MY ACTIVITIES AT THE IMID 2020-2024

Martin Vrbka

30 years
at **FME BUT**
1995-2025

20 years
at **IMID**
2004-2024

Biotribology Research Group

Department of Tribology
Institute of Machine and Industrial Design
Faculty of Mechanical Engineering
Brno University of Technology

Brno, 26th February 2025

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

CONTENT OF PRESENTATION

- Biotribology as a part of Biomedical Engineering
- Biotribology Research Group

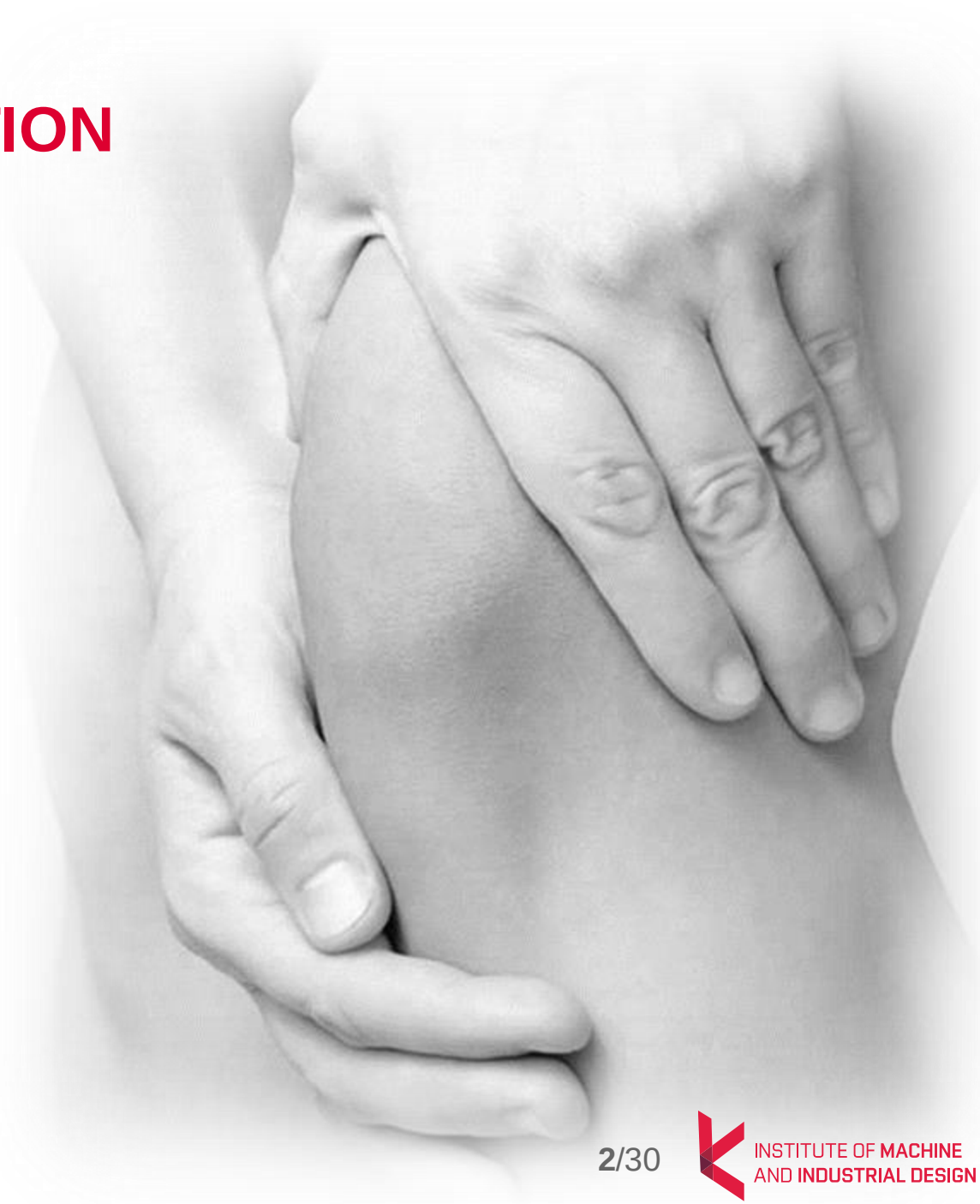
- Viscosupplementation of articular cartilage
- Superlubricity of synovial joint
- Lubrication of 3D printed joint implants
- Loss of shoe outsole adhesion

fundamental research

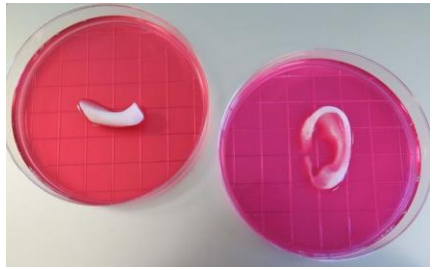
- Treatment of dry eye syndrome
- Treatment of lower back pain
- Effect of toothpaste on teeth brushing
- Development of dental lacquer

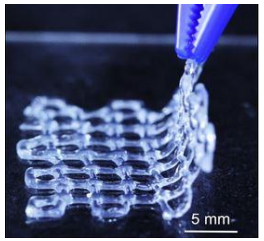
applied research

- Teaching & other activities
- About me & my hobbies



BIOMEDICAL ENGINEERING (BME)



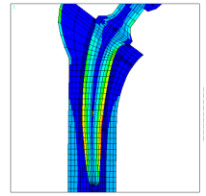


Biomechanics

Biomaterials

Biotribology

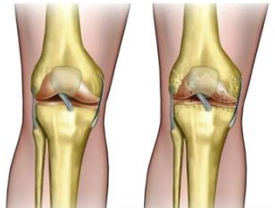
Human performance engineering



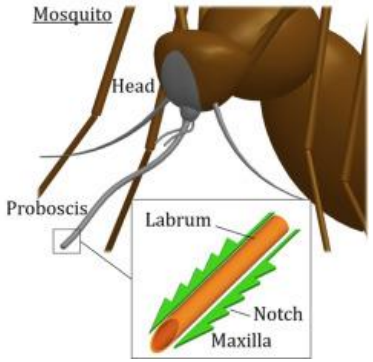
Molecular, cell, and tissue engineering

Rehabilitation engineering

Drug design and delivery systems



Bioelectric and physiologic systems modeling

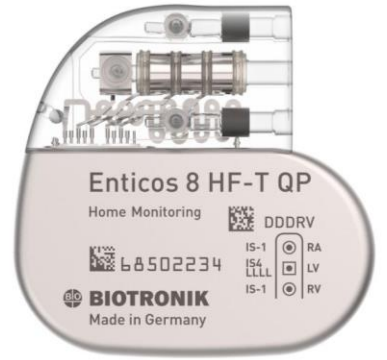


Regenerative medicine and cell therapies

Biosignals and biosensors

Personalized medicine, genomics, and proteomics

Biomedical instrumentation and devices



Biomimetics

Neural engineering

Micro and nanotechnology and bioMEMs

Medical and infrared imaging

Prosthetic devices and artificial organs

Medical robotics

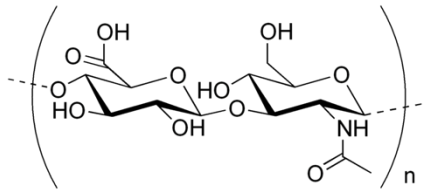
Telemedicine and E-health

Medical and biological analysis

Clinical engineering

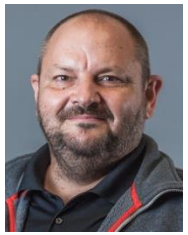
Biotechnology

Medical and bioinformatics



BIOTRIBOLOGY RESEARCH GROUP

Prof., IMID director



Prof., Head of Dept. of Tribology

Prof., Head of Biotribology Research Group

Assoc. Prof.



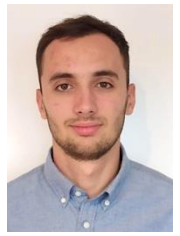
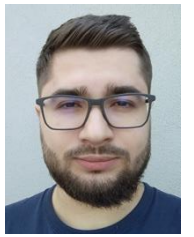
Assist. Prof. (postdoc)

- Established in **2010**
- Members: **∼20**
- PhD students: **4**
- Defended PhD: **5**
- Defended MSc: **20**
- Defended BSc: **20**
- Papers in IF journals: **44**
- Papers in Scopus: **11**
- Received projects: **13**
- Project funds: ***45/88 mil. CZK**
- Awards: **8**

*without MEBioSys




PhD students – 1st to 4th year




MSc students – 4th and 5th year

OUR RESEARCH TASKS IN BIOTRIBOLOGY (2020-2024)

