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# AI in orthopedics, traumatology and rehabilitation

Bohdan Ponomar





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# State Institution «Sytenko Institute of Spine and Joint Pathology, NAMS of Ukraine

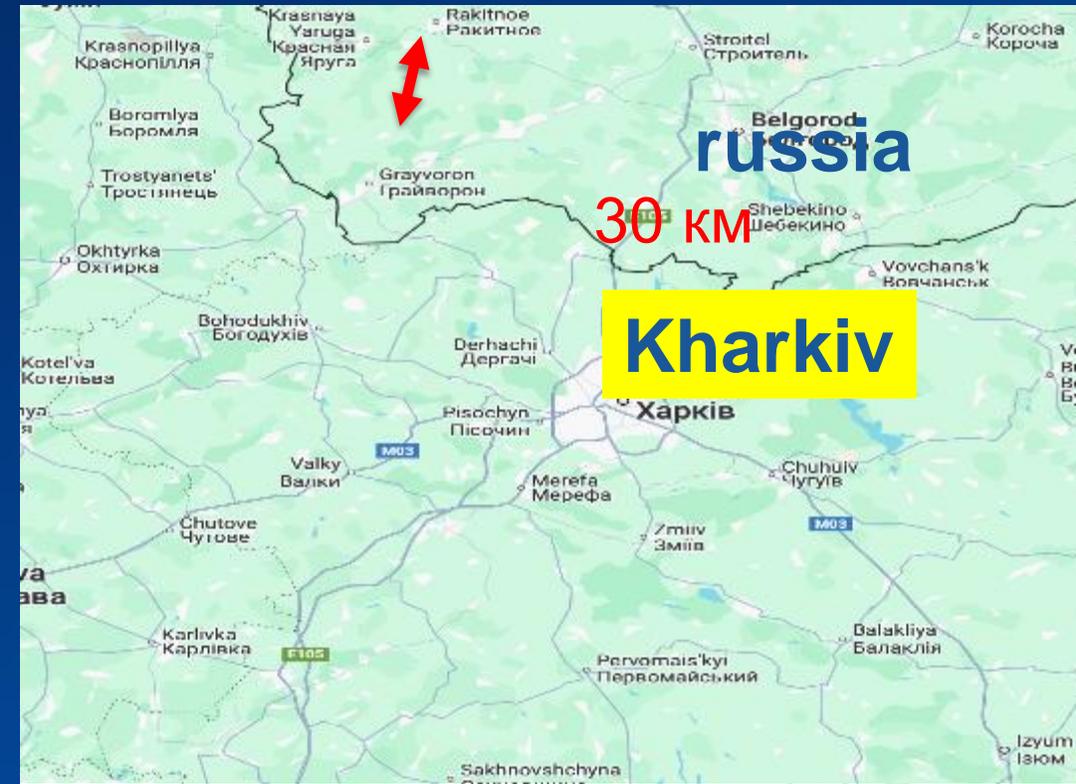




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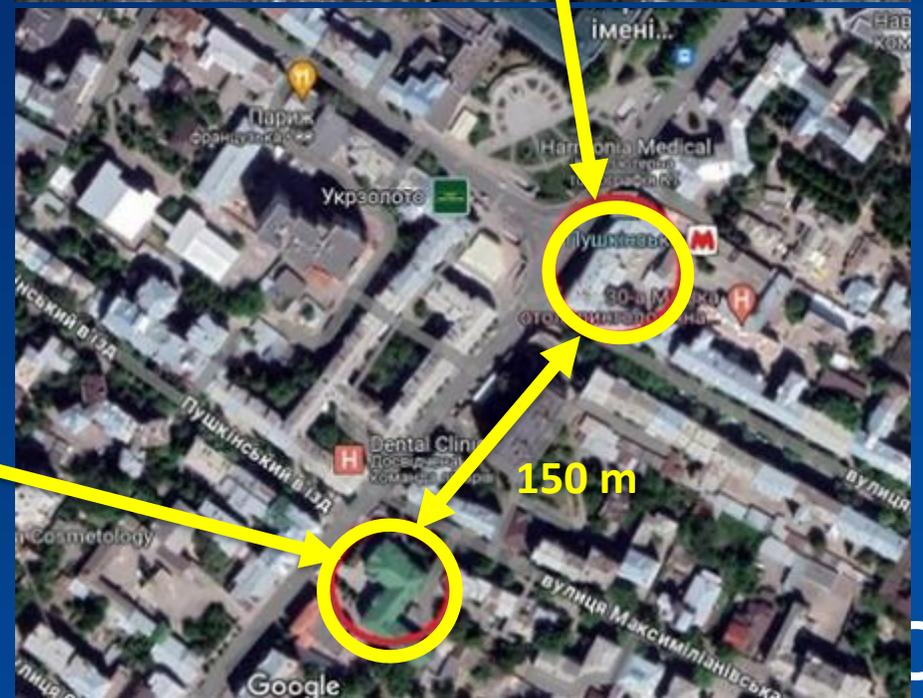
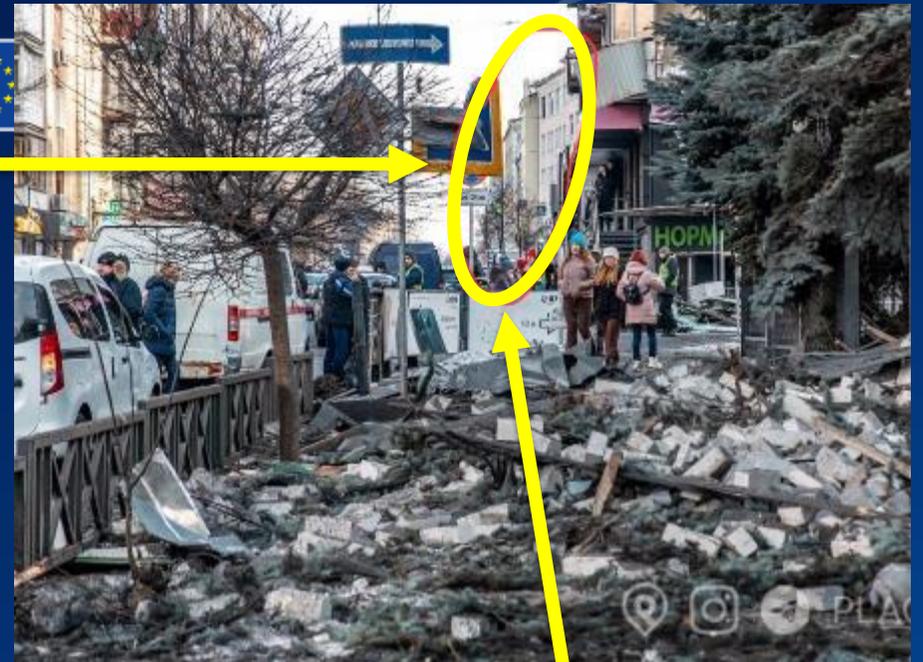




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(150 meters from the Institute of...)





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# Sytenko Institute of Spine and Joints Pathology of the AMS of Ukraine”

- ✓ 16 scientific divisions
- ✓ clinic with 240 beds
- ✓ consultative outpatient department for 150 visits per day





