Implementation of Percutaneous Osseointegrated Prosthetics in Veterinary Practice and Development of Limb Prosthetics

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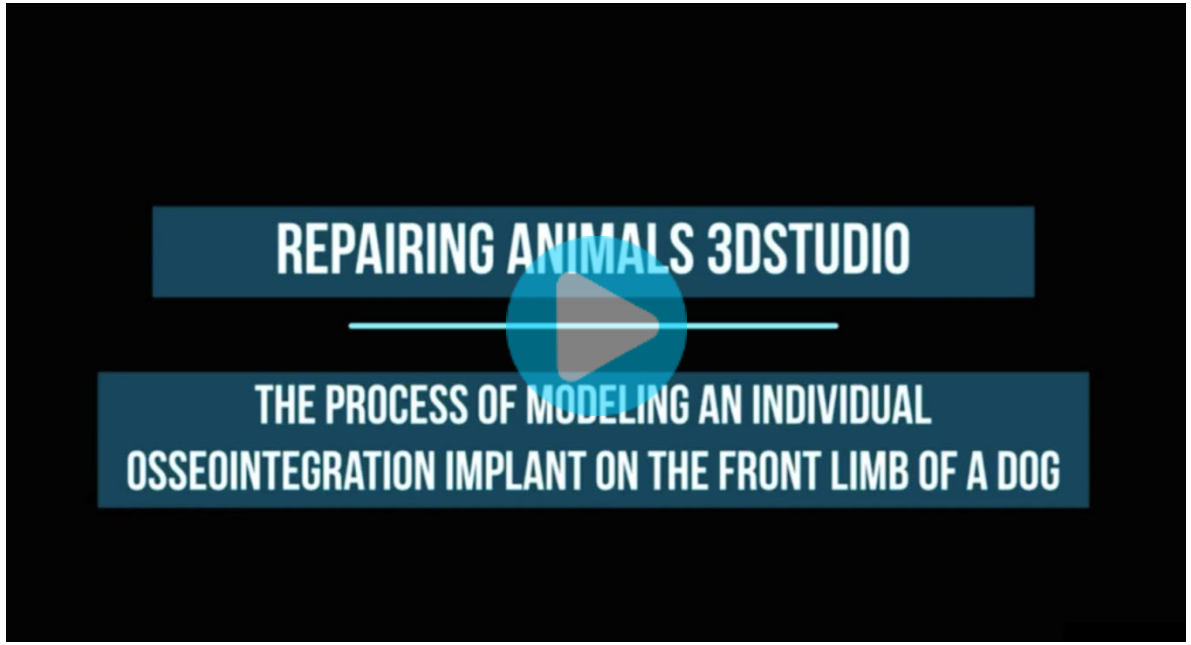
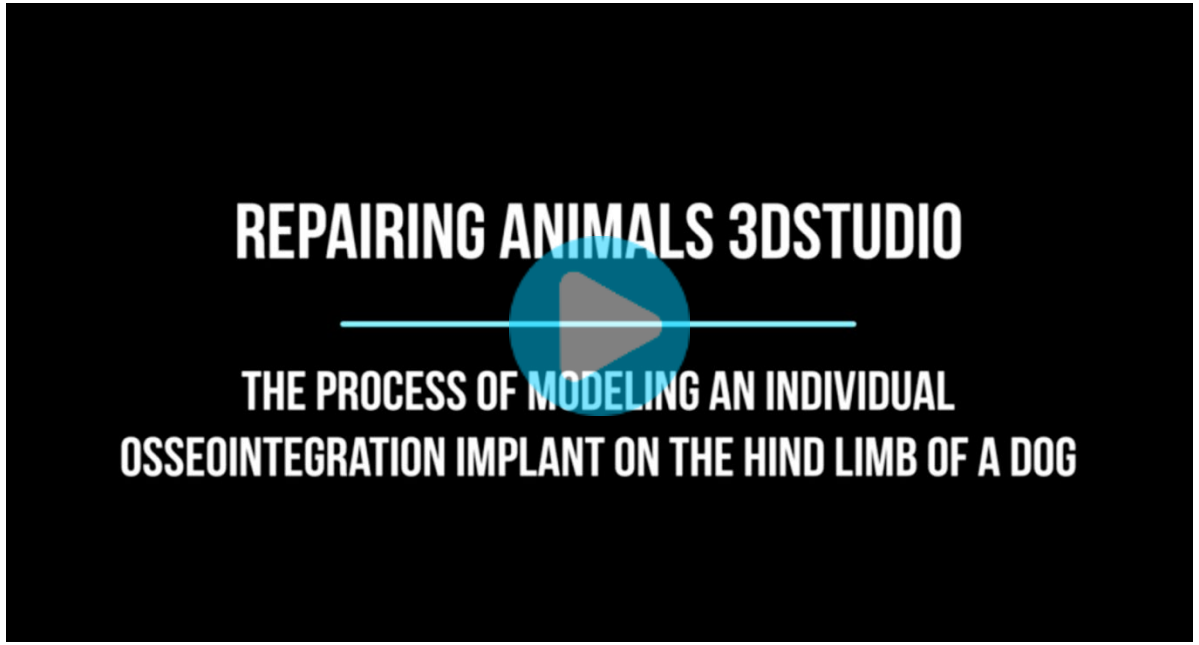
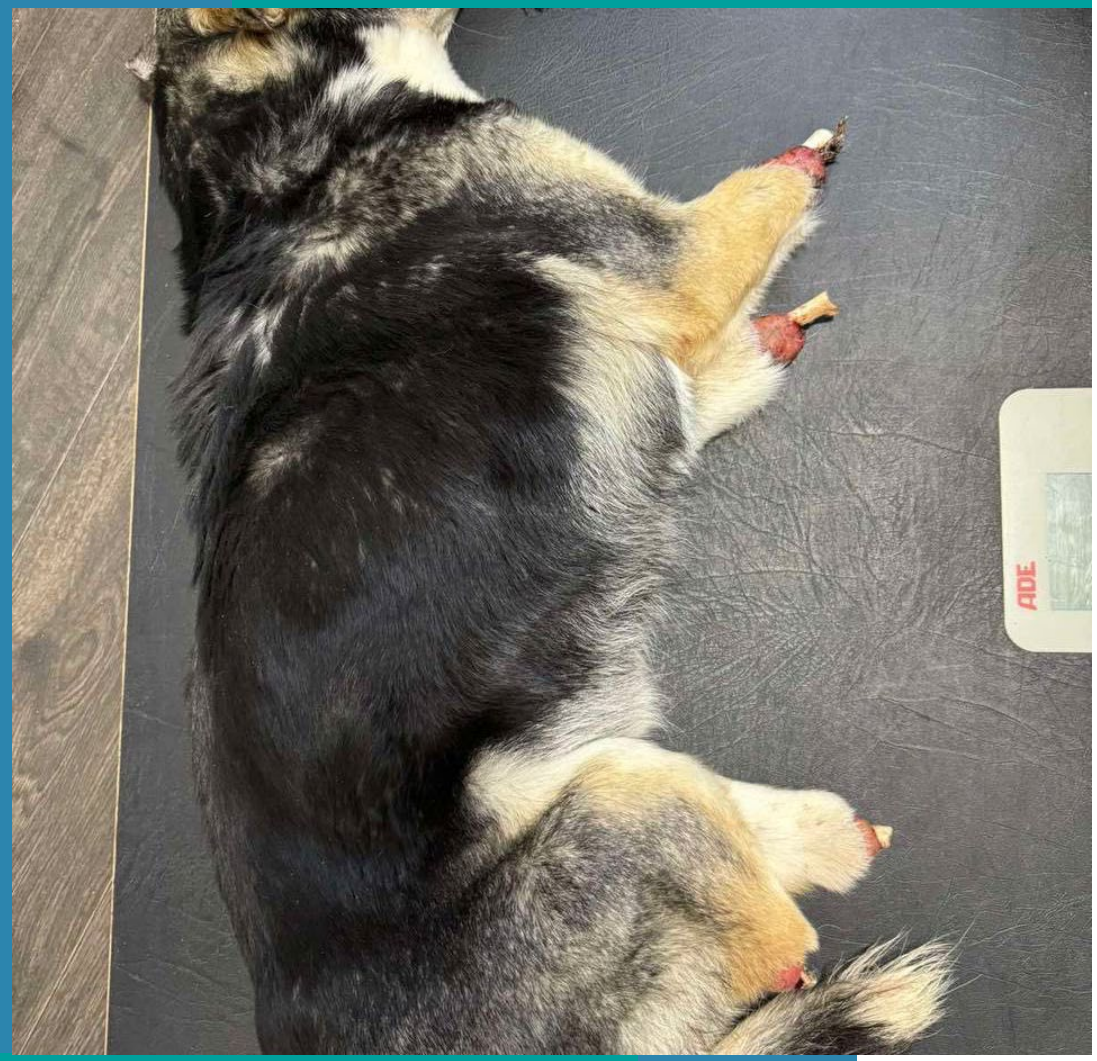
ХАРКІВСЬКИЙ ВЕТЕРИНАРНИЙ ГОСПІТАЛЬ