1. Viscosupplementation of articul. cartilage
GA ČR Standard (2020-2022)

2. Superlubricity of the synovial joint
MŠMT OP JAK, WP A.2.1 (2023-2028)

3. Lubrication of 3D printed joint implants
GA ČR Standard (2022-2024)

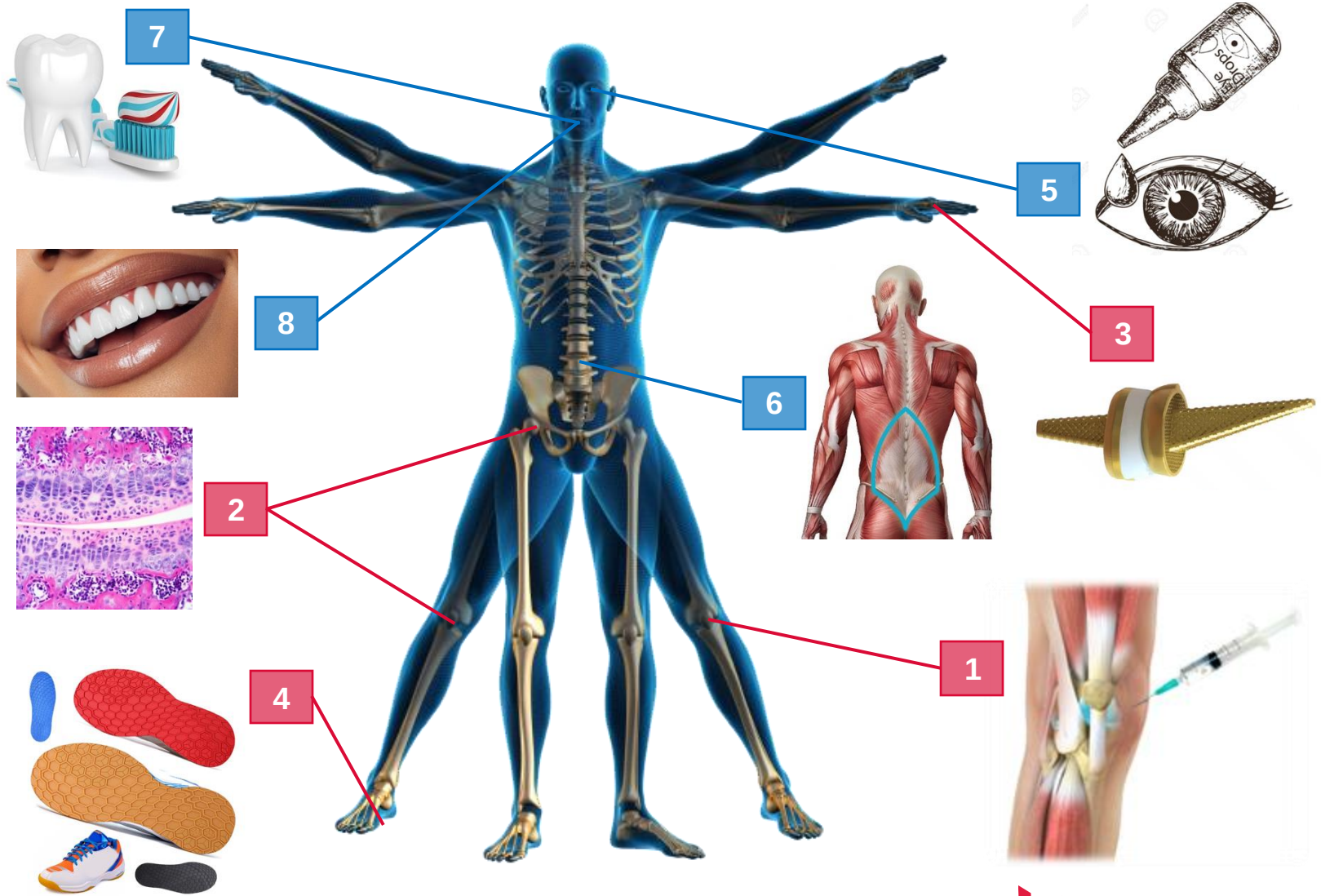
4. Loss of shoe outsole adhesion
Specific University Research (2024)

5. Treatment of dry eye syndrome
TA ČR Trend (2020-2023)

6. Treatment of lower back pain
OP PIK Applications (2020-2022)

7. Effect of toothpaste on teeth brushing
Innovation vouchers (2023 & 2024)

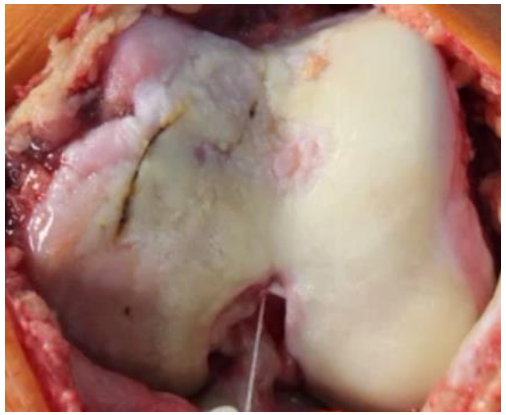
8. Development of dental lacquer
OP PIK Applications (2021-2023)



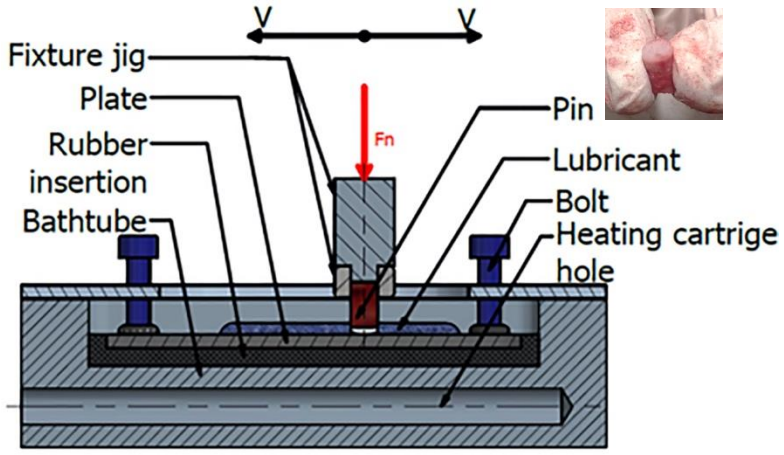
VISCOSUPPLEMENTATION OF ART. CARTILAGE

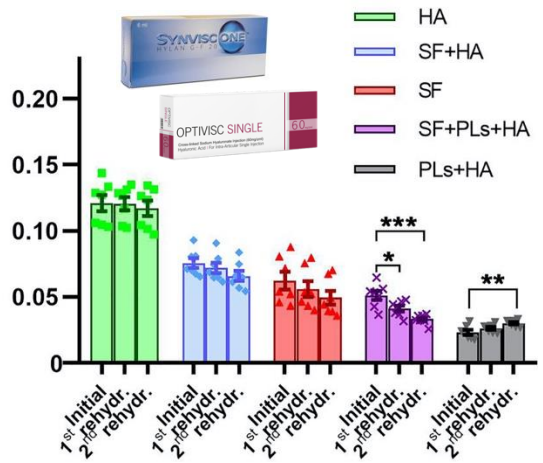
GAČR
GRANTOVÁ AGENTURA ČESKÉ REPUBLIKY

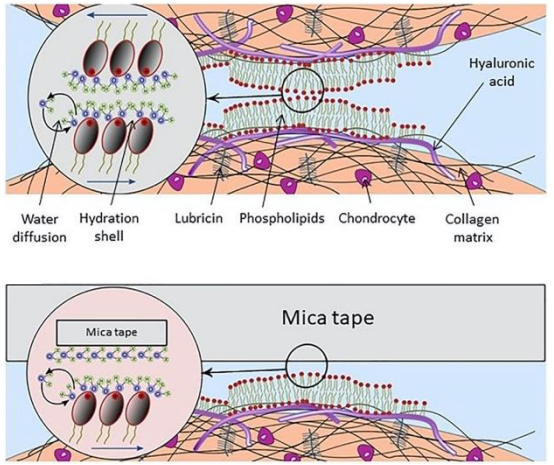
- THR and TKR = radical treatment
- Revision operation is complex and costly
- Delaying implantation until the patient is older
- Viscosupplementation = conservative treatment
- Injection of HA preparation into the joint
- Viscosupplementation as a placebo effect



AIM: experimentally describe the mechanism of viscosupplementation



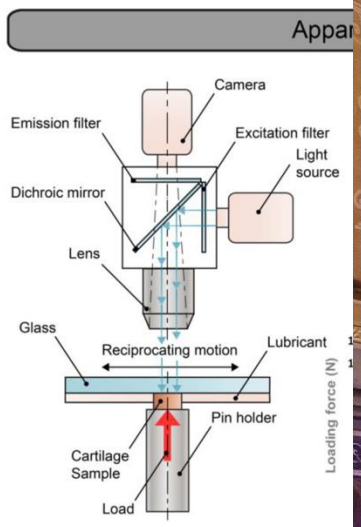


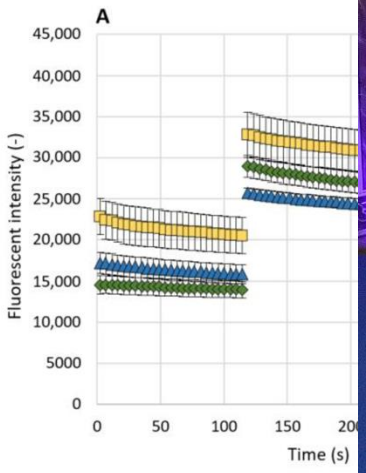


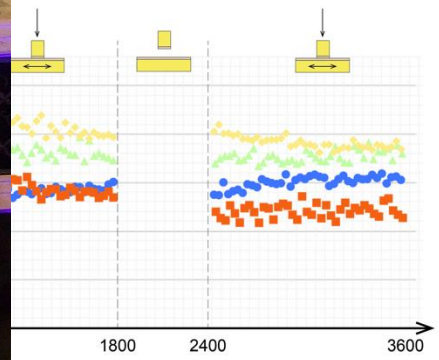
GA ČR, 20-00483S, Standard project, An investigation of synovial fluid viscosupplementation and its impact on friction and lubrication, 2020-2022, principal investigator: MV, evaluation: Excellent