# Main directions of work

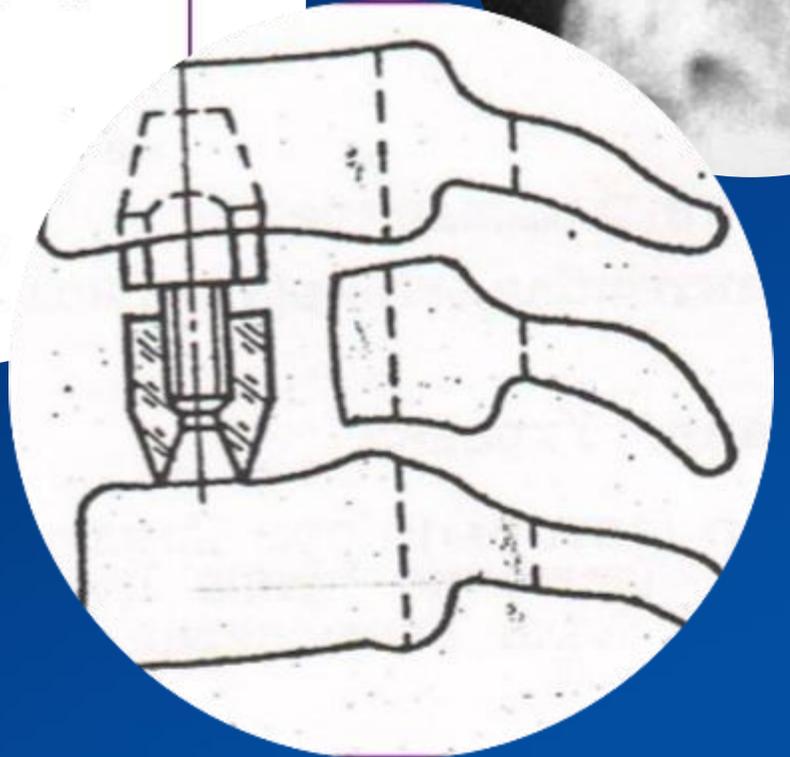
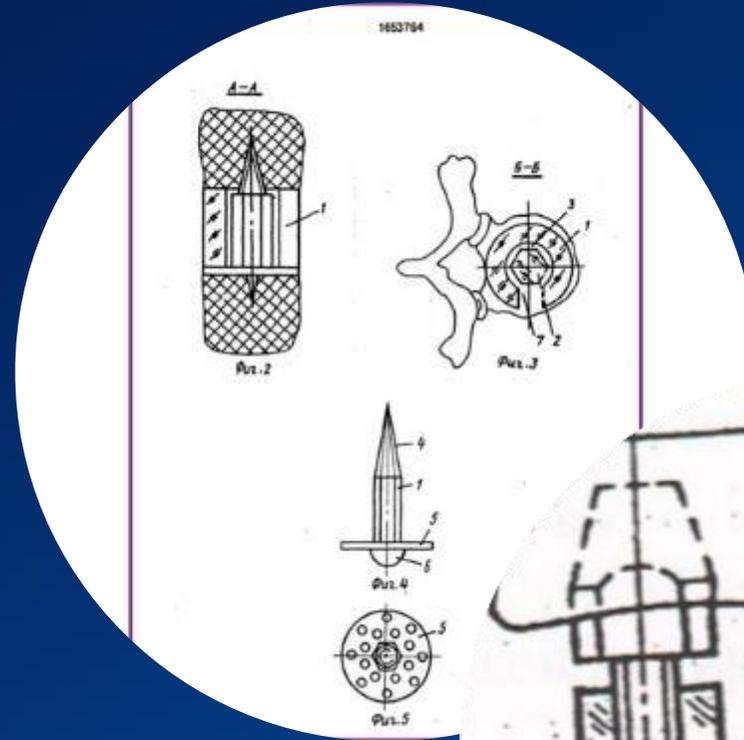
Experimental-theoretical studies in orthopedics and  
traumatology

Problems of spine pathology

Orthopedic arthrology

Traumatology of the spine and joints

Orthopedic oncology





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# Privileged research directions of the institution

- ✓ experimental and theoretical investigation of the problems of diagnostics, conceptual foresight of the states of diseases and injuries of the joints and spine,
- ✓ complications preventing,
- ✓ working-out of new treatment technologies,
- ✓ working-out of the techniques of patients rehabilitation according to the different stages of treatment





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# Privileged research directions of the institution

Working-out of new bioinert implant materials for the plastic  
repair of vertebral and joints bone defects





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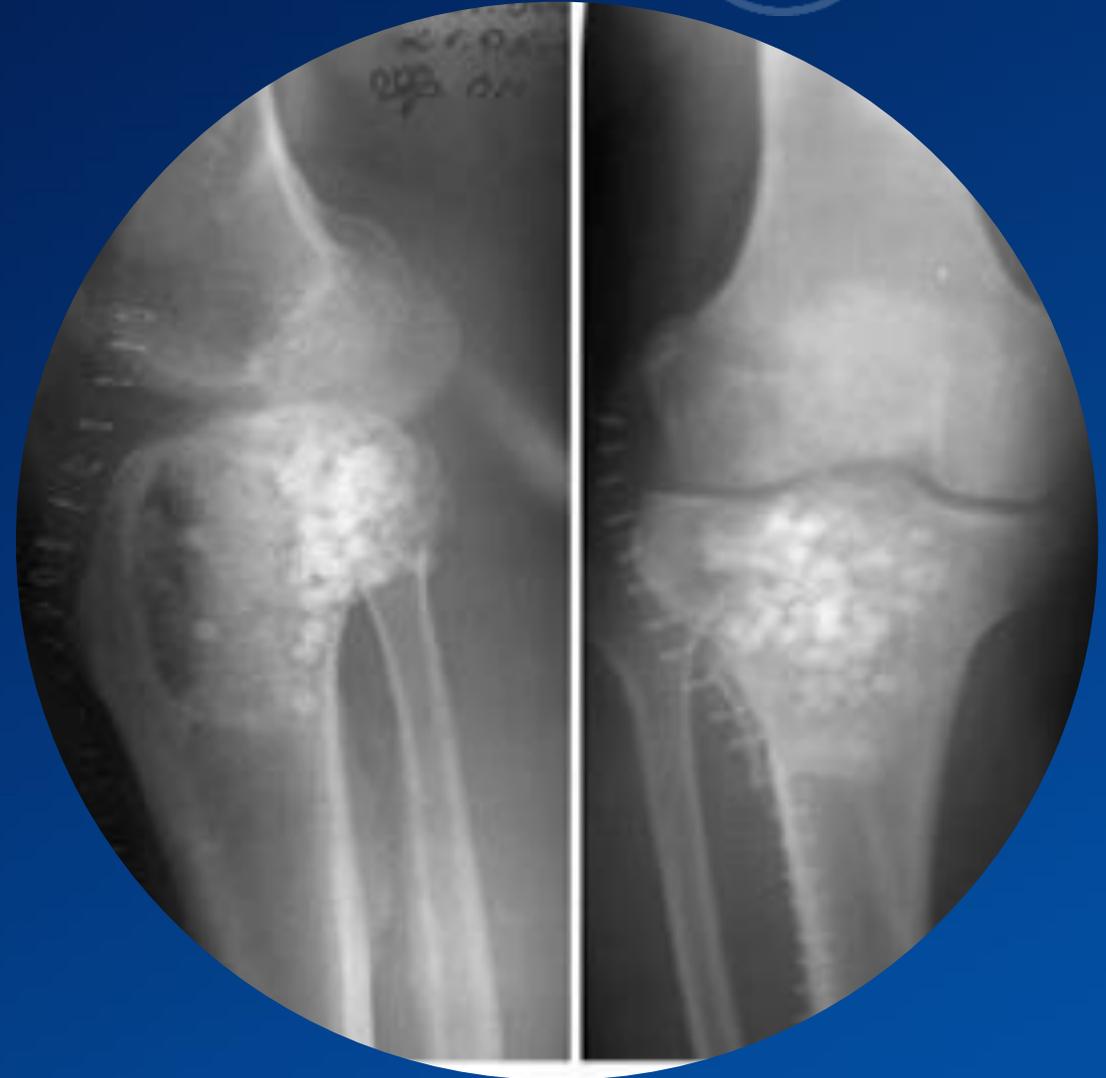


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# Privileged research directions of the institution

Investigation of the possibilities and usage of surgical  
treatment of benign and malignant bone tumors with the  
focus on the organ preserving surgery on spine and  
extremities





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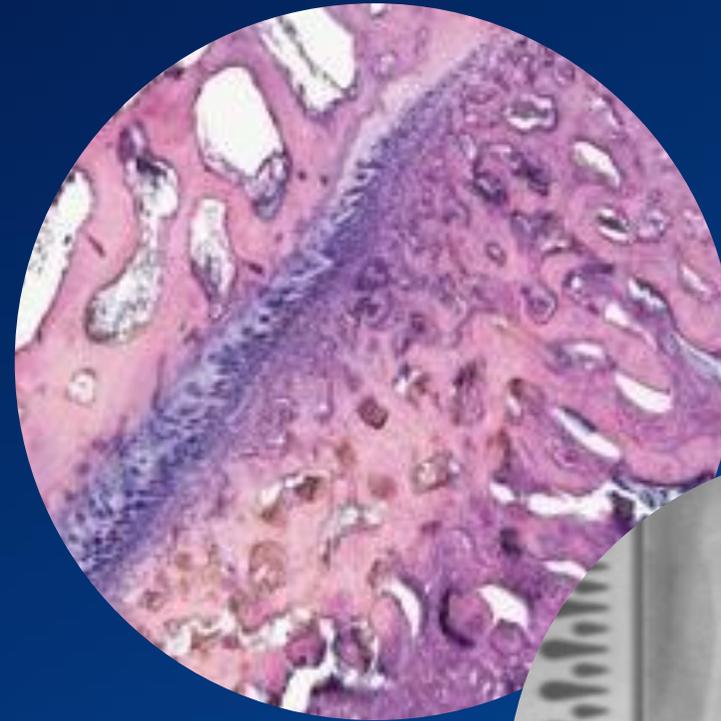


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# Privileged research directions of the institution

Development of advanced methods of tissue engineering,  
directed on the restoration of function of loco-motor  
apparatus, particularly, in the case of injury and disease of  
spine and joints.





