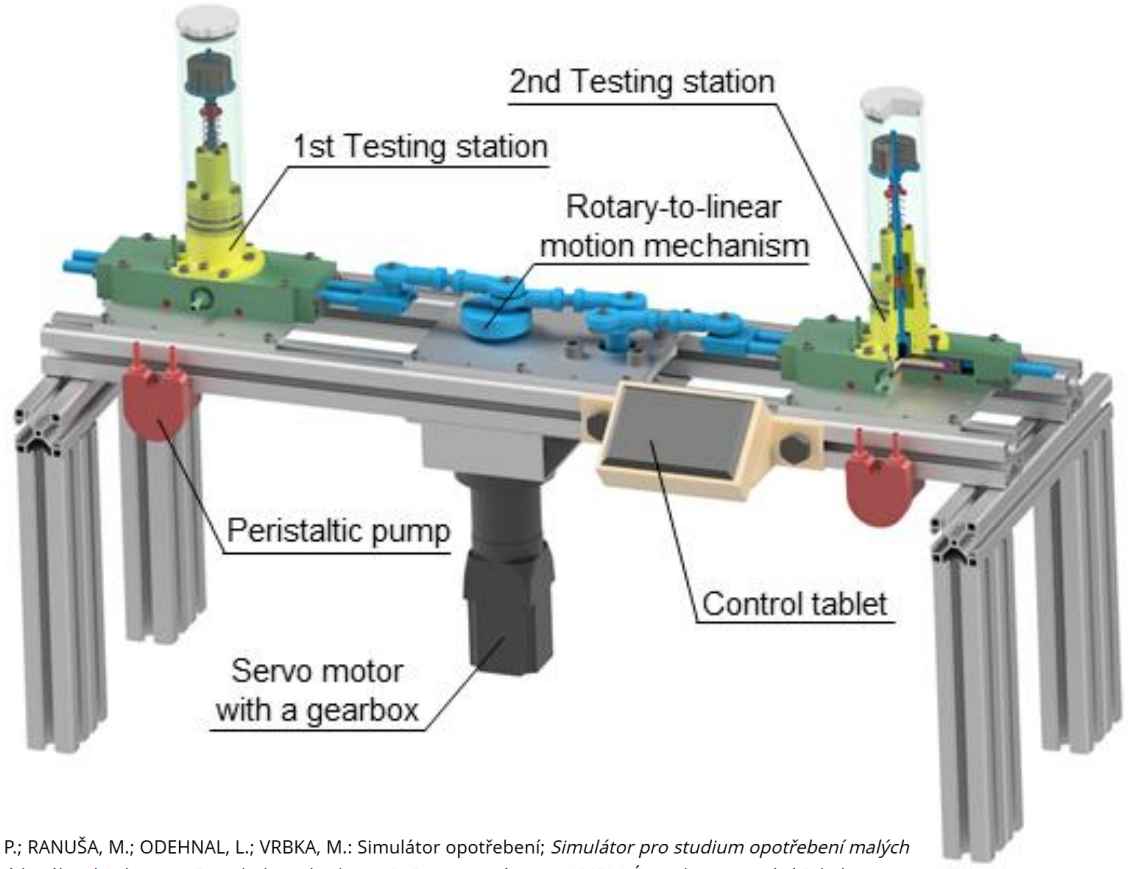
Abstract
The number of endoprosthetic implants for both large and small joints is increasing at a steady rate, thereby creating a growing demand for durable products that closely replicate the functionality of human joints. Notwithstanding the aforementioned advancements, challenges pertaining to implant fixation and tribological surfaces persist. The advent of progressive technologies, such as three-dimensional printing, offers a promising avenue for addressing these challenges in implant design and surface engineering. The Ti6Al4V and CoCrMo alloys, renowned for their biocompatibility and osseointegration properties, represent promising printable materials, although they are susceptible to wear on articulating surfaces. In order to mitigate the effects of abrasion, it is essential to implement surface treatments to facilitate the formation of a robust lubricating film. This research investigates the potential of texturing and electrochemical polishing to enhance protein aggregation in the contact area. The study employs a reciprocating simulator and colorimetric interferometry to observe the contact area and measure the coefficient of friction (CoF) of modified surfaces. The findings demonstrate that textured surfaces and the combination of electrochemical polishing result in an increase in the thickness of the protein lubrication film, which may potentially reduce wear. These outcomes suggest the potential for the utilization of Ti6Al4V alloy implants with fewer elements manufactured by additive technology.



PhD study and research – Long-term experiments

2025





- ČÍPEK, P.; RANUŠA, M.; ODEHNAL, L.; VRBKA, M.: Simulátor opotřebení; *Simulátor pro studium opotřebení malých kloubních náhrad.* Laborator Biotribologie budova A3, 6. patro, místnost A3/614 Ústav konstruování Fakulta strojního inženýrství VUT v Brně. URL: https://intranet.ustavkonstruovani.cz/file-download/get-project-pdf/486. (funkční vzorek)
  https://intranet.ustavkonstruovani.cz/file-download/get-project-pdf/486, počet stažení: 0
  Detail

Planned Internship at EPFL (1.6. – 31.8.)