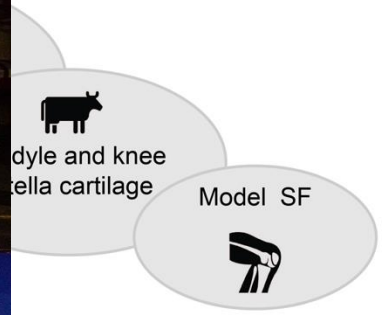
INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN

VISCOSUPPLEMENTATION OF ART. CARTILAGE



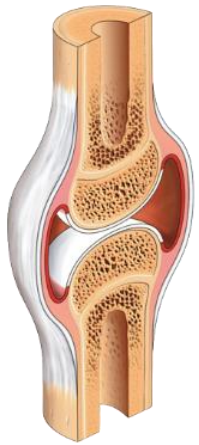


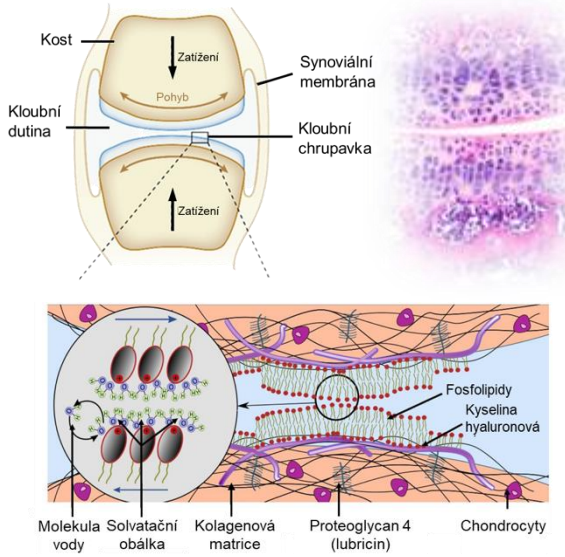




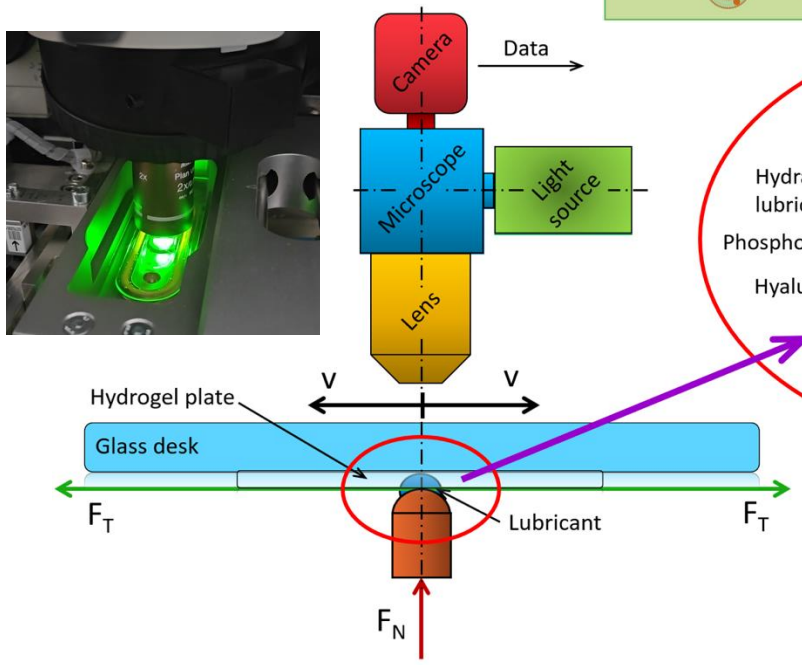
GA ČR, 20-00483S, Standard project, An investigation of synovial fluid viscosupplementation and its impact on friction and lubrication, 2020-2022, principal investigator: MV, evaluation: Excellent

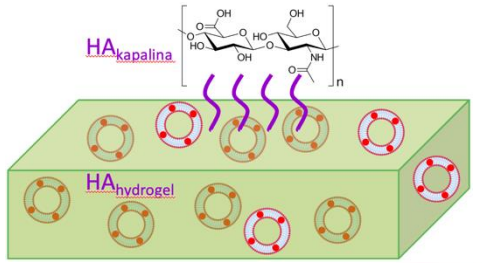
SUPERLUBRICITY OF SYNOVIAL JOINT

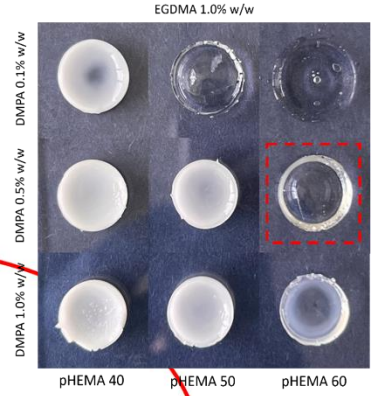


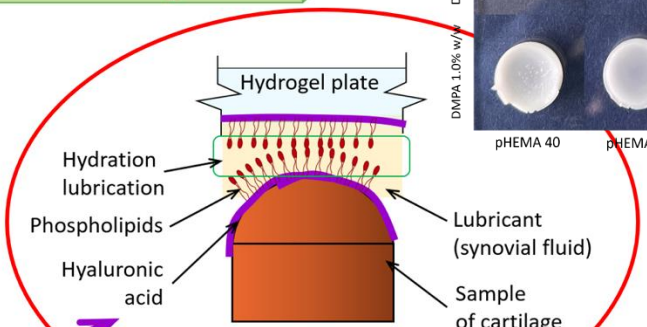


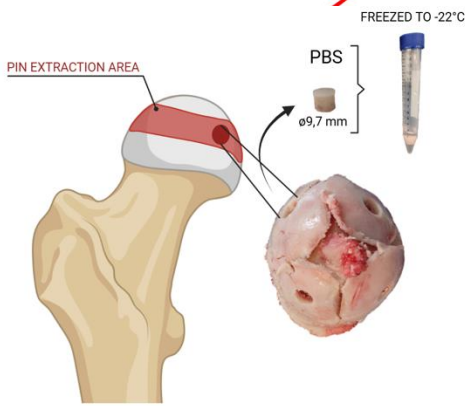
Coefficient of friction = 0.01-0.001
(SUPERLUBRICITY)









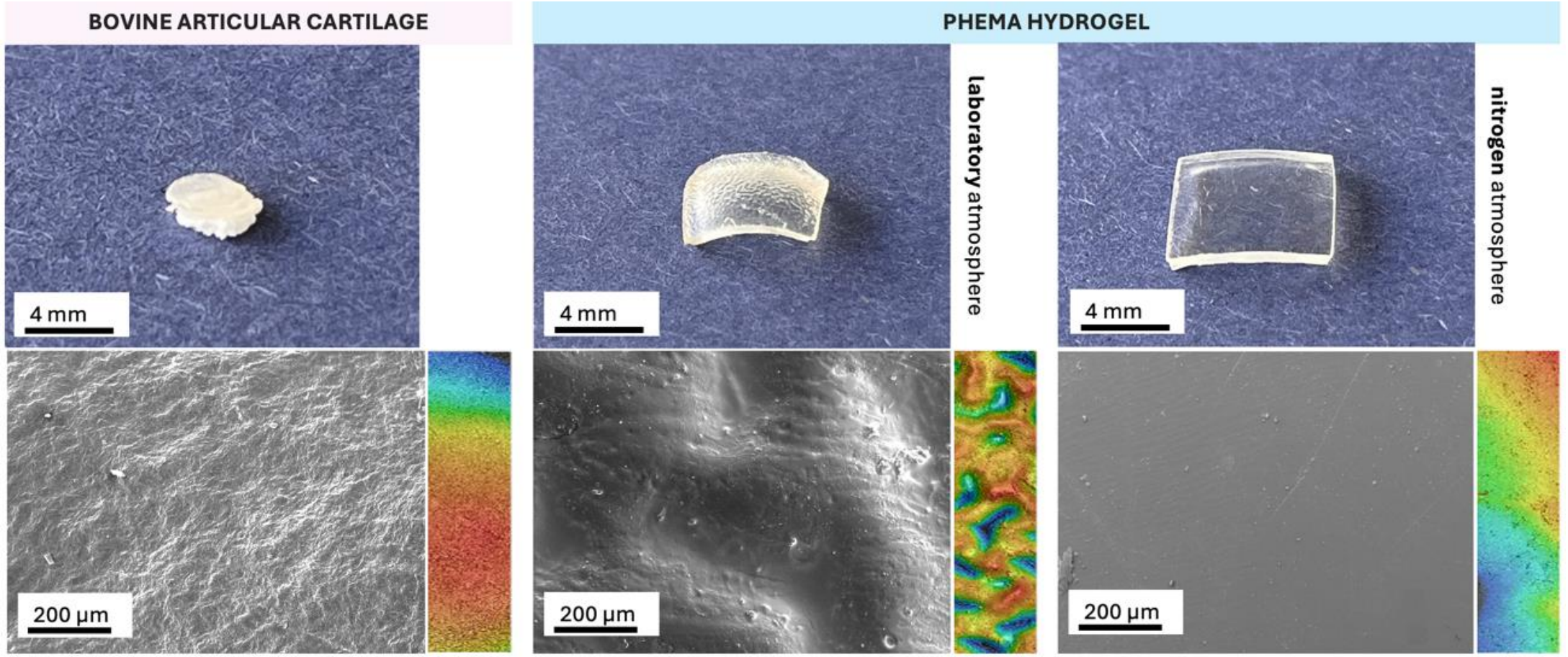


EXPERIMENTAL MODEL

OP JAK, Excellent Research, CZ.02.01.01/00/22_008/0004634, MEBioSys, WP A.2.1: Mechanisms of superlubricity in biosystems, 2023-2028, principal investigator: MH, WP A.2.1 guarantor: MV