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# Privileged research directions of the institution

- ✓ Reconstructive surgery for severe consequences of injuries and diseases of skeleton,
- ✓ primary and intricate revision arthroplasty of large joints, decompressive-stabilizing surgical operations in spine-vertebral injury,
- ✓ surgical interventions in severe forms of scoliosis on different part of spine





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# Privileged research directions of the institution

Unique treatment system for the correction of skeleton  
deformities in adults and children using apparatus of external  
fixation





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# Privileged research directions of the institution

- ✓ new and improvement of existing methods for prevention,
- ✓ diagnostics and treatment of disabling diseases and injuries of spine and joints in children





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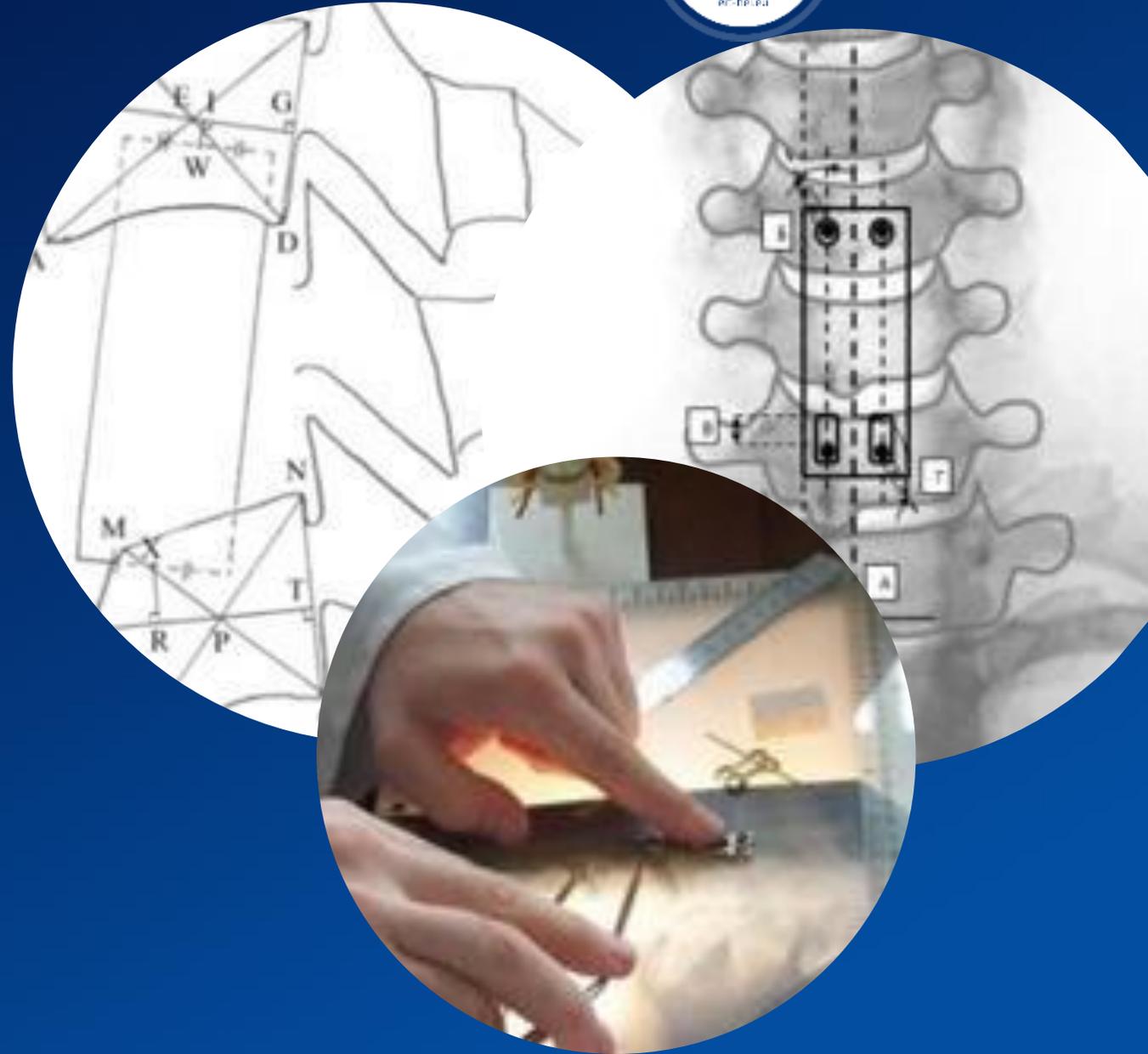


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# Privileged research directions of the institution

The system of X-ray evaluation of the multiplane position of  
the cervical vertebrae after the anterior spondylodesys





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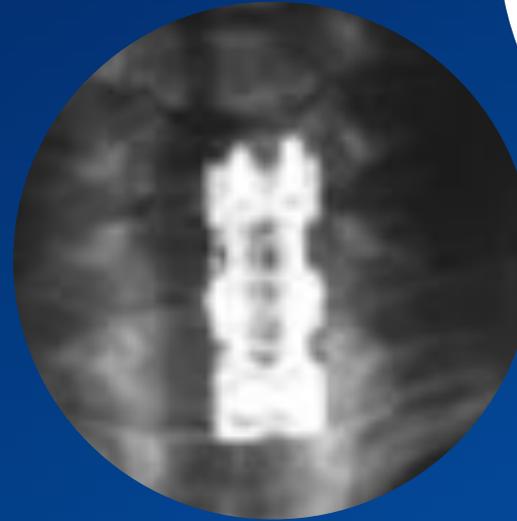
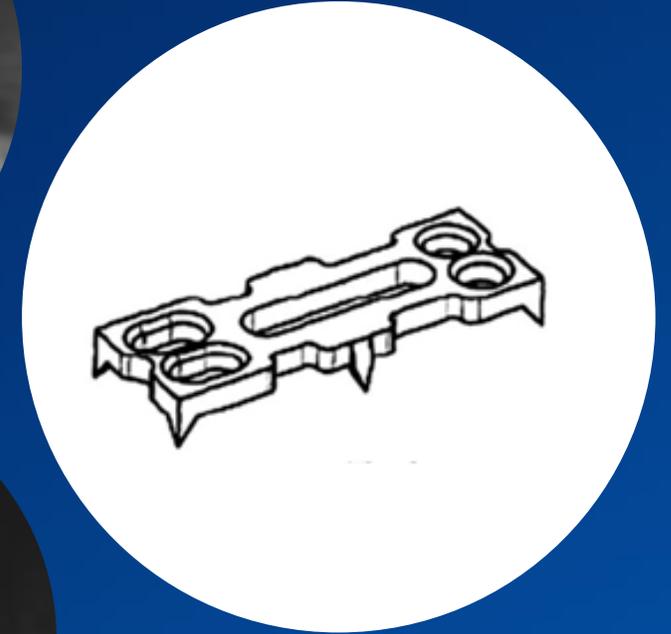


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# Privileged research directions of the institution

- ✓ techniques of the spondylodesis and external immobilization,





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# Privileged research directions of the institution

- ✓ more fixation of the vertebrae in comparison with the single-rod metal structure