Visual Overview of the Process







Relevance of the Topic

- Due to the ongoing war in Ukraine, the number of amputations has increased.
- Large and giant dog breeds, in most cases, cannot move properly without one forelimb and have difficulty moving without one hind limb.
- There are also many cases of amputations of both limbs, in which animals struggle to move and are forced to rely on their stumps, causing additional pain.
- In cases of oncological conditions, limb preservation is possible through percutaneous biointegrated prosthetics.

Case Study: Canine Prosthetic Limbs

- A stray, mixed-breed dog was found with amputations of three limbs. His name is Mai.

Video: the prosthetic in action

Advantages of Osseointegrated Prosthetics Over Socket-Based Prosthetics

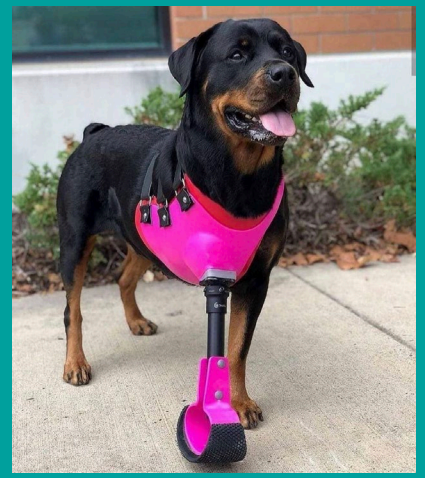
Using conventional socket prostheses comes with several drawbacks:

- Persistent pain
- Discomfort
- Skin irritation and chafing

Additionally, these prostheses require frequent removal and reattachment, which can be inconvenient for pet owners.

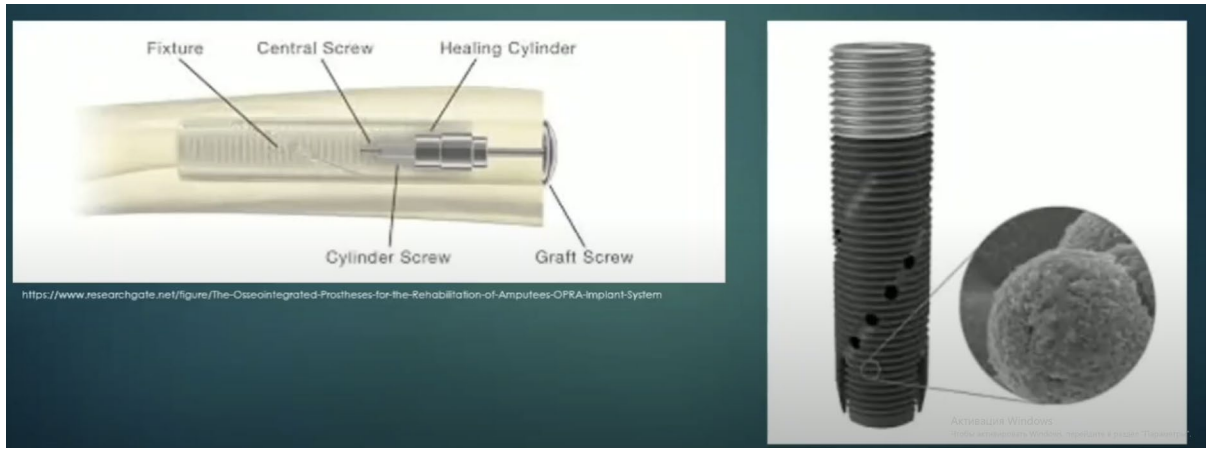
They may also be non-functional or of poor quality.

Osseointegrated prostheses are particularly suitable for cases of complete forelimb loss or when only a small limb fragment remains.



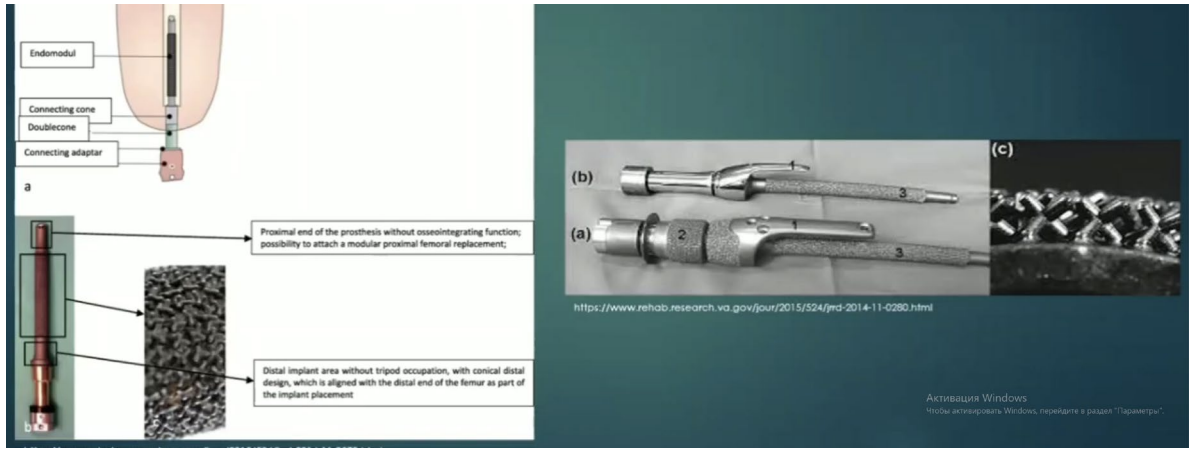
Types of Biointegrated Prosthetics in Medicine

OPRA Implant System (Sweden)



- Screwed into the bone canal using a threaded design.
- Suitable for long tubular bones and finger phalanges.
- Features laser engraving on metal, which enhances osseointegration over time.