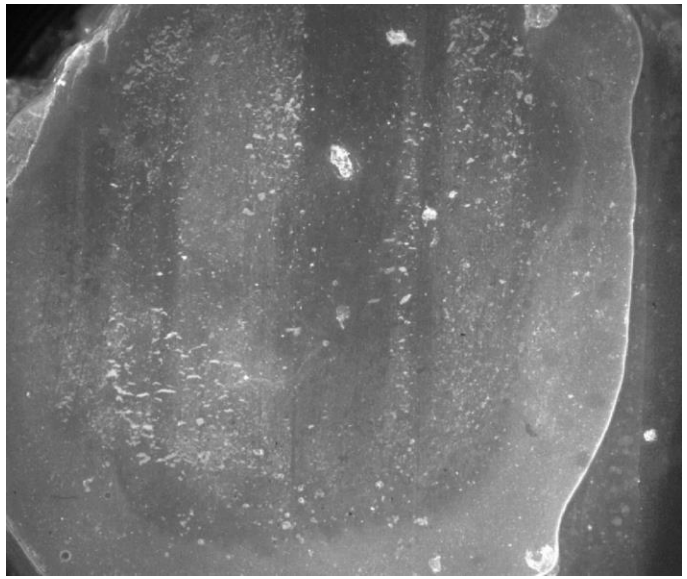
INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN

SUPERLUBRICITY OF SYNOVIAL JOINT



OP JAK, Excellent Research, CZ.02.01.01/00/22_008/0004634, MEBioSys, WP A.2.1: Mechanisms of superlubricity in biosystems, 2023-2028, principal investigator: MH, WP A.2.1 guarantor: MV

SUPERLUBRICITY OF SYNOVIAL JOINT



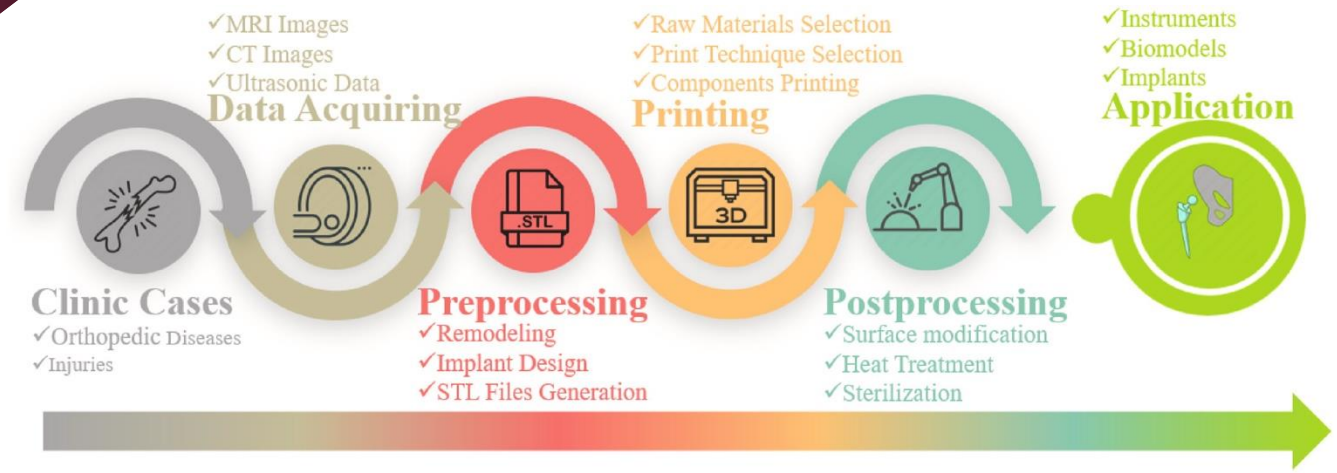
Swelling

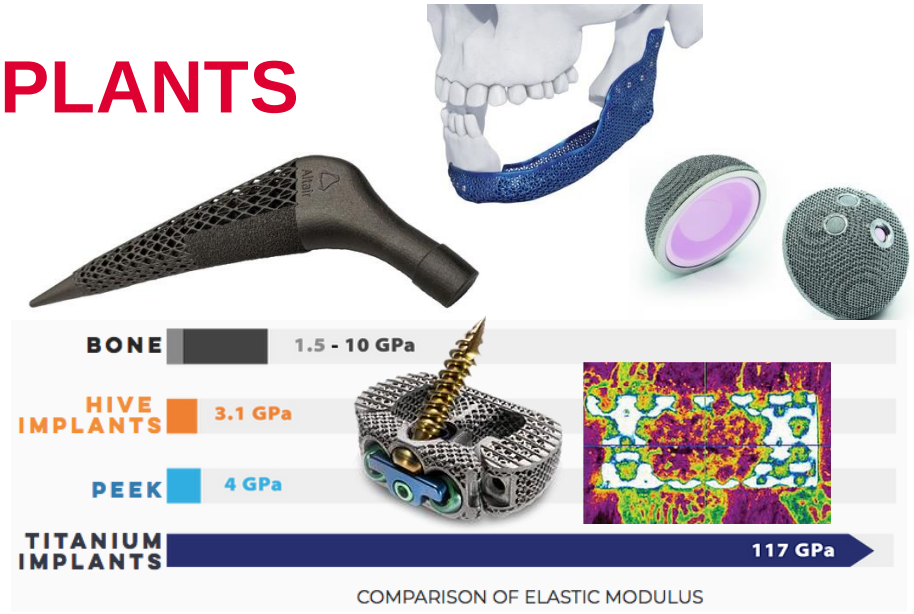
Coefficient of friction

Visualization of synovial fluid components

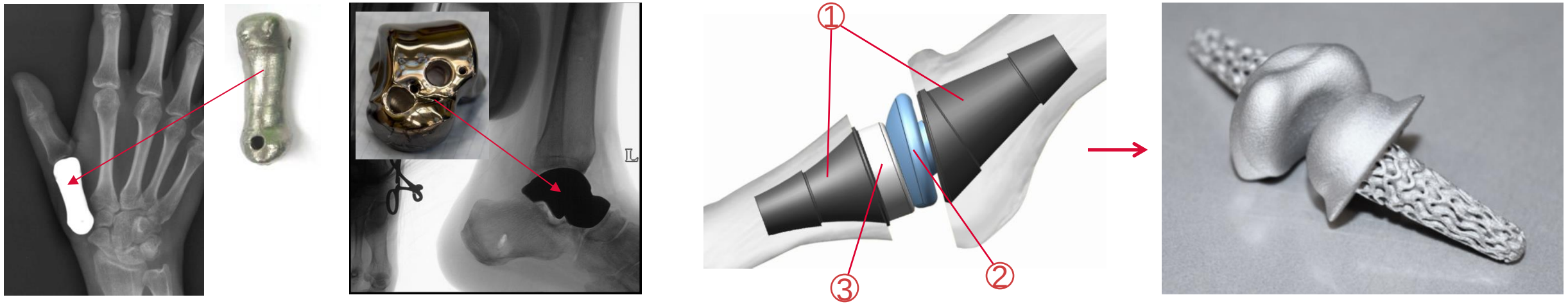
OP JAK, Excellent Research, CZ.02.01.01/00/22_008/0004634, MEBioSys, WP A.2.1: Mechanisms of superlubricity in biosystems, 2023-2028, principal investigator: MH, WP A.2.1 guarantor: MV