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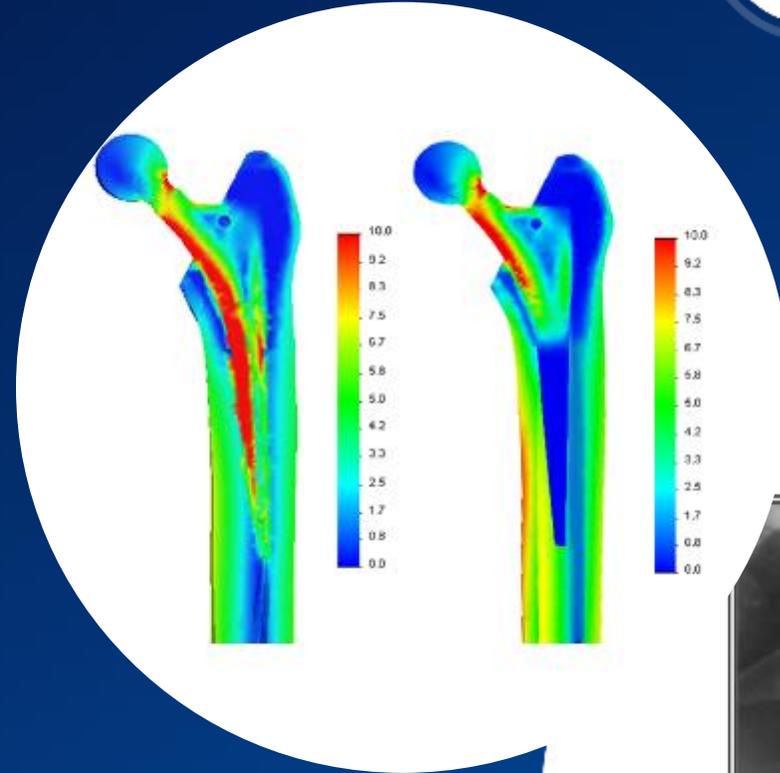


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# Privileged research directions of the institution

- ✓ **Mathematical modeling**

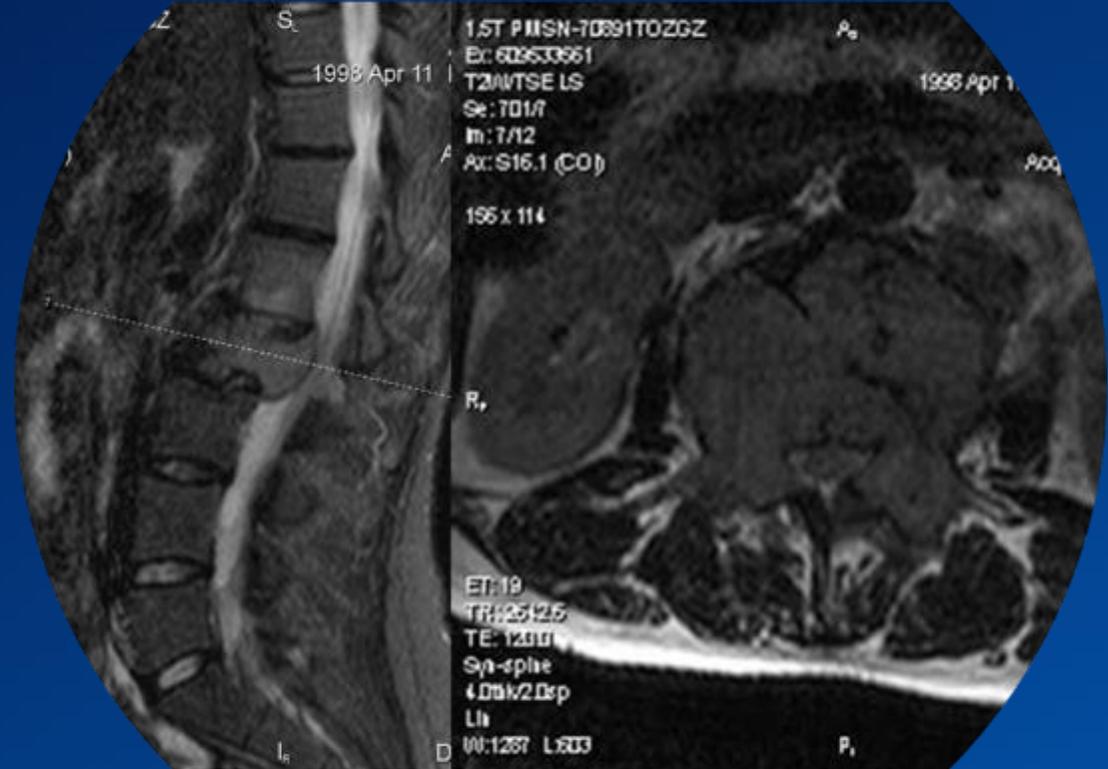


# Navigation systems!



# Navigation systems

Minimization the risk of vertebral wall perforation, spinal cord injury, nerve root or vascular damage





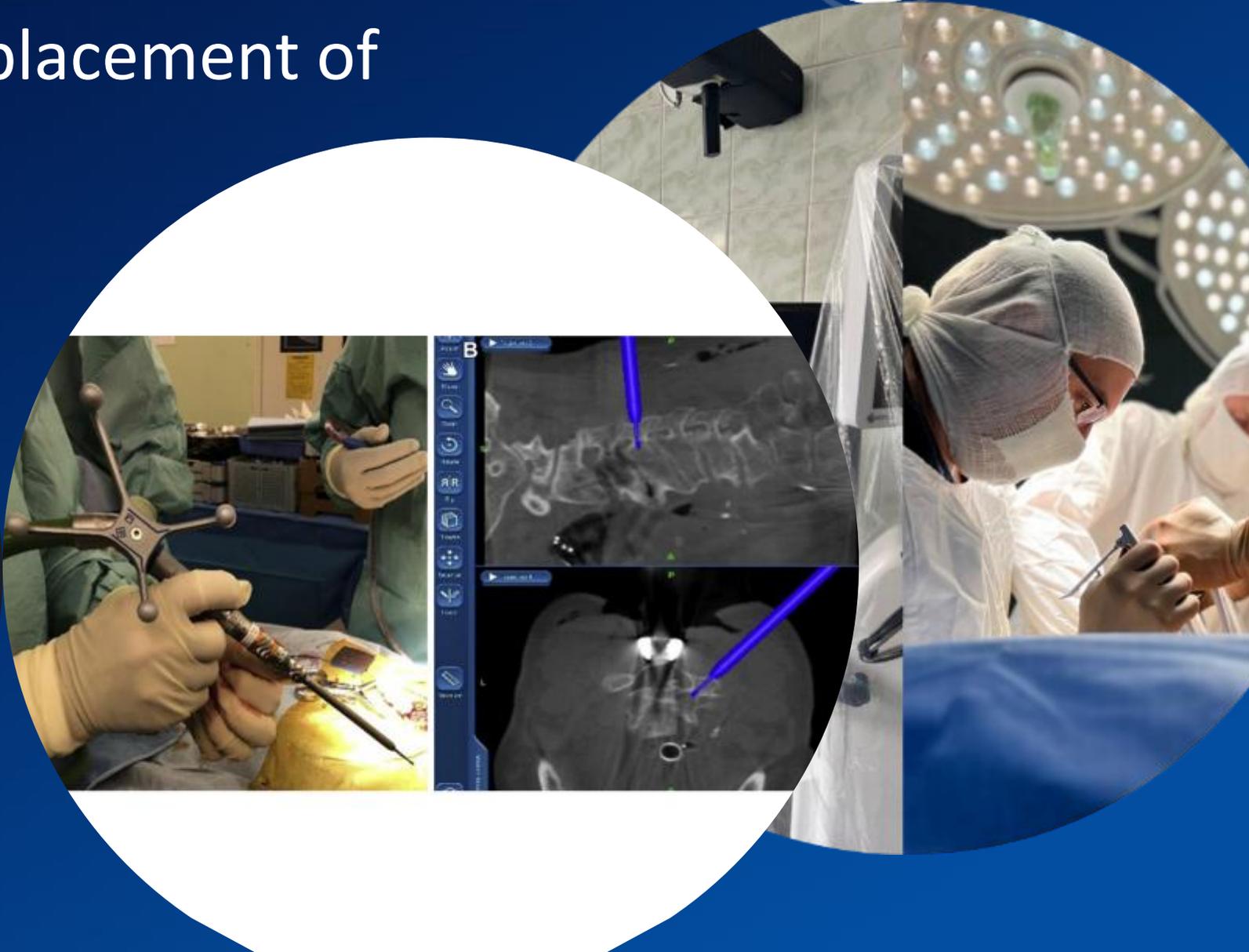
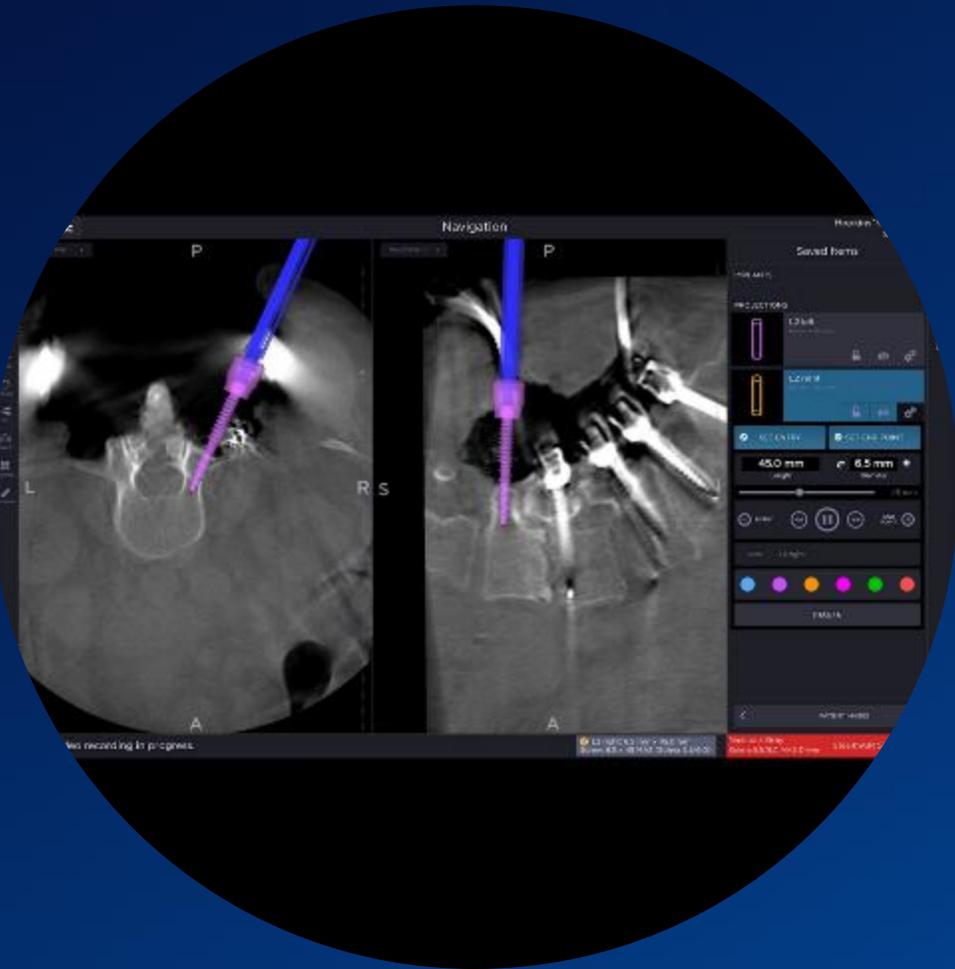
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# Navigation during the placement of transpedicular screws