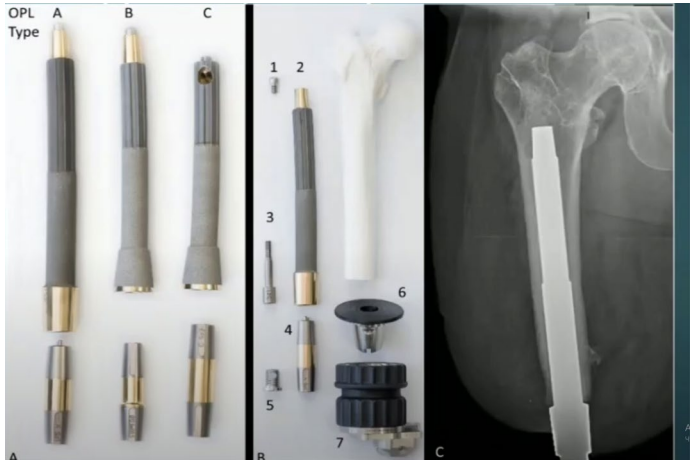
Integral Leg Prosthesis (ILP) (Germany)



- Made from cobalt-chromium-molybdenum alloy.
- Held in the bone marrow canal through press-fit fixation.
- Coated with a "Czech Hedgehog" surface, 1.5 mm thick, to promote integration.
- The first generation included an additional plate for fixation to the bone.

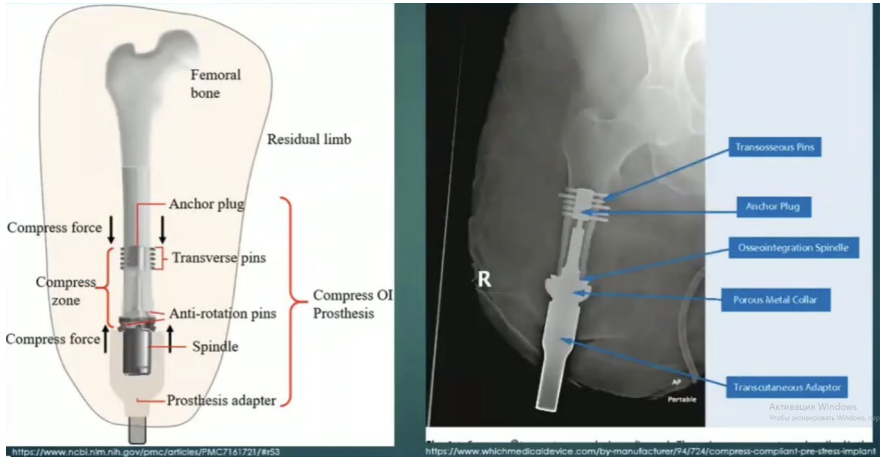
Types of Biointegrated Prosthetics in Medicine

Osseointegration Prosthetic Limb (OPL) (Australia)



- Made from titanium.
- Secured in the bone marrow canal through press-fit fixation.
- Designed for long tubular bones.
- Features a plasma-sprayed coating, 0.5 mm thick.
- The most widely implanted system globally, with over 800 units installed.

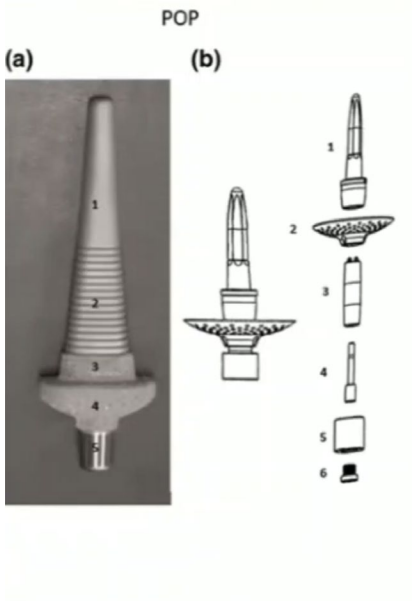
Compress Device (USA) (In Development)



- Made from titanium.
- Secured in the bone marrow canal using transversely placed pins.
- Designed for humeral and femoral bones.

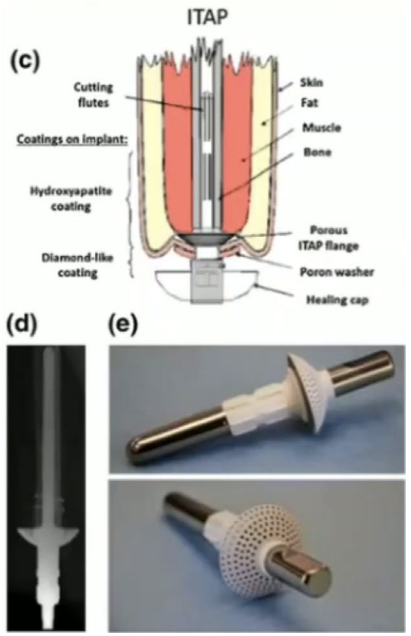
Types of Biointegrated Prosthetics in Medicine

Percutaneous osseointegrated Prosthesis (POP USA)



- Made from titanium.
- Implanted using a press-fit method.
- Designed exclusively for femoral bone implantation.
- Features a porous coating for enhanced osseointegration.

Intraosseous Transcutaneous Amputation Prosthesis (ITAP USA)



- Made from titanium.
- Implanted using a press-fit method.
- Suitable for both femoral and humeral bone implantation.
- Coated with hydroxyapatite to promote bone integration.

Contraindications for Biointegrated Prosthetics

- Diseases leading to bone fragility or brittleness (e.g., hyperparathyroidism, renal insufficiency).
- Congenital disorders affecting skeletal health (e.g., mucopolysaccharidosis).
- Endocrine disorders (e.g., hypothyroidism), which may delay or halt healing processes.
- Active infections.
- Oncological diseases with metastasis.
- Advanced age.
- A short remaining segment of the tubular bone.
- Lack of sufficient skin flap coverage at the stump site.
- Severe muscle damage in the limb planned for prosthetics, as well as nerve damage leading to loss of innervation.

Indications for Biointegrated Prosthetics

- Traumatic injuries of two or more limbs. Percutaneous biointegrated prosthetics can be applied in cases of trauma leading to the amputation of forelimbs, hind limbs, or all four limbs.
- The best candidates for prosthetics are animals that have undergone partial amputation of the forelimbs or hind limbs while preserving the epiphyses of long tubular bones.
- Neoplastic lesions. Indicated for bone tumors in the distal limb regions without metastasis.
- Congenital progressive genetic disorders causing skeletal deformities. Examples include osteochondrodystrophy in Scottish Fold cats.
- Congenital progressive bone deformities. Cases such as the absence of tibial bones or forearm bones.

The First Step in Prosthetics: Proper Amputation

Fundamentals of a Properly Performed Amputation

The most important aspect is preserving as much skin as possible. All successful outcomes in percutaneous prosthetics have been achieved when the stump retained enough skin.

It is important to remove only the minimally necessary portion of the bone whenever possible.

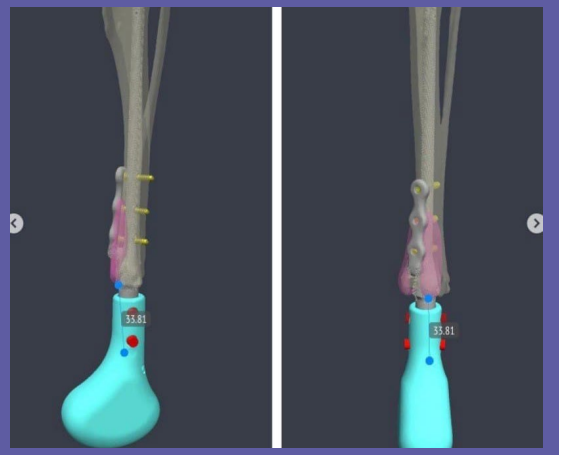
It is crucial to tie and suture tendons and muscles properly.

Applying ligatures to nerves is extremely important to prevent phantom pain in the future.

If possible, it is better to perform a skin transfer rather than remove more bone.