3D PRINTING OF SMALL JOINT IMPLANTS



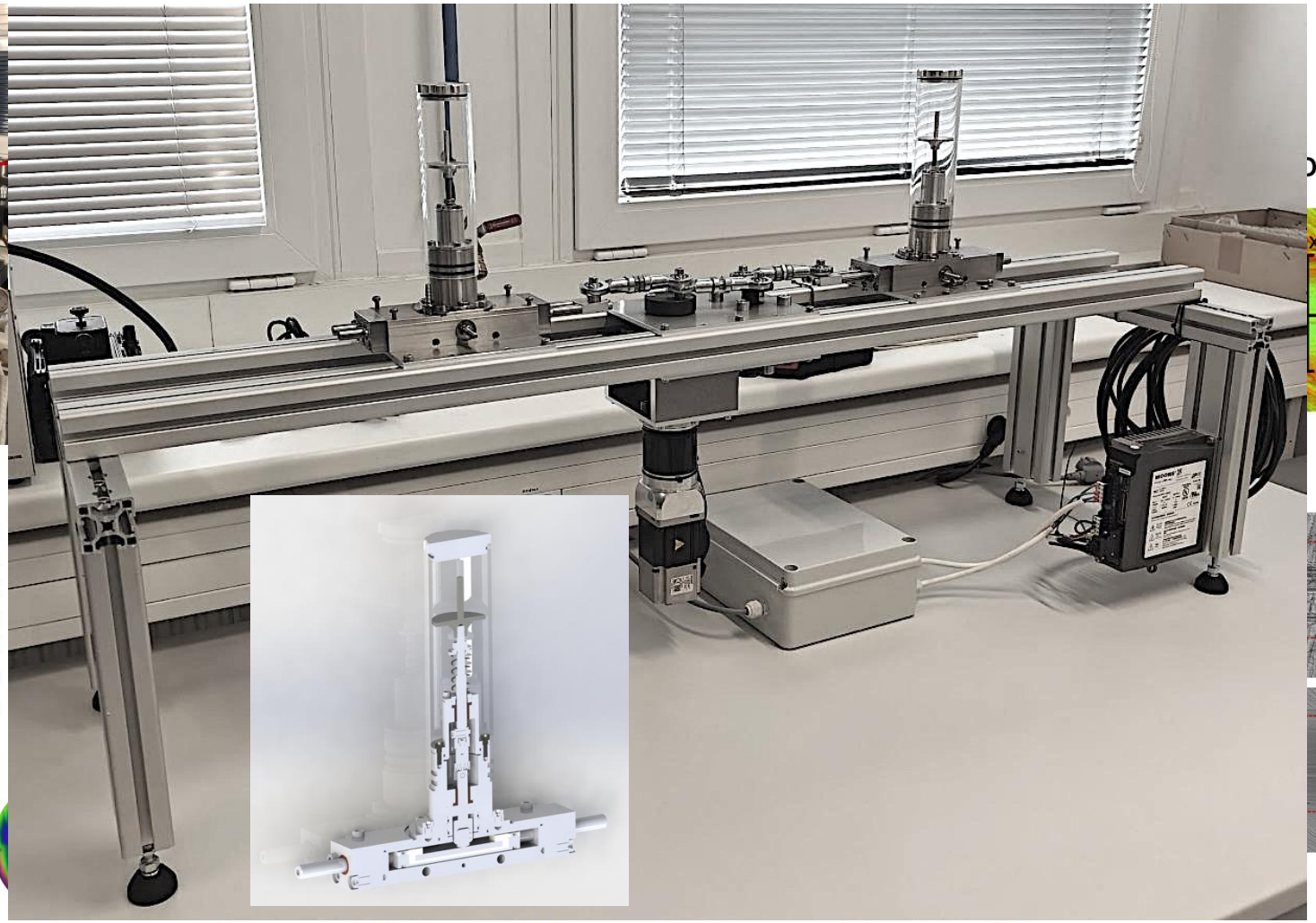


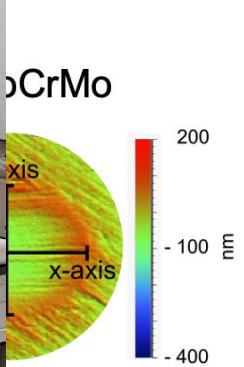
AIM: exp. describe the friction and lubrication mechanisms of 3D printed surfaces

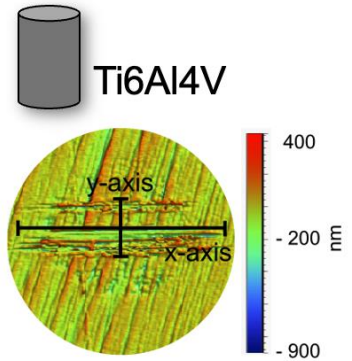


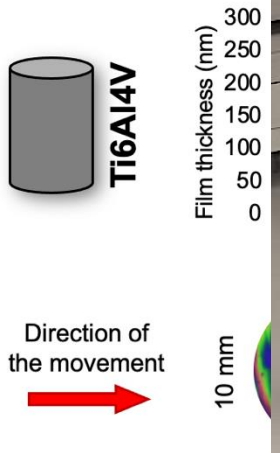
GA ČR, 22-02154S, Standard project, Friction and lubrication of small joint implants produced by 3D metal printing additive technology, 2022-2024, principal investigator: MV, under evaluation

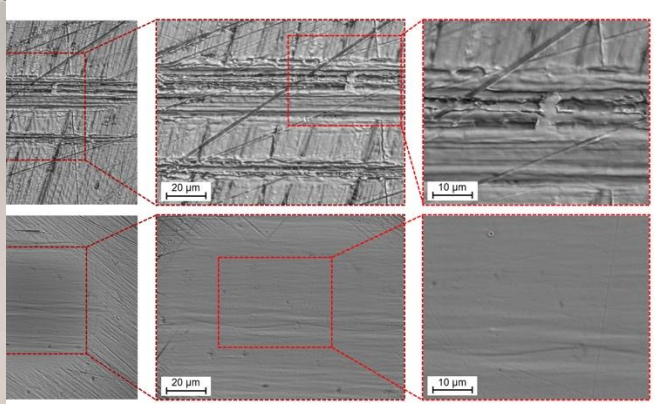
3D PRINTING OF SMALL JOINT IMPLANTS







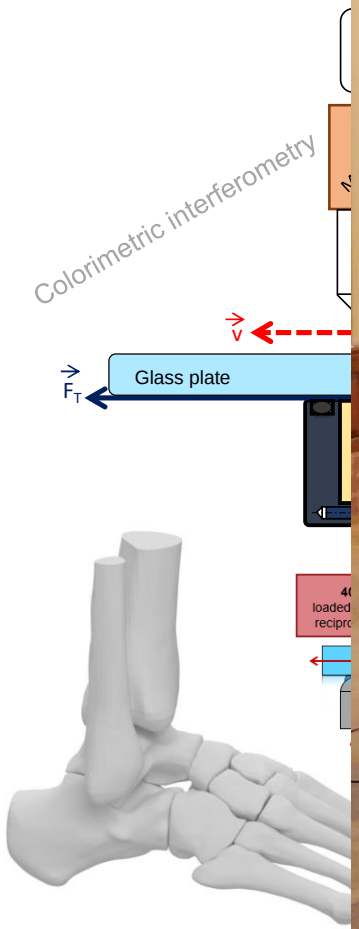




GA ČR, 22-02154S, Standard project, Friction and lubrication of small joint implants produced by 3D metal printing additive technology, 2022-2024, principal investigator: MV, under evaluation

3D PRINTING OF SMALL JOINT IMPLANTS

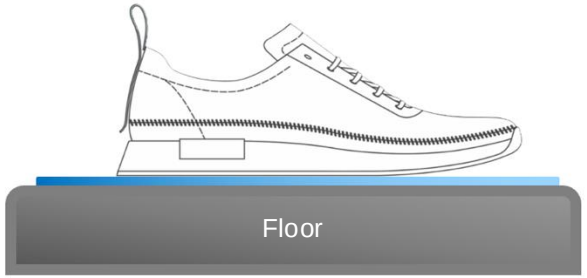
Materials and



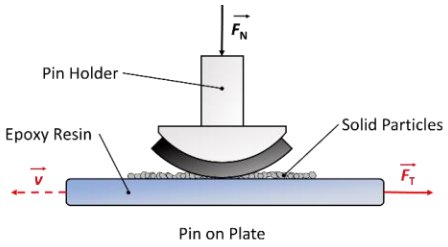
GA ČR, 22-02154S, Standard project, Friction and lubrication of small joint implants produced by 3D metal printing additive technology, 2022-2024, principal investigator: MV, under evaluation