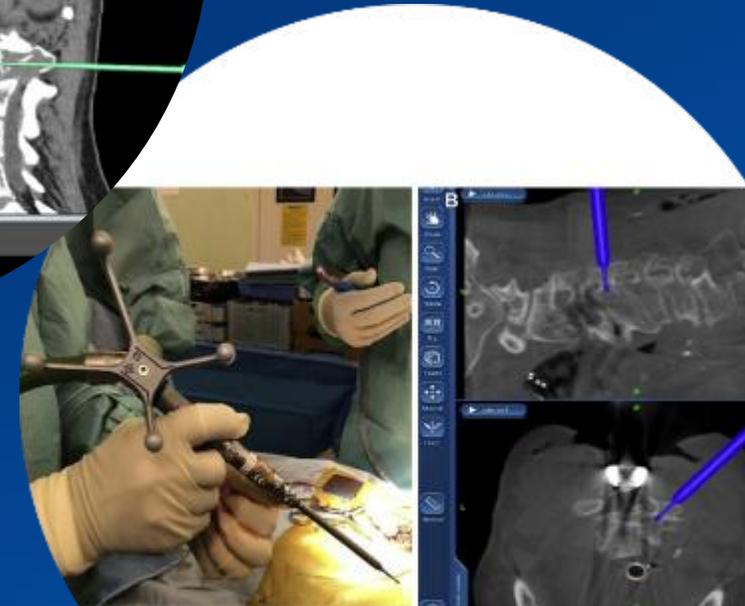
# Principles of navigation use:

Preoperative scanning (CT or intraoperative 3D scan): a virtual model of the patient's spine is created.

Registration of patient anatomy: the navigation system matches the scan data with the actual anatomy on the operating table.

Use of navigational instruments: the surgeon sees in real time on the monitor the exact trajectory of instruments and screws relative to anatomical structures.

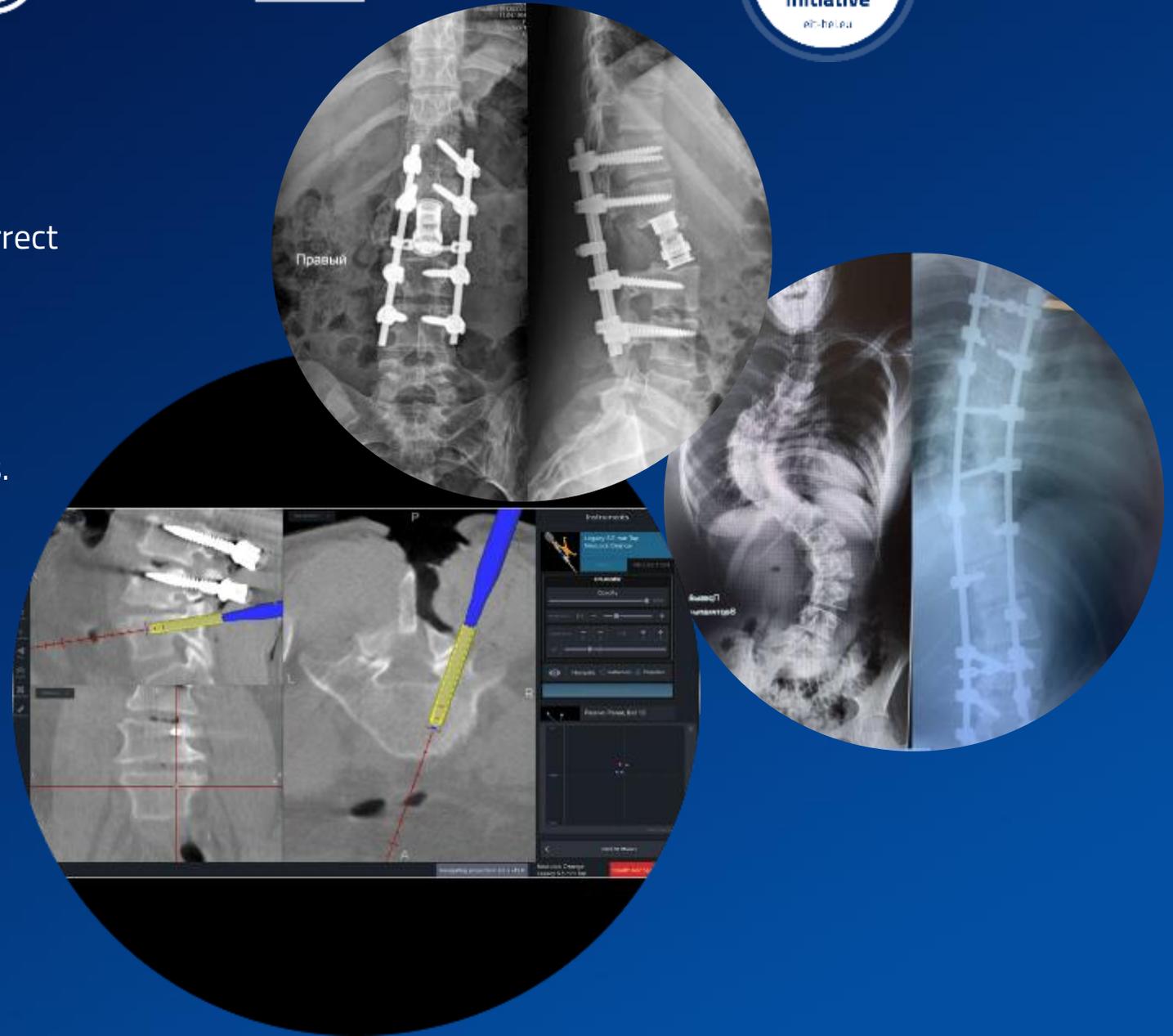
Quality control: navigation allows checking the depth, direction, and position of the screw before insertion, reducing the need for fluoroscopy.