2025

Tribology and Interfacial Chemistry

Stefano Mischler

Head of the laboratory
H-index 48

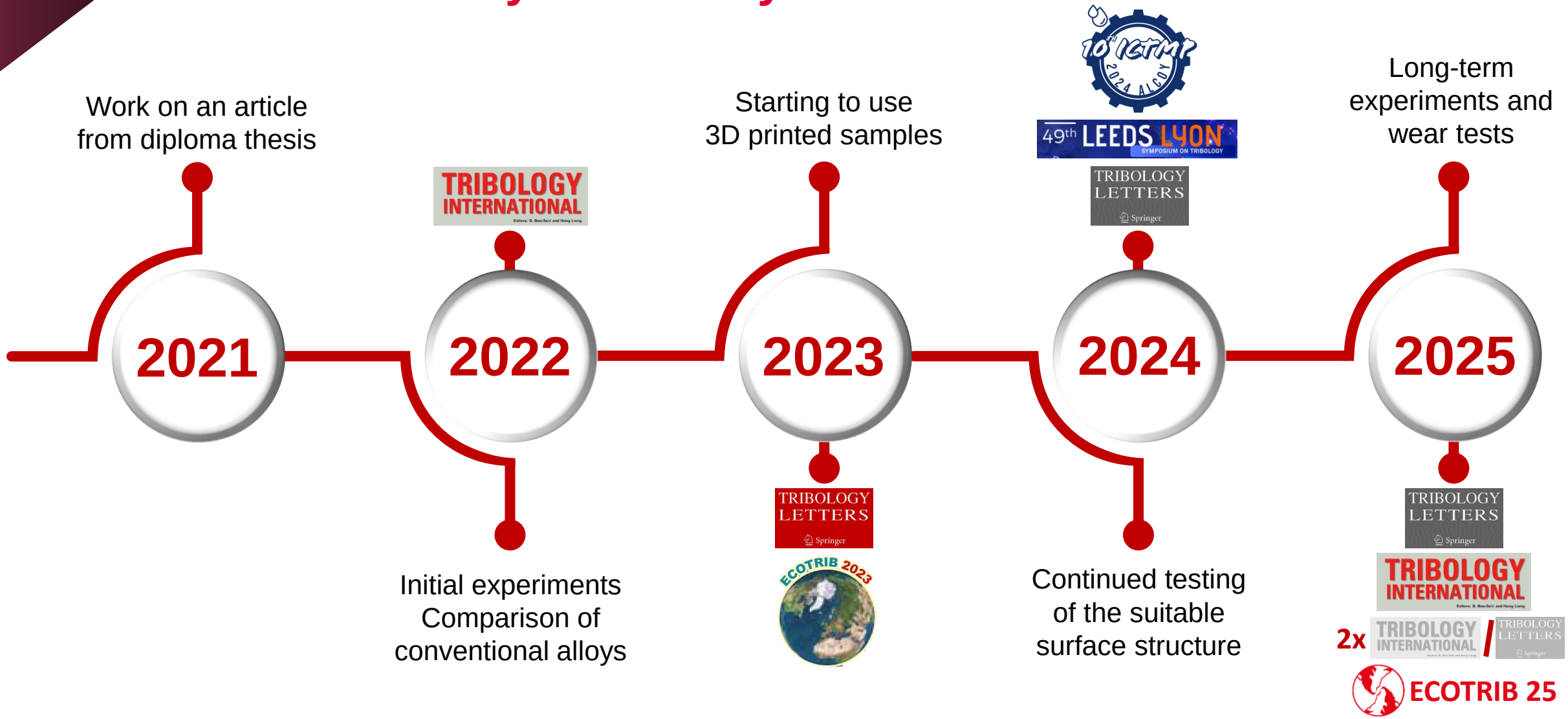
Anna Neus Igual Muñoz

Supervisor
H-index 30

The group is active in the field of advanced tribology as a multi-disciplinary, multi-scale discipline at the interface between material science, mechanics and surface chemistry and physics.

École polytechnique fédérale de Lausanne (EPFL)

Outline of my PhD study



Future Focus and Research

?

3D tištěná individualizovaná segmentální kloubní náhrada: optimalizace fixace do kosti a biotribologie artikulačního povrchu

AZV ČR AGENTURA PRO ZDRAVOTNICKÝ VÝZKUM ČESKÉ REPUBLIKY

Brno University of Technology
prof. Ing. Martin Vrbka, Ph.D.
doc. Ing. Daniel Koutný, Ph.D.

Motol University Hospital
prof. MUDr. Vojtěch Havlas, Ph.D.

University of Chemistry and Technology
prof. Dr. Ing. Dalibor Vojtěch

BUDOUCNOST ORTOPEDIE: V MOTOLE PROVEDLI PRVNÍ SEGMENTÁLNÍ NÁHRADU KYČELNÍ HLAVICE V ČR

14. 1. 2025

Lékaři z Kliniky dětské a dospělé ortopedie a traumatologie 2. LF UK a FN Motol provedli v loňském roce první implantaci individuálně vyrobené částečné povrchové náhrady hlavice kyčelního kloubu u mladého pacienta se segmentální nekrózou hlavice kyčelní kosti. Šlo o vůbec první implantaci na bázi individuálně zhotoveného implantátu tohoto typu v České republice.

About Me

THANK YOU FOR YOUR ATTENTION

Lukáš Odehnal

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