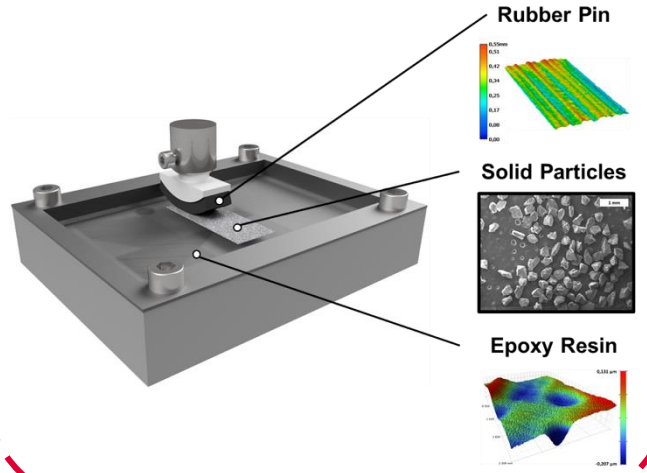
LOSS OF SHOE OUTSOLE ADHESION

Shoe-floor contact

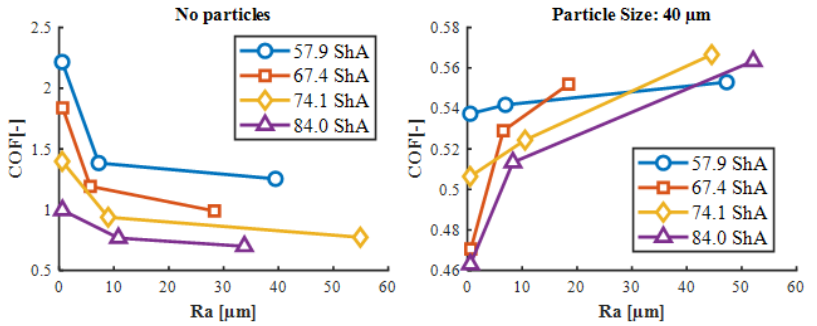


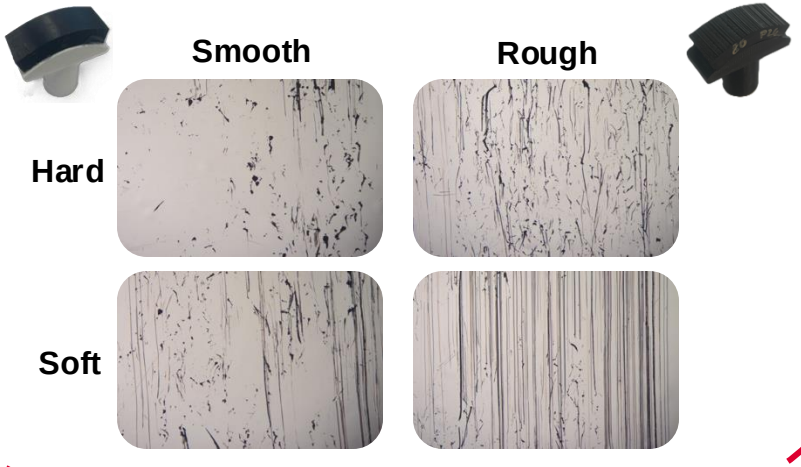
Lab-scale simulation





COF & Floor Wear



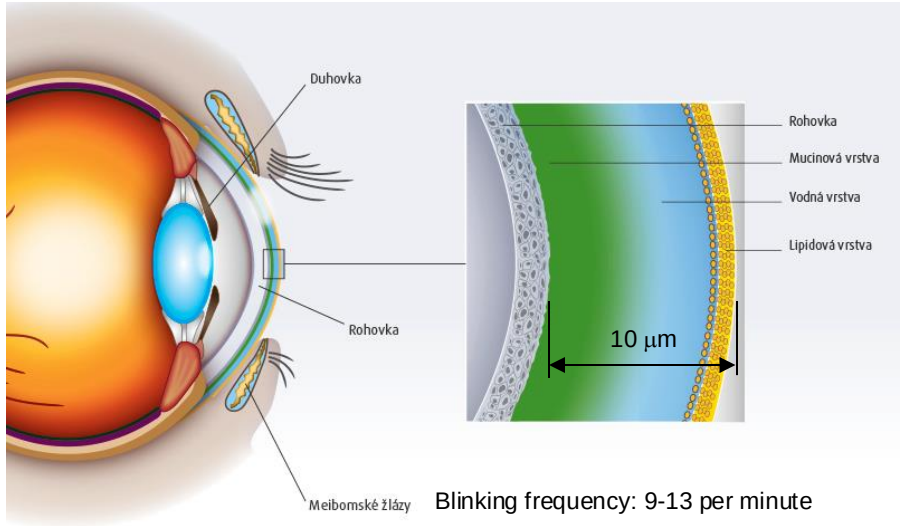


Specific University Research, FCH/FSI-J-24-8561, Role drsnosti a tvrdosti materiálu podešve ve vztahu k uklouznutí na povrchu kontaminovaném pevnými částicemi, 2024, principal investigator: MŽ

INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN

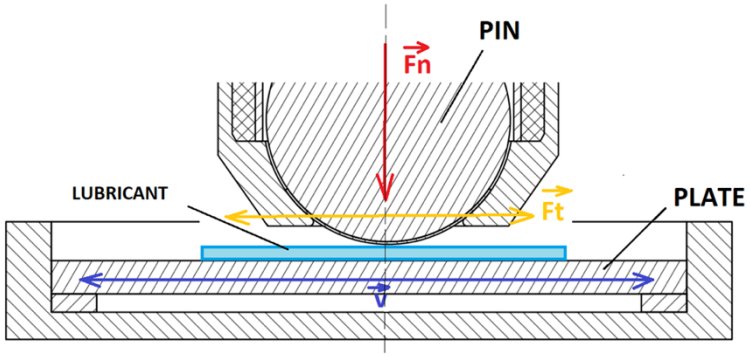
TREATMENT OF DRY EYE SYNDROME

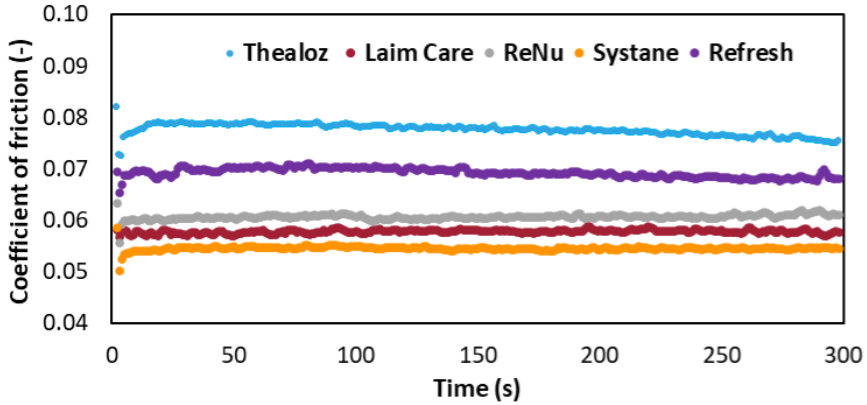
- Ageing population, diabetes
- Monitor, TV and phone viewing
- Tear film quality and its evaporation
- Increased friction = cornea damage
- Artificial tears in the form of eye drops
- Cooperation with Contipro, Inc.



Blinking frequency: 9-13 per minute

AIM: optimize the composition of artificial tears based on HA

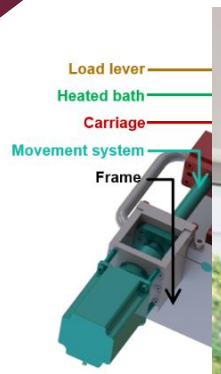




TA ČR, TREND, FW01010060, Research and development of pharmaceutical ingredient to artificial tears for the treatment of dry eye syndrome, Contipro, 2020-2023, principal investigator: MV, evaluation: Excellent

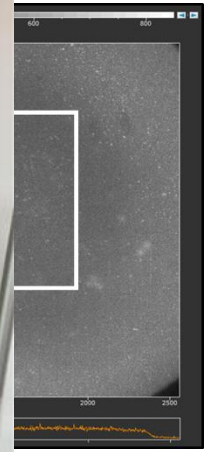
TREATMENT OF DRY EYE SYNDROME

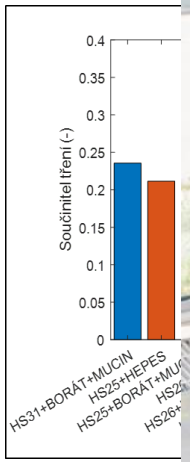
Reciprocal pin-on-plate simulator



Experiment scheme - in situ observation

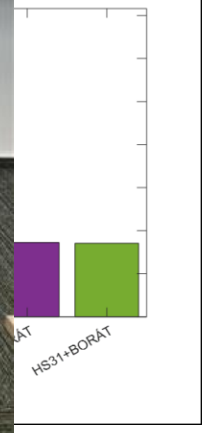
Friction coefficient as a function of time + images of the observed area





Coefficient of friction

Lubrication vs. coefficient of friction



Contact lens performance

TA ČR, TREND, FW01010060, Research and development of pharmaceutical ingredient to artificial tears for the treatment of dry eye syndrome, Contipro, 2020-2023, principal investigator: MV, evaluation: Excellent

INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN

TREATMENT OF DRY EYE SYNDROME

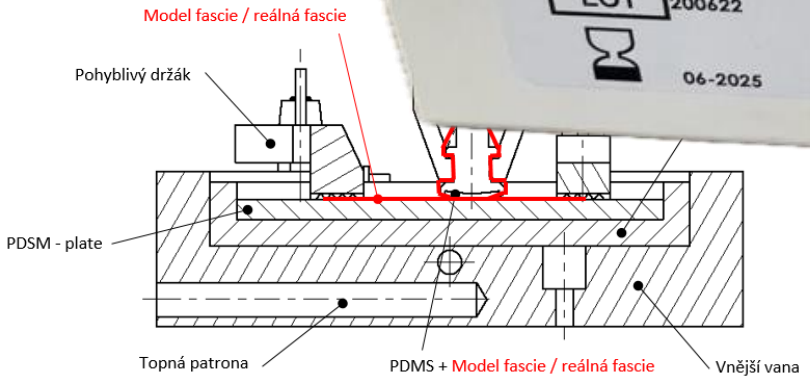
TA ČR, TREND, FW01010060, Research and development of pharmaceutical ingredient to artificial tears for the treatment of dry eye syndrome, Contipro, 2020-2023, principal investigator: MV, evaluation: Excellent

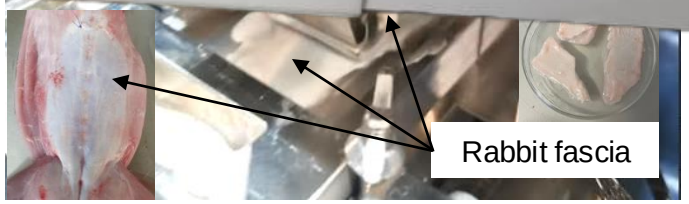
INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN

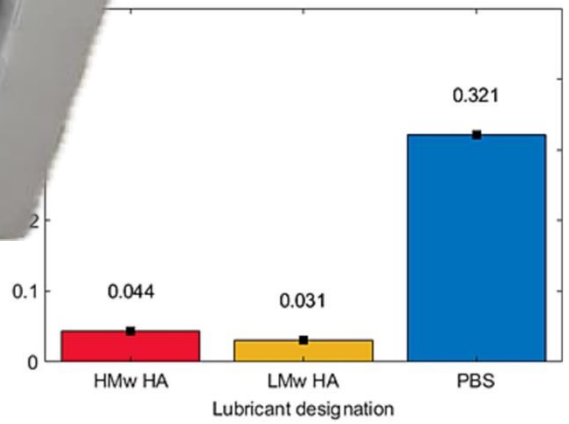
TREATMENT OF LOWER BACK PAIN

- Myofascial pain in the L1-L5 vertebral region
- Fibrosis and d[illegible] of thoracolumbar fascia
- Limitation [illegible]
- Increased f[illegible]
- Injection of t[illegible]
- Cooperation

AIM: optimise







OP PIK, Applications VII, CZ.01.1.02/0.0/0.0/19_262/0020005, Fascia lubrication and regeneration by hyaluronan, Contipro, 2020-2022, principal investigator: MV, evaluation: Excellent

TREATMENT OF LOWER BACK PAIN

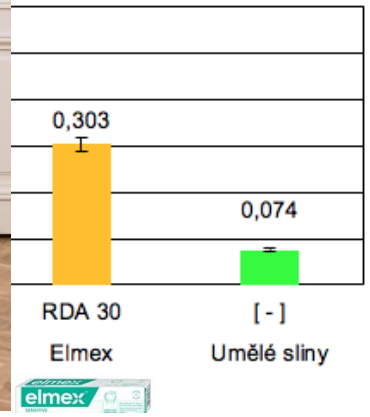
OP PIK, Applications VII, CZ.01.1.02/0.0/0.0/19_262/0020005, Fascia lubrication and regeneration by hyaluronan, Contipro, 2020-2022, principal investigator: MV, evaluation: Excellent

INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN

EFFECT OF TOOTHPASTE ON TEETH BRUSHING

- Actively add
- Wear of nat
- Effect of the
- Effect of abr
- Comparisor
- Cooperatior

AIM: clarify t



OP PIK Inovační Vouchery – Výzva VI., CZ.01.1.02/0.0/0.0/20_358/0028049, Odborné posouzení abrazivity dětské zubní pasty, Nobilis Tilia, 2022-2023, řešitel: MV

INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN

EFFECT OF TOOTHPASTE ON TEETH BRUSHING

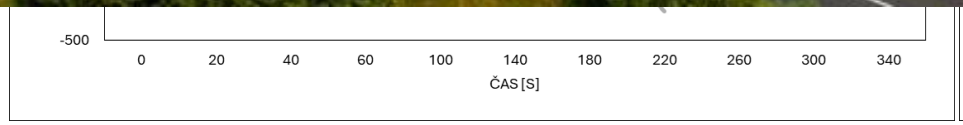
OP PIK Inovační Vouchery – Výzva VI., CZ.01.1.02/0.0/0.0/20_358/0028049, Odborné posouzení abrazivity dětské zubní pasty, Nobilis Tilia, 2022-2023, řešitel: MV

EFFECTIVENESS OF PLAQUE REMOVAL

1. PŘÍPRAVA - příprava

2. NANÁŠENÍ – **aplikace** umělého zubního plaku na vzorky zubních

3. ZNAČENÍ – **značení**



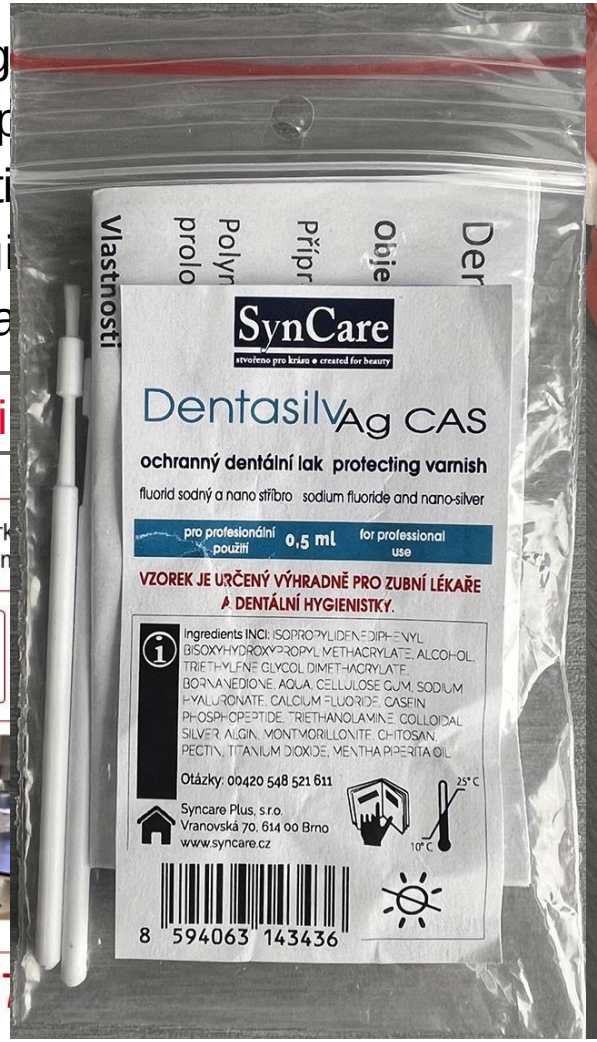
OP TAK Inovační Vouchery – Výzva II., CZ.01.01.01/05/23_009/0004317, Odborné posouzení účinnosti čištění vyvíjené dětské zubní pasty (Benjamínek nové generace), Nobilis Tilia, 2024-2025, řešitel: MV

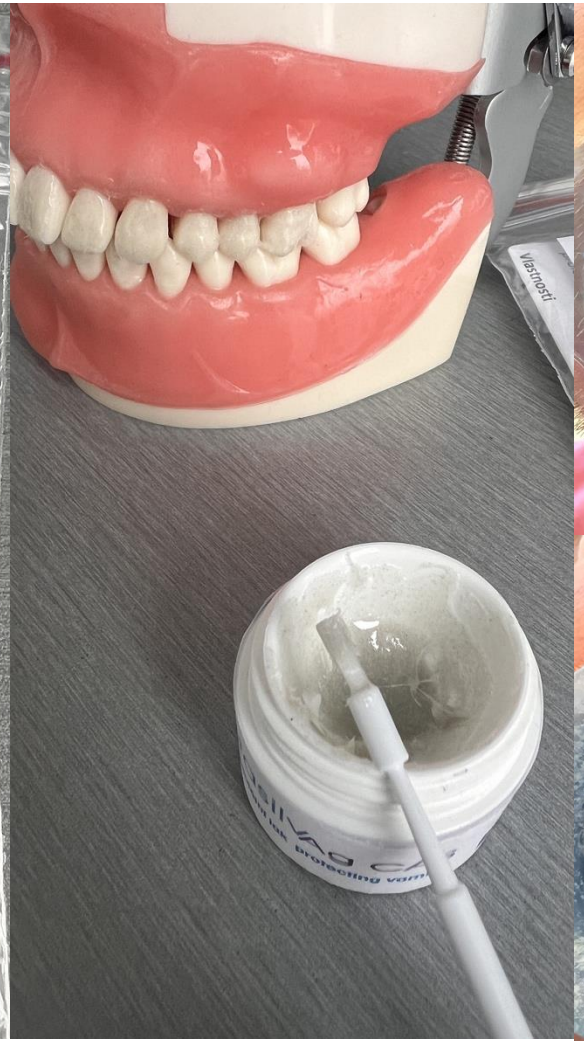
INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN

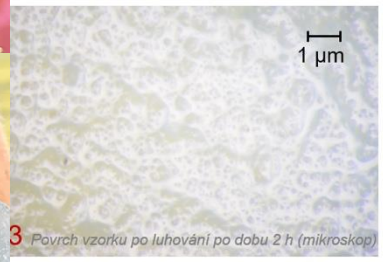
DEVELOPMENT OF DENTAL LACQUER

- Growing
- Drastic p
- Applicati
- Tribologi
- Coopera

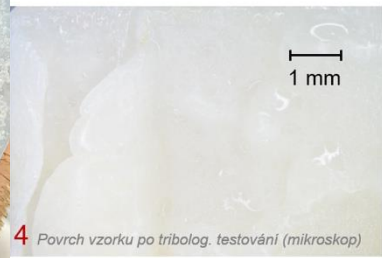
AIM: opti







3 Povrch vzorku po luhování po dobu 2 h (mikroskop)



4 Povrch vzorku po tribolog. testování (mikroskop)

1 Snímek vzork mikroskopen

7

1,3,

OP PIK, Applications IX, CZ.01.1.02/0.0/0.0/21_374/0026954, Development of biocompatible polymer dental polish with nano silver incorporated into sodium fluoride, SynCare, 2021-2023, principal investigator: MV

INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN

CONTRACTS FOR EXPLOITATION OF RESULTS

V Brně dne: 30. 1. 2024

[redacted]

Renata Svobodová
jednatelka
Syncare Plus, s.r.o.