# Benefits:

- Increased screw placement accuracy (up to 95–98% correct positioning);
- Reduced radiation exposure for the patient and staff;
- Shortened surgery duration in experienced hands;
- Possibility of performing minimally invasive procedures.





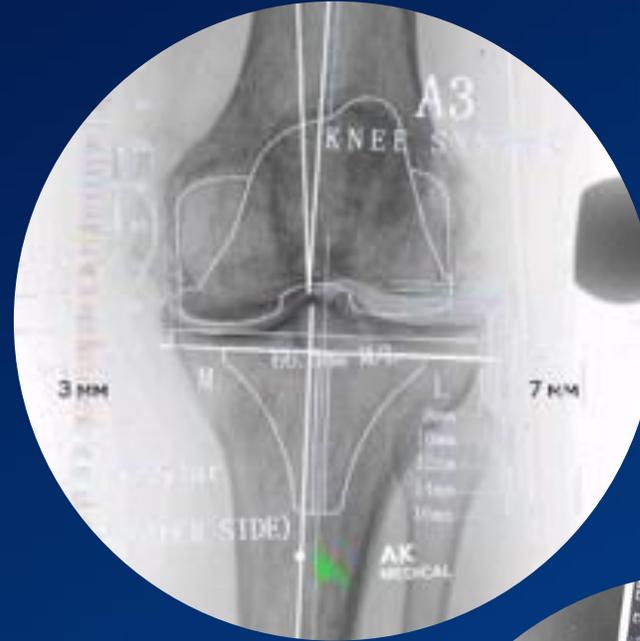
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# Preoperative planning





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# Preoperative templating





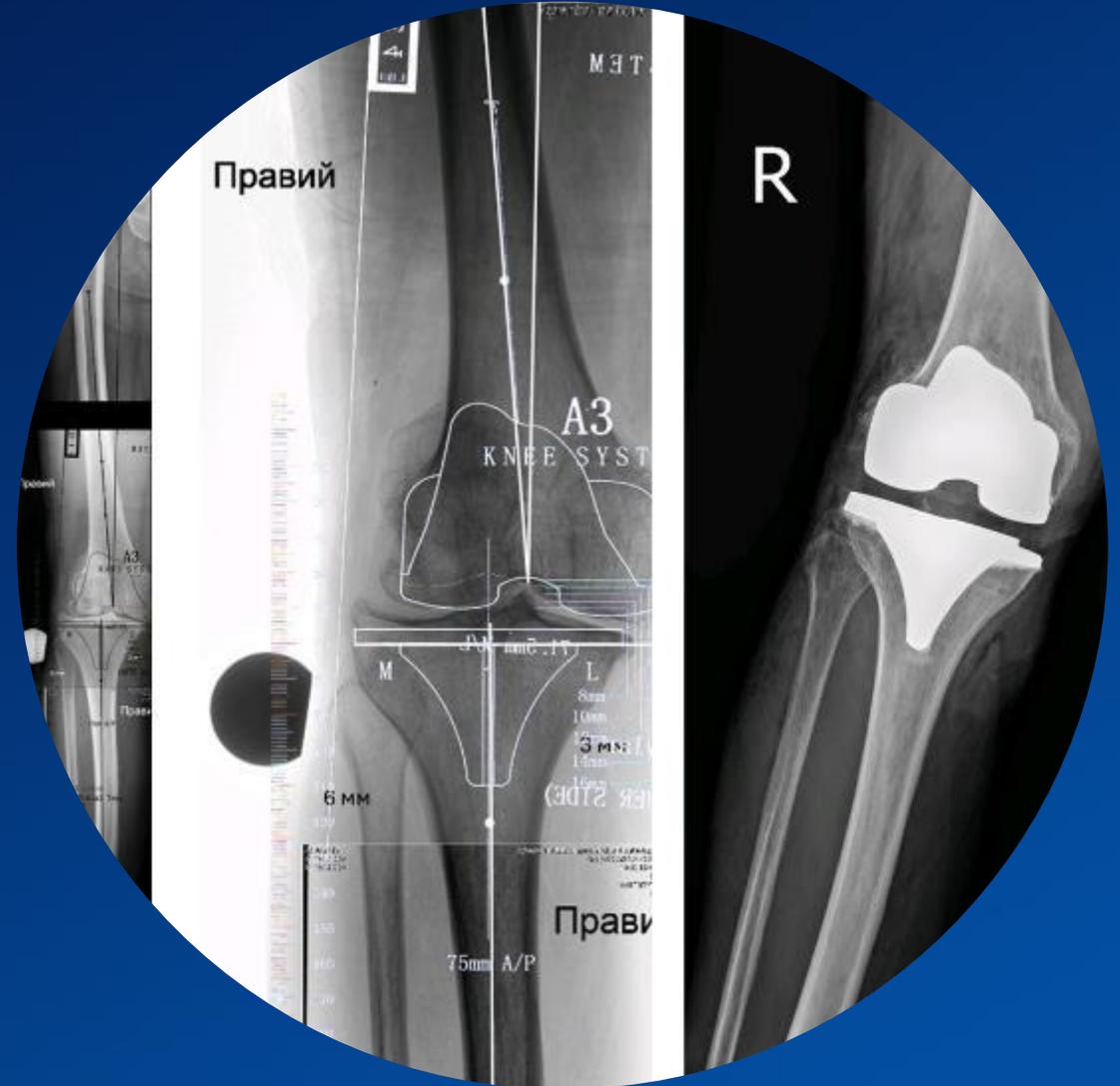
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# Joint templating





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# Challenging economic environment

medc-201 medCAD® Classic Hospital Expert, 3 users	- 1 +	1 444 350.20 € 600 HJC 1 732 990.20 € c HJC
medc-101 medCAD® Classic Hospital, 3 users	- 1 +	796 750.20 € 600 HJC 956 900.20 € c HJC
medc-100 medCAD® Classic Hospital, Additional user	- 1 +	174 250.20 € 600 HJC 209 100.20 € c HJC
medc-104 medCAD® Classic Hospital, Unlimited	- 1 +	1 593 550.20 € 600 HJC 1 912 260.20 € c HJC
medc-200 medCAD® Classic Hospital Expert, 3 users, Standard- Maintenance (p.a.)	- 1 +	144 420 € 600 HJC 173 300 € c HJC
medc-204 medCAD® Classic Hospital Expert, Unlimited	- 1 +	2 738 950.20 € 600 HJC 3 286 700.20 € c HJC
med3d-101 medCAD® 3D Hospital, 1 users	- 1 +	298 750.20 € 600 HJC 366 900.20 € c HJC
med3d-103 medCAD® 3D Hospital, 3 users	- 1 +	796 750.20 € 600 HJC 956 900.20 € c HJC
med3d-100 medCAD® 3D Hospital, Additional user	- 1 +	174 250.20 € 600 HJC 209 100.20 € c HJC



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# 3D printing

3D printing is actively used in our institute, especially for joint replacement procedures. CT/MRI scans are automatically processed and converted into 3D models in STL format using DICOM image segmentation. Artificial intelligence helps optimize model design for printing: it improves structure, reduces weight, and enhances strength.