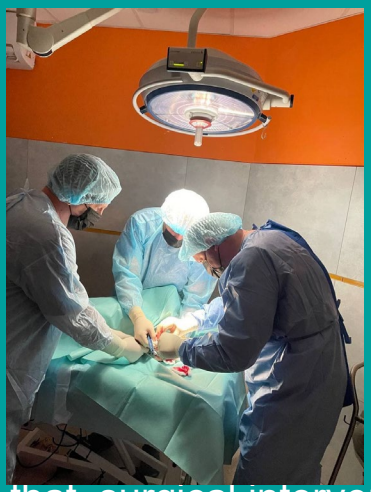
Stages of Prosthetic Implementation

After the decision for prosthetics is made and the stump has healed, a CT scan is performed and sent to the bioengineer.



Kateryna then develops a design, which, after approval by the doctor, is sent for printing.

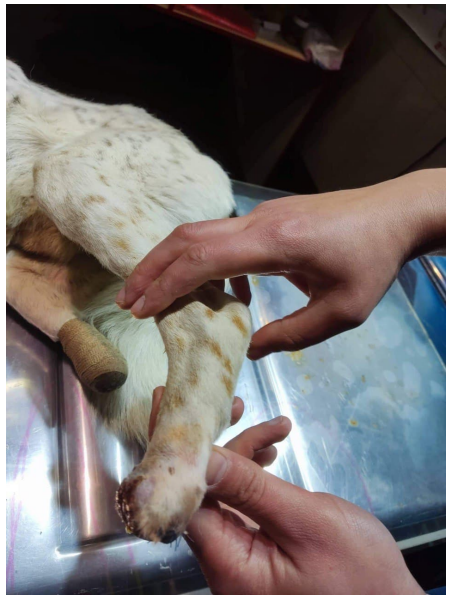
First, the design is printed in plastic and sent to the doctor along with a video instruction. If the doctor conducts a test operation on the plastic model and everything is satisfactory, the final version is printed in titanium.



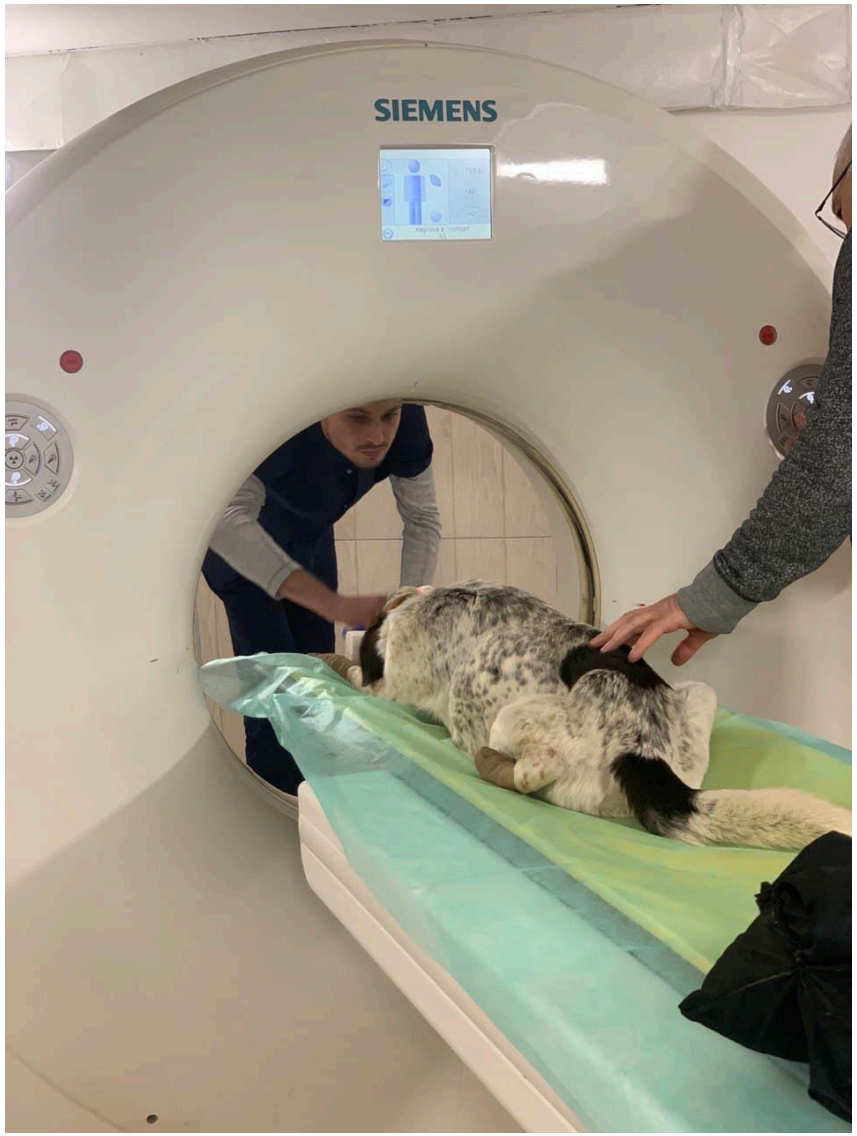
After that, surgical intervention takes place. Depending on the treatment plan, the procedure may be performed in two stages. In the first stage, the implant is inserted. In the second stage, once it has integrated (after about two months), the external component is attached.

Case Study: First Single-Stage Prosthetic Implantation of a Forelimb and Hind L

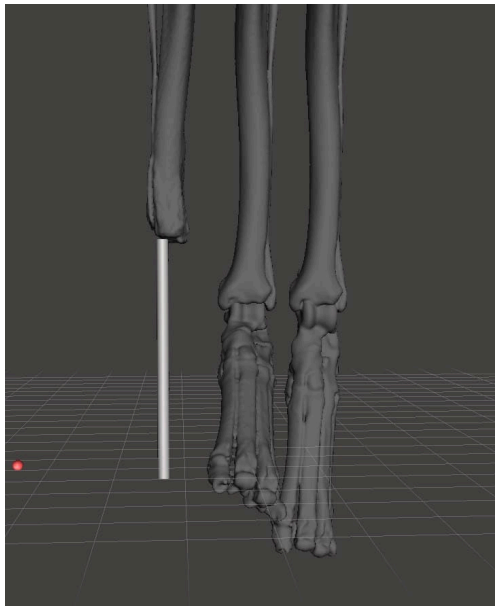
A 4-year-old mixed-breed dog was found with partial amputations of three limbs.