SYNCARE PLUS s.r.o.
Vranovská 70, 614 00 Brno
IČO: 255 36 591 DIČ: CZ25536591
Tel.: 548 521 611
e-mail: plus@syncare.cz
www.syncare.cz

V Brně dne: 30 -01- 2024

[redacted]

doc. Ing. Jiří Hlinka, Ph.D.
děkan FSI
Vysoké učení technické v Brně

VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ
FAKULTA STROJNÍHO INŽENÝRSTVÍ
DĚKAN

V Dolní Dobrouči dne (dle elektronického podpisu)

doc. RNDr.
Vladimír Velebný
CSc.

Digitálně podepsal doc. RNDr. Vladimír Velebný CSc.
Datum: 2024.03.26 10:58:
+01'00'

doc. RNDr. Vladimír Velebný, CSc
předseda představenstva
Contipro a. s.

V Brně dne (dle elektronického podpisu)

[redacted]

doc. Ing. Jiří Hlinka, Ph.D.
děkan Fakulty strojního inženýrství
Vysoké učení technické v Brně
na základě plné moci

Digitálně podepsal doc. Ing. Jiří Hlinka, Ph.D.
Datum: 2024.03.26 15:32:21 +01'00'

V Dolní Dobrouči dne (dle elektronického podpisu)

doc. RNDr. Vladimír Velebný CSc.

Digitálně podepsal doc. RNDr. Vladimír Velebný CSc.
Datum: 2024.06.12 10:31:26 +02'00'

doc. RNDr. Vladimír Velebný, CSc.
předseda představenstva
Contipro a. s.

V Brně dne (dle elektronického podpisu)

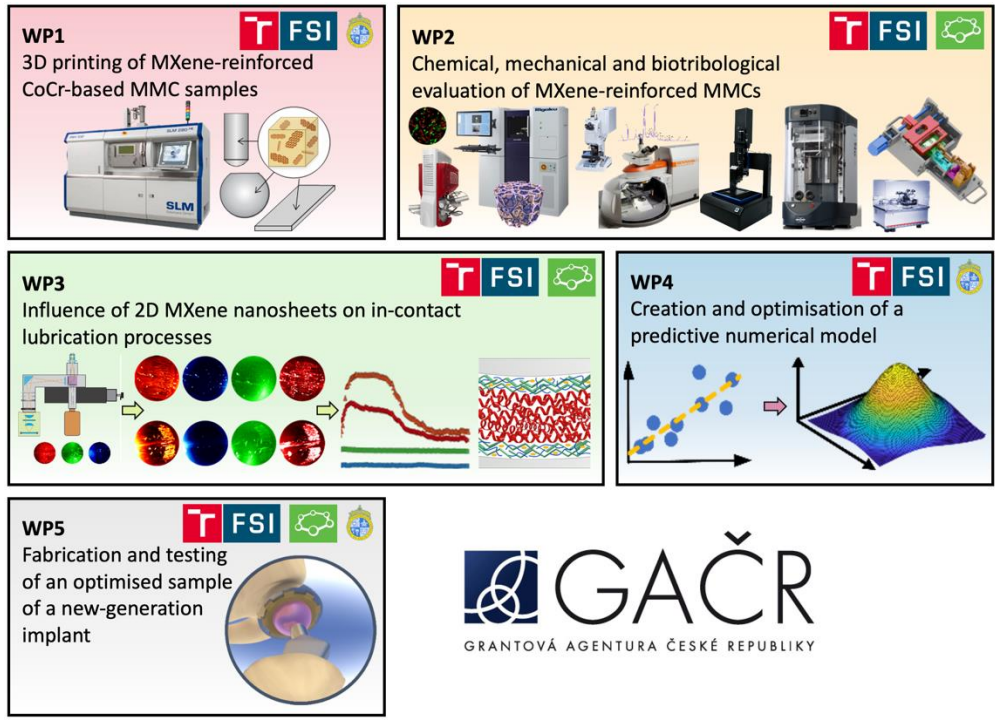
[redacted]

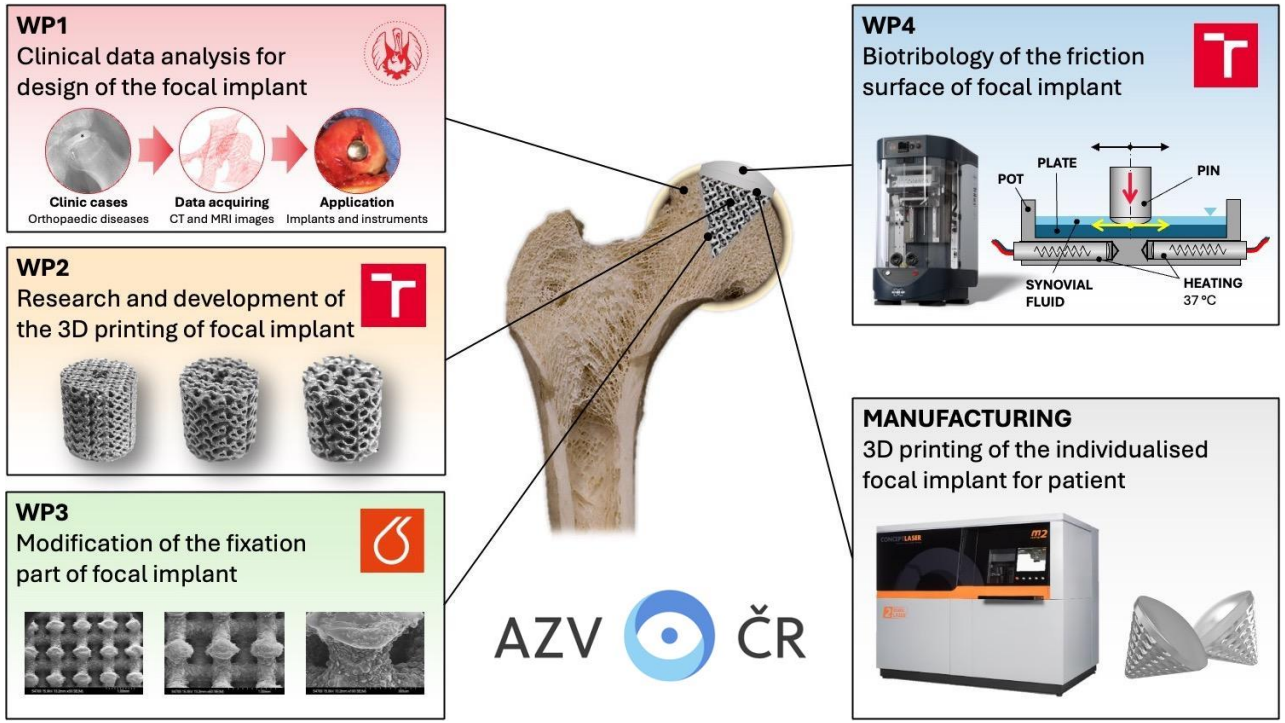
doc. Ing. Jiří Hlinka, Ph.D.
děkan Fakulty strojního inženýrství
Vysoké učení technické v Brně
na základě plné moci

Digitálně podepsal doc. Ing. Jiří Hlinka, Ph.D.
Datum: 2024.06.12 13:38:58 +02'00'

NEW PROJECTS (START OF SOLUTION IN 2025)

- **3D printed metal matrix composites reinforced by 2D MXene nanosheets for new-generation biomedical implants**, GA ČR Standard, 25-15390S, 2025-2027, principal investigator: David Nečas
- **3D printed individualised segmental joint implant: optimisation of fixation to bone and biotribology of articular surface**, AZV MZ, NW25-08-00044, 2025-2028, principal investigator: Martin Vrbka





HOW TO GET PARTNERS FOR COOPERATION?

TEACHING & OTHER ACTIVITIES

- Diploma Project - Concept (ZD1)
- Diploma Project - Bibliography and Goals (ZD2)
- Master Thesis Project - Methods and Results (ZDP)
- Master Thesis Project - Results and Discussion (ZD5)

- Biomechanic Systems (ZBS)

- Coordinator of teaching in bachelor study programmes (3rd year)
- Member of IMID Council

- Public Relations lectures (BiGy, GymBos, GyBnP, SPŠ HK, VIDA!, Science and Technology Club, IngCamp)
- Podcast Technicky vzato

ABOUT ME & MY HOBBIES

Pohled na můj dům, tehdy dům panského šafáře, později Wirtshaus, majitelé rod Honrichsů.

Olej na plátně, po roce 1800, státní zámek Kunštát

Ty můj kraji! Jsi tam, kde Vysočina nabírá dech a pole skládají slib chudoby…

František Halas, Já se tam vrátím, 1939

ABOUT ME & MY HOBBIES

- Hiking & Nordic skiing

- MTB & Gravel riding

- HD & MG motorcycle riding

THANK YOU FOR YOUR ATTENTION

Martin Vrbka

martin.vrbka@vut.cz

https://www.facebook.com/BioTribo/

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

www.**ustavkonstruovani**.cz