## 3D models

- ✓ Personalized surgical guides, implants, and simulation models for the spine and joints.
- ✓ Automatic segmentation of anatomical structures, model design optimization,





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# 3D printing





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# Rehabilitation

COMOS treadmill with gait analysis and individualized training programs





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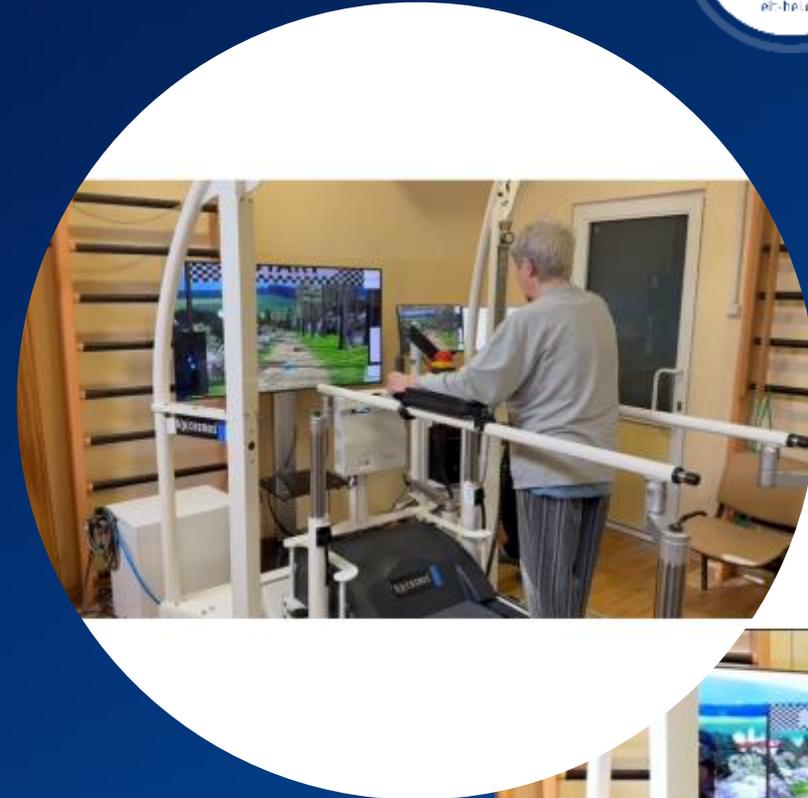


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## Treadmill sensors record:

- ✓ ■ the duration and symmetry of gait phases (stance/swing),
- ✓ ■ step speed and length,
- ✓ ■ load on each limb,
- ✓ ■ trunk balance and stability.





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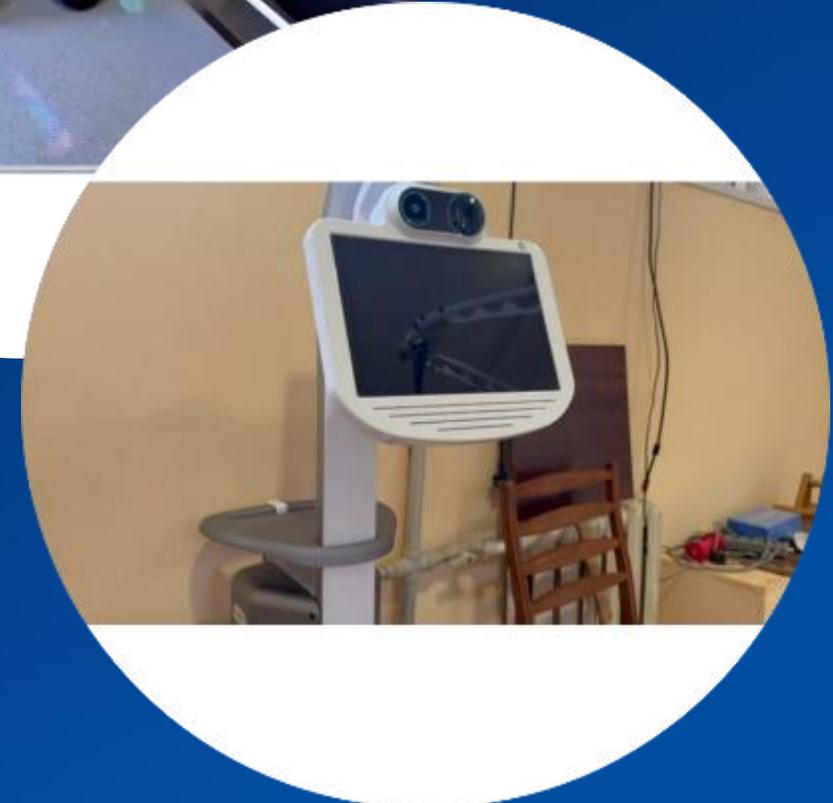


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# Personalized training plan:

- ✓ ■ dominant impairments (asymmetry, weakness, instability),
- ✓ ■ current physical condition,
- ✓ ■ the patient's goal (e.g., restoring speed, improving endurance, achieving symmetry).



# Applications:

- Endoprosthesis, amputations, post-traumatic conditions
- Gait disorders in geriatrics, fall prevention





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# Virtual reality glasses

- ✓ integrate motion analysis modules,
- ✓ virtual simulations of daily activities, and neuroplasticity-enhancing exercises,
- ✓ opening a new level of functional therapy.





## The VR system uses:

- body and limb position trackers (built-in or external),
- computer vision algorithms and skeletal motion models.

This allows accurate assessment of:

- range of active joint movements,
- movement speed and smoothness,
- motor control, stability, and presence of pathological movement patterns.





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# The advantages of using virtual reality glasses in rehabilitation include:

- A high level of patient motivation
- Stimulation of neuroplasticity through immersive contextual action
- The ability to detect even minimal dynamic changes
- A safe environment for practicing high-risk scenarios (e.g., balance training)





# Suggestion of exercises adapted to the patient's functional level.

Therapy is conducted in the form of:

- virtual simulations of everyday situations (carrying objects, self-care),
- game-based tasks that activate both motor and cognitive engagement (e.g., accurate target hitting, bilateral coordination),
- dynamic balance and reaction training modules.





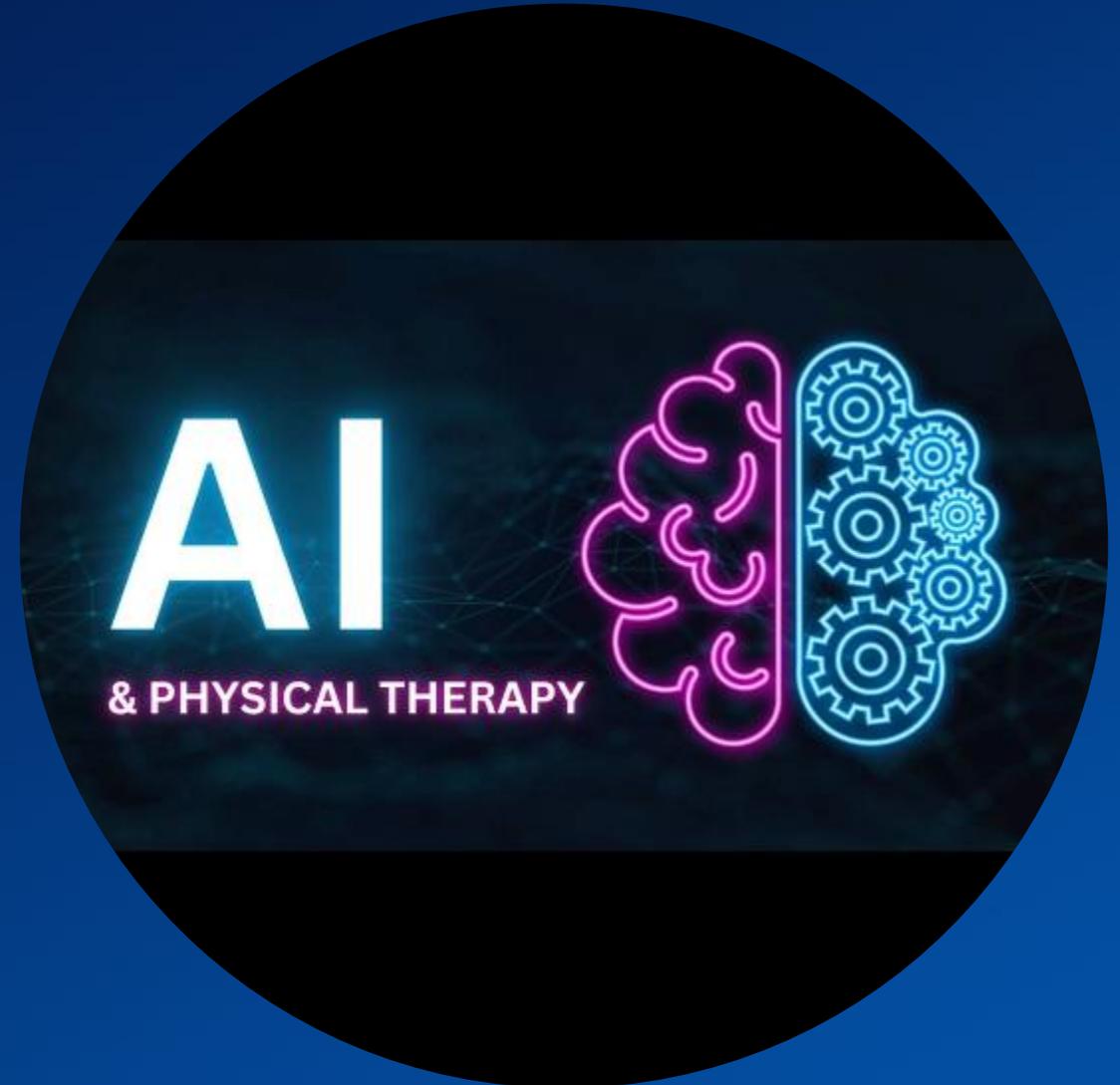
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# Improvement of recovery outcomes