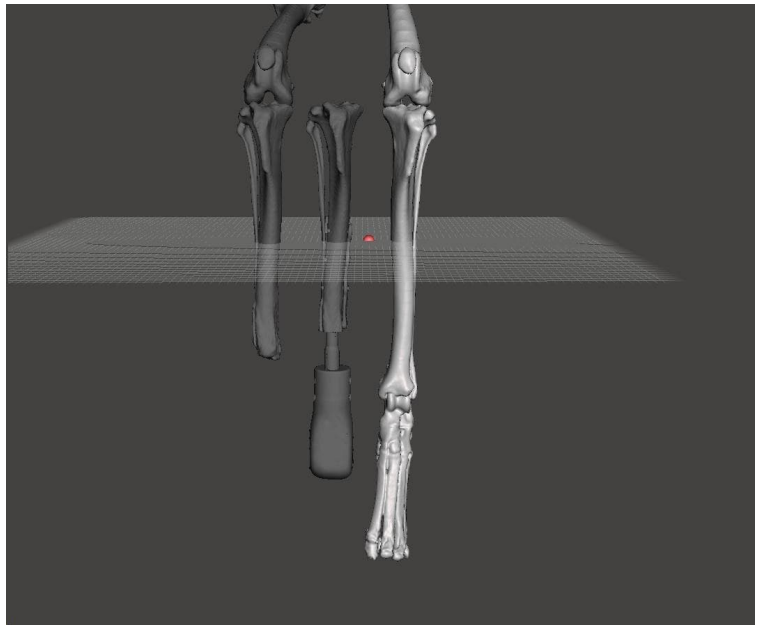


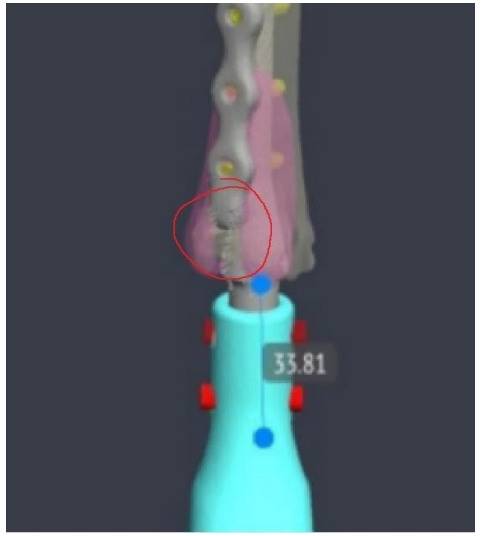
First Step: Conducting a CT scan

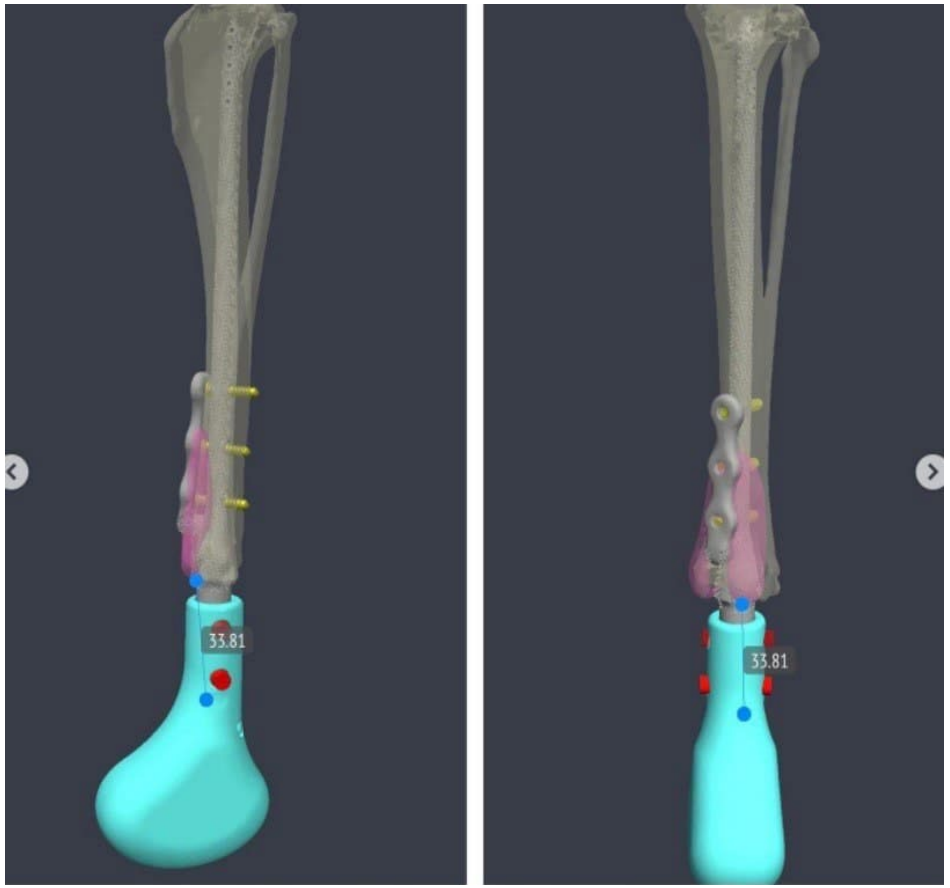


Then, our Prosthetic Designer Processes the CT Data and Develops the Design









3D Printing of Models and Implant Components

Surgical Intervention

The stages of installation:

• Skin incision, access to the bone fragment, scalping (maximal skin preservation).

• Preparation of the bone fragment for the guide placement, after which a saw cut is made and the fragment is removed.

• Drilling the canal with drills of different diameters (it is important not to crack the bone). It may be necessary to prepare a seating area for the implant.

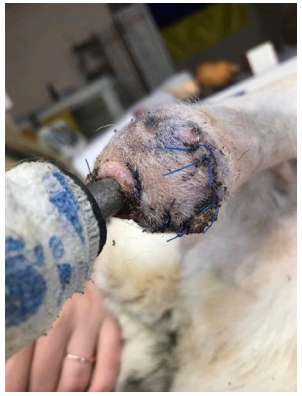
• The implant is inserted and screws are fastened.

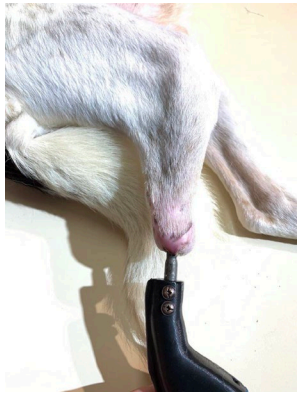
• Skin suturing follows.

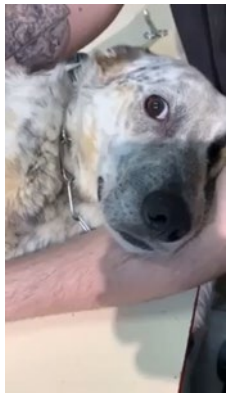
• Implantation can be performed in two stages.

Dr Kluban and His Surgical Team

Wound Healing



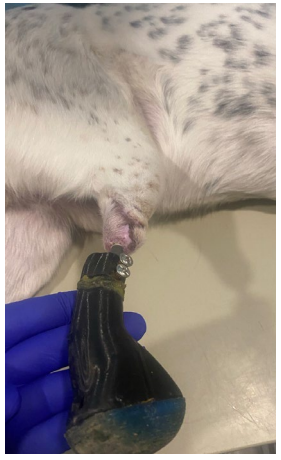


Videos of Postoperative Result


Complications We Encountered

Initially, the limb prosthetic would often break

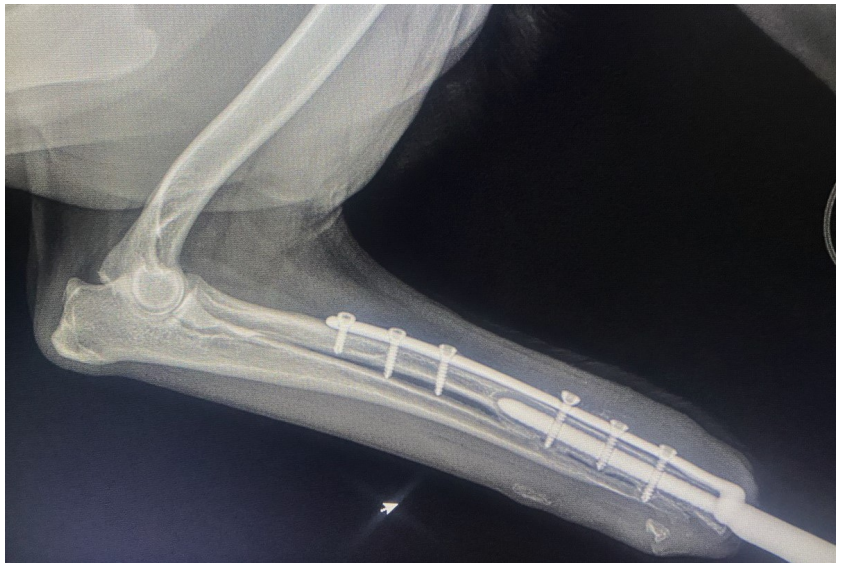
A new, more structurally rigid prosthetic, was developed by Kateryna

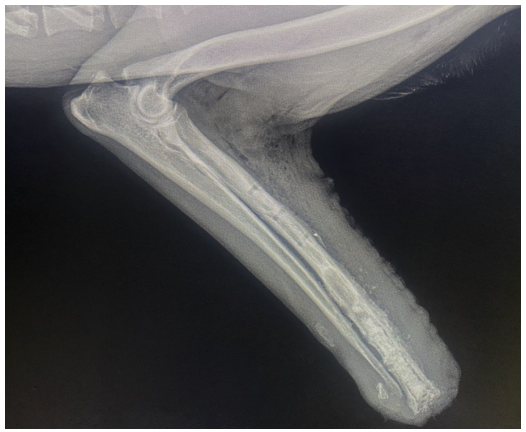


Complications We Encountered

After 1 year, we encountered implant loosening and infection on the forelimb.

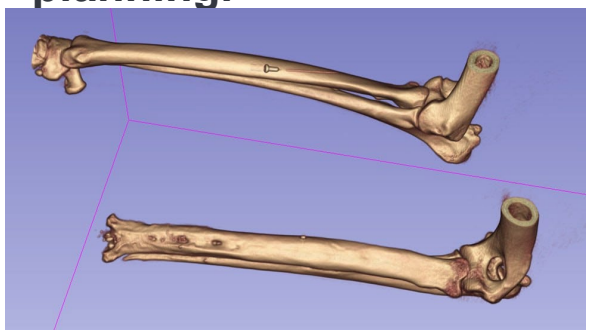
The solution was to remove the implant, wash the canal, and introduce bone chips.

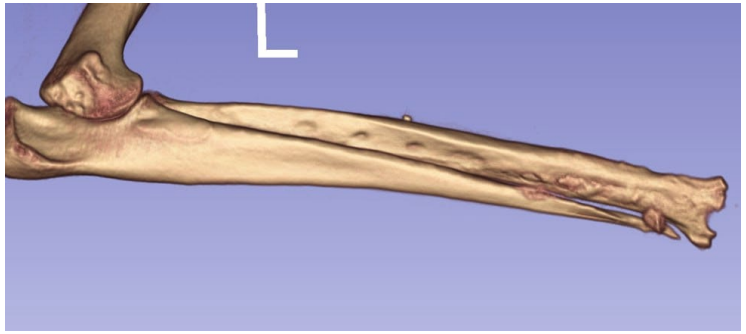


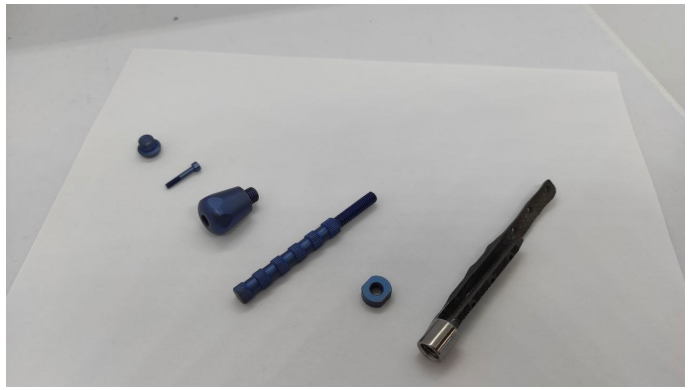


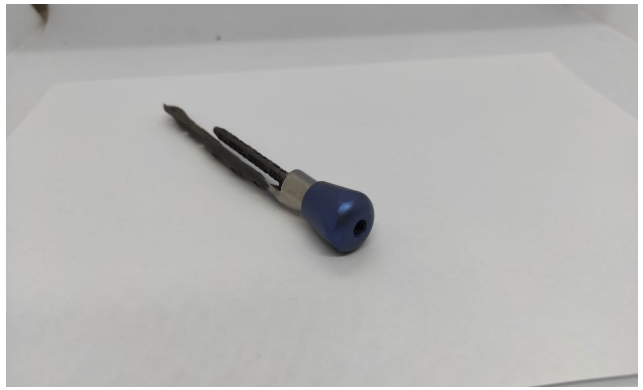
Complications We Encountered

It was decided that after healing, a new implant would be created and implanted under the skin, and only after osseointegration, the external structure would be connected. A CT scan was performed again before planning.

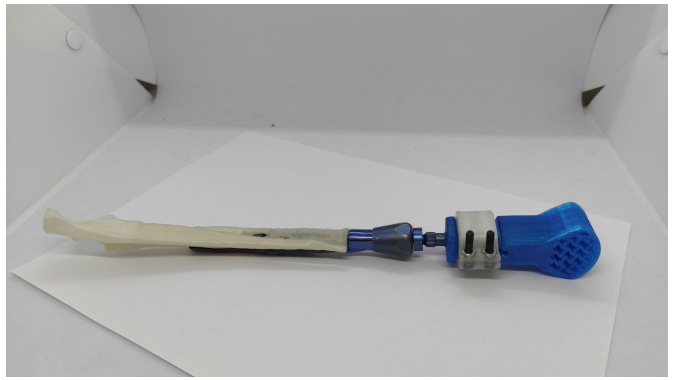


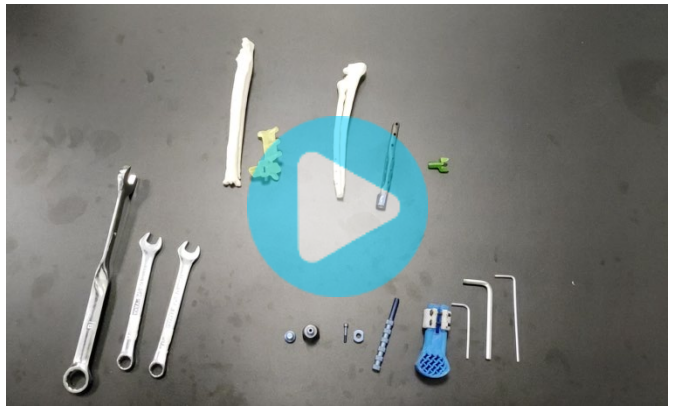






The development of an intramedullary two-stage implant was carried out.





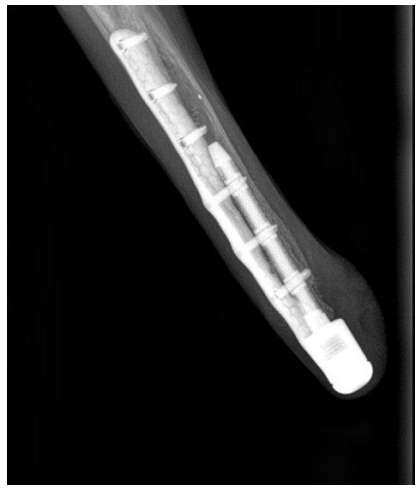
Complications We Encountered

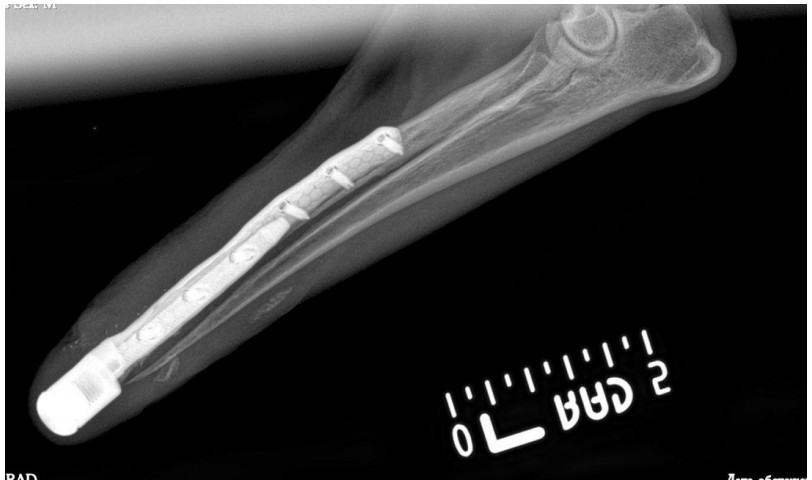
Afterwards, the surgical intervention was performed, and the implant was inserted under the skin for further osseointegration.

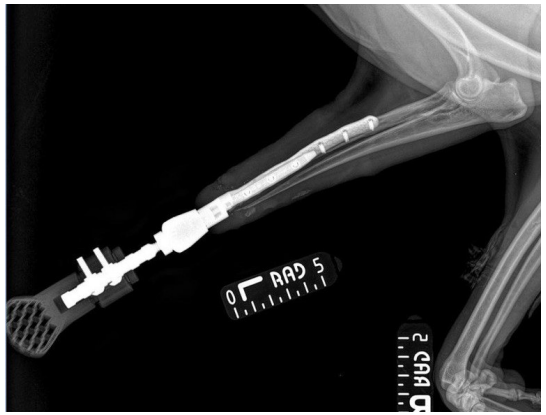
The Surgical Team Making It Happen

Osseointegration of the hind limb

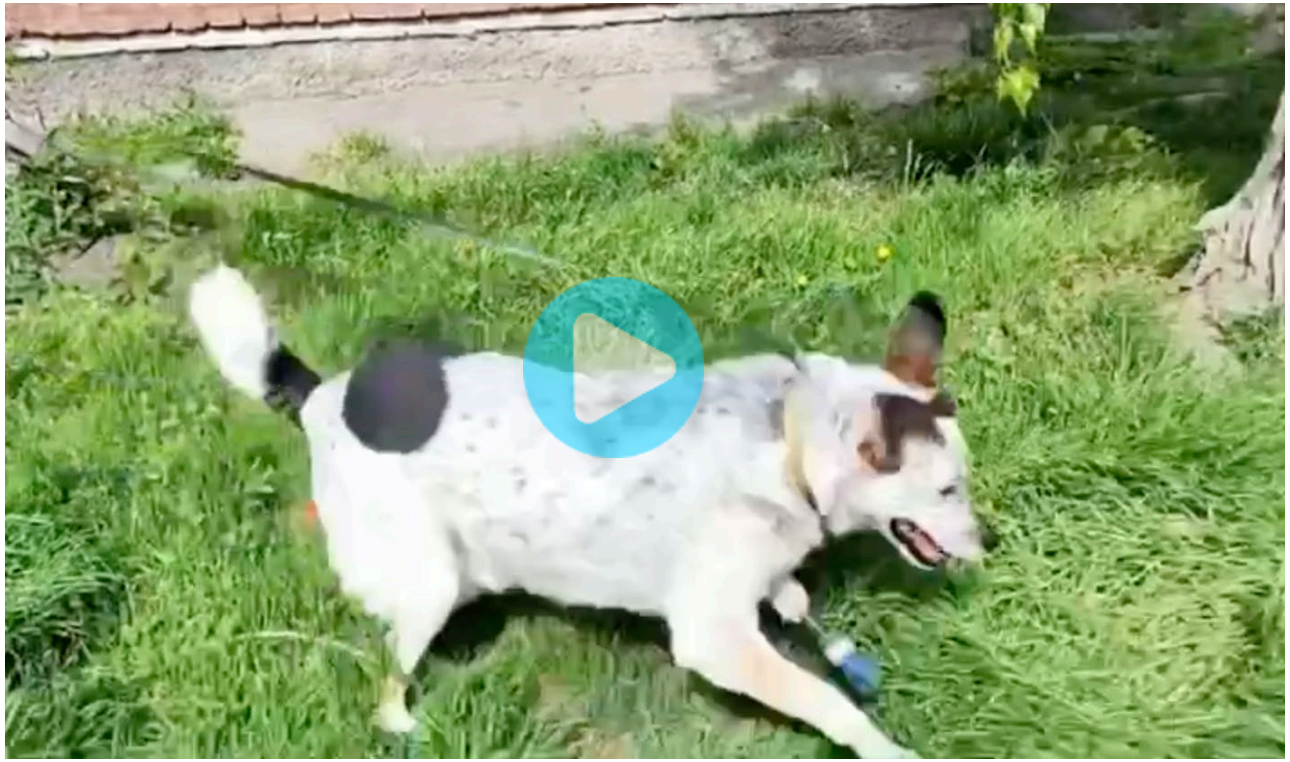
After 3 Months, the External Structure is Installed



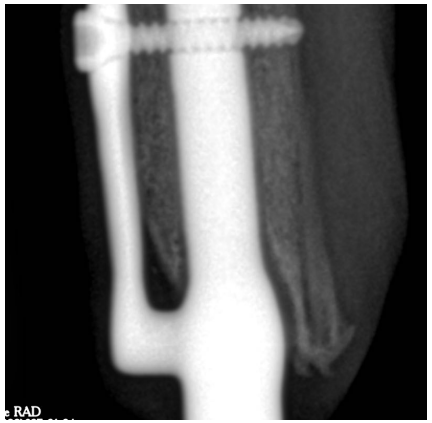


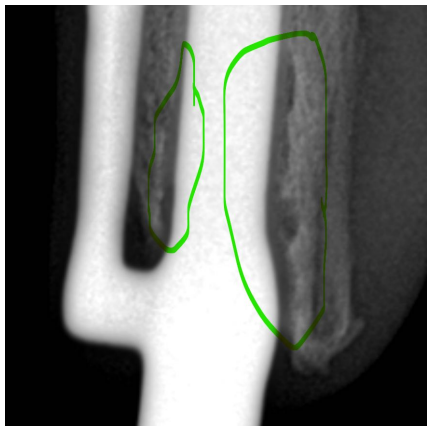


Videos of Final Results



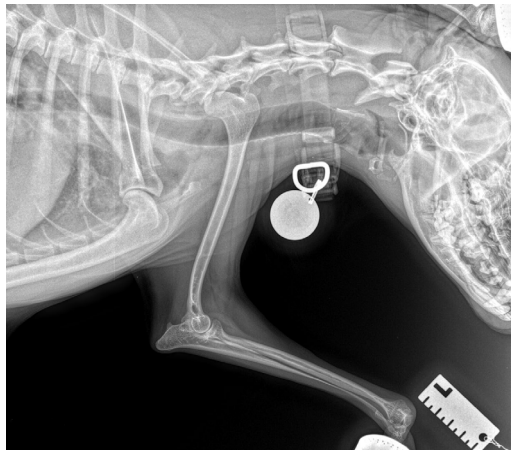
X-rays after 2.5 years

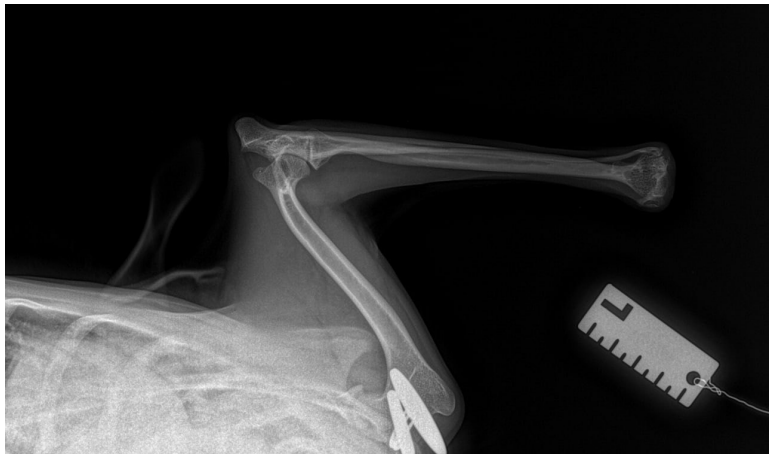


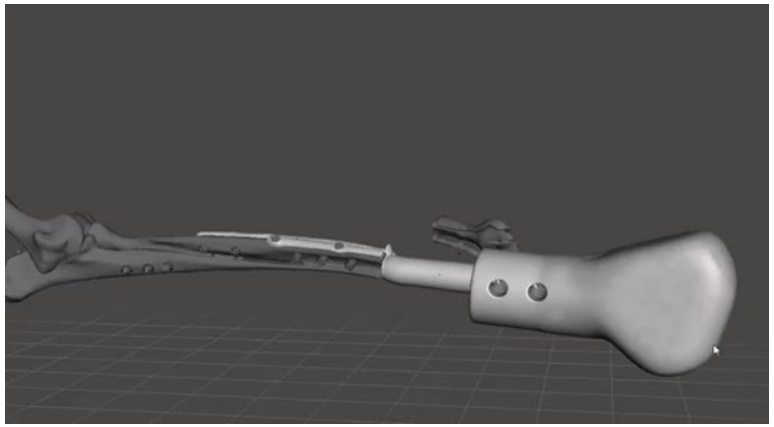


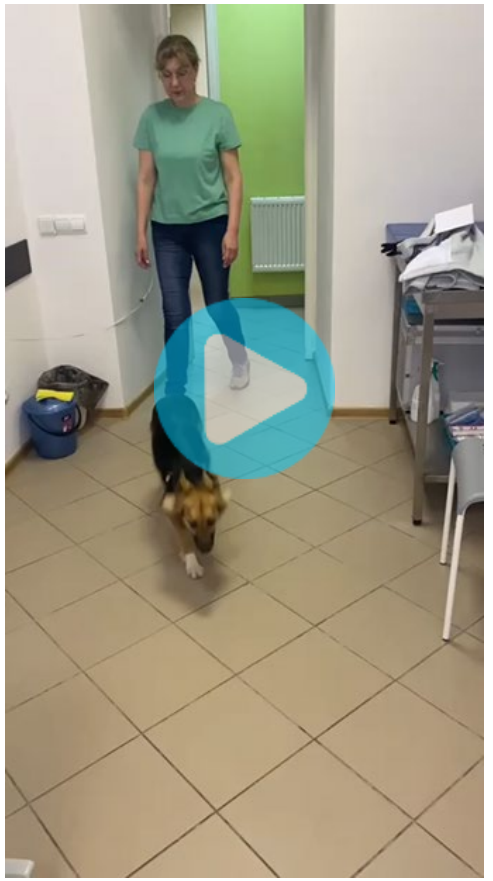
Case Study: Forelimb Prosthetics

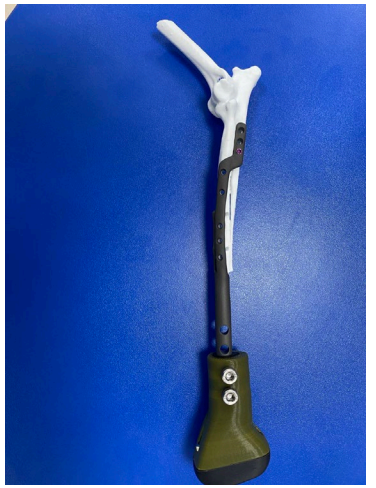
Mixed-breed dog Elia, 3 years old.

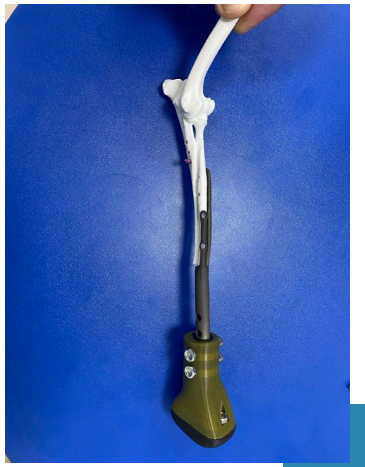




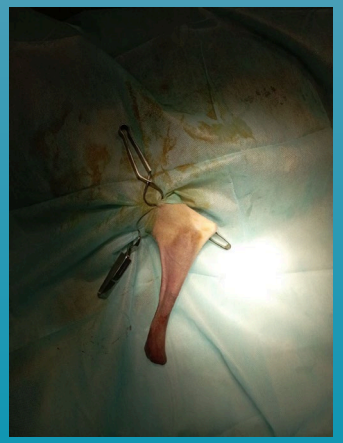






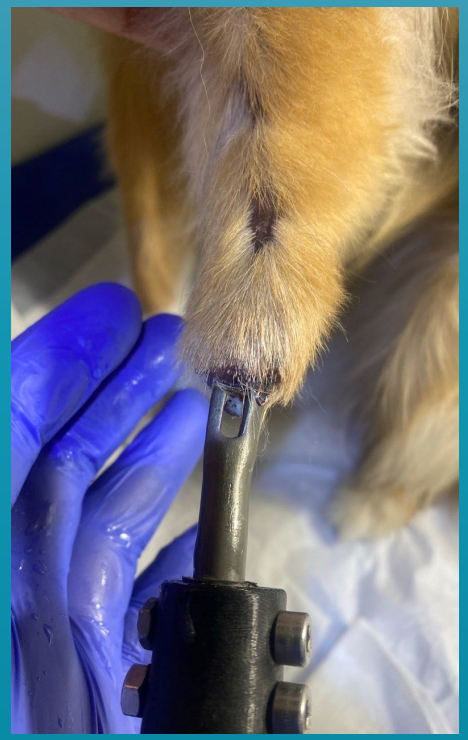


Surgical Implantation of the Prosthetic

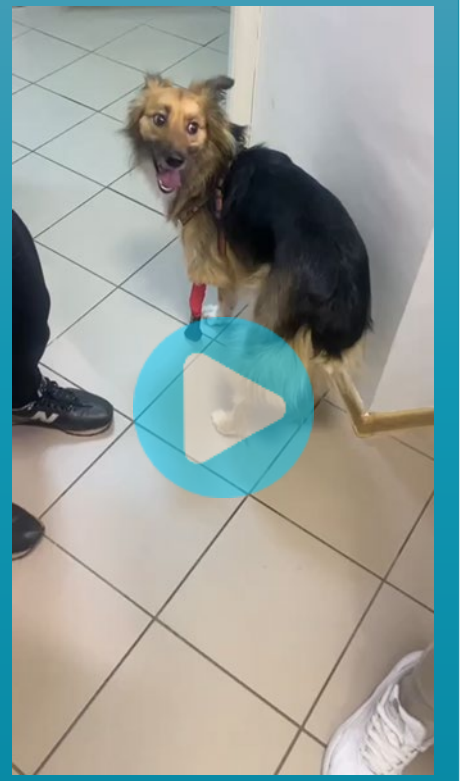


Post-Operative Follow-Up and Healing

The skin lifted, revealing partial bone lysis.