# Detection and correction of movement disorders

- analyzing video or sensor-based movement data
- identifying inefficient or unsafe movement patterns,
- generating feedback for both the patient and the therapist.





# Motion recognition and correction

- ✓ video or sensor data of the patient's movements (for example, in children with cerebral palsy or patients with Parkinson's disease),
- ✓ detecting inefficient or dangerous movements,
- ✓ generating feedback for the patient and therapist.





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## Robotic simulation and exoskeleton

- ✓ adjusting the strength and amplitude of assistance depending on the patient's activity,
- ✓ “learning” together with the patient,
- ✓ providing safe and effective therapy even in severe cases





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# Emotional support and cognitive stimulation

- ✓ support patients with neurocognitive disorders
- ✓ assist with memory, attention, and orientation exercises,
- ✓ reduce feelings of isolation.





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# Documentation and assessment of patient functioning





# Patient diaries, pain assessment

We widely use AI-generated templates in our practice for patient diaries, pain assessment, and clinical scales in both digital and paper formats.



## Sytenko Institute of Spine and Joint Pathology National Academy of Medical Sciences of Ukraine

### Post-Surgery Patient Questionnaire

(Your feedback helps us improve our care and services. All responses are confidential.)

#### Patient Information

1. Full Name (optional): \_\_\_\_\_
2. Date of Birth: \_\_\_\_\_
3. Date of Surgery: \_\_\_\_\_
4. Type of Surgery (e.g., endoprosthesis, spinal surgery, fracture repair): \_\_\_\_\_

#### Surgical Experience

Please rate the following aspects of your surgical experience at the Sytenko Institute (1 = Poor, 5 = Excellent):

1. Clarity of pre-surgery information provided by the medical team:  
1 2 3 4 5
2. Professionalism and support of the surgical team:  
1 2 3 4 5
3. Quality of communication with your surgeon:  
1 2 3 4 5
4. Comfort and cleanliness of the hospital facilities:  
1 2 3 4 5

#### Post-Surgery Recovery

Please answer the following questions about your recovery process:

1. How would you rate the pain management provided after surgery?  
1 2 3 4 5
2. Were you provided with clear instructions for post-surgery care at home?



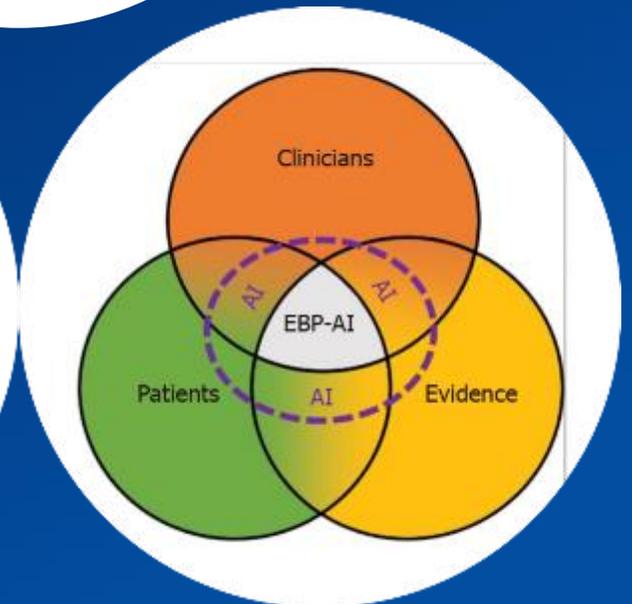
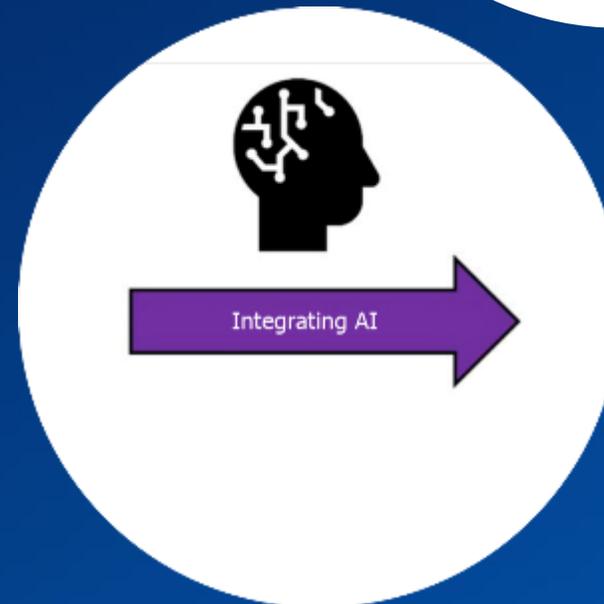
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# Evidence-based physical therapy





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# Videoinstruction for physical therapy





# Scientific work

Продовжує роботу навчальний курс «Advanced training SOLOMIYA» організований українсько-німецьким проектом SOLOMIYA, ДУ «ІПХС ім. проф. М.І.Ситенка НАМН України», кафедрою травматології та ортопедії, фізичної та реабілітаційної медицини ННІПО ХНМУ та Харківським обласним осередком ВГО «УАОТ».

Продовжує роботу навчальний курс «Advanced training SOLOMIYA» організований українсько-німецьким проектом SOLOMIYA, ДУ «ІПХС ім. проф. М.І.Ситенка НАМН України», кафедрою травматології та ортопедії, фізичної та реабілітаційної медицини ННІПО ХНМУ та Харківським обласним осередком ВГО «УАОТ». Тема вебінару: Фізична реабілітація для ортопедів, травматологів, фізіотерапевтів, фізично-анестезіологів, спеціалістів з реабілітаційної медицини. Восьмий вебінар пройшов 06 липня 2023р. Тема: «Терапія опіків та їх наслідки».




**OSSEOINTEGRATIVE PROSTHETICS: OPPORTUNITIES, CHALLENGES, AND PROSPECTS FOR ITS APPLICATION IN THE REHABILITATION OF PATIENTS WITH AMPUTATED LIMBS (LITERATURE REVIEW)**

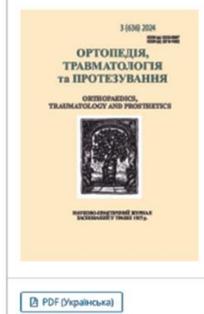
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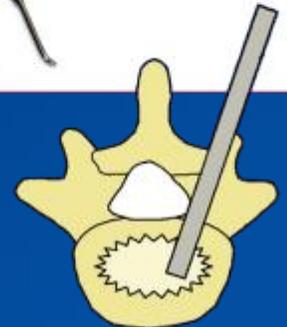


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# Local Ethics committee

Every study at the institute is conducted following approval by the local ethics committee. We also use AI in the committee's work—primarily for verifying the protocol's compliance with ethical standards (Helsinki Declaration, CIOMS, Ministry of Health orders). AI helps quickly identify contradictions between protocol text and current regulations. It also assists in evaluating the language of informed consent—whether it is understandable to non-specialists—and analyzing the risk/benefit balance in sections such as "study rationale" or "methods."





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# Questions?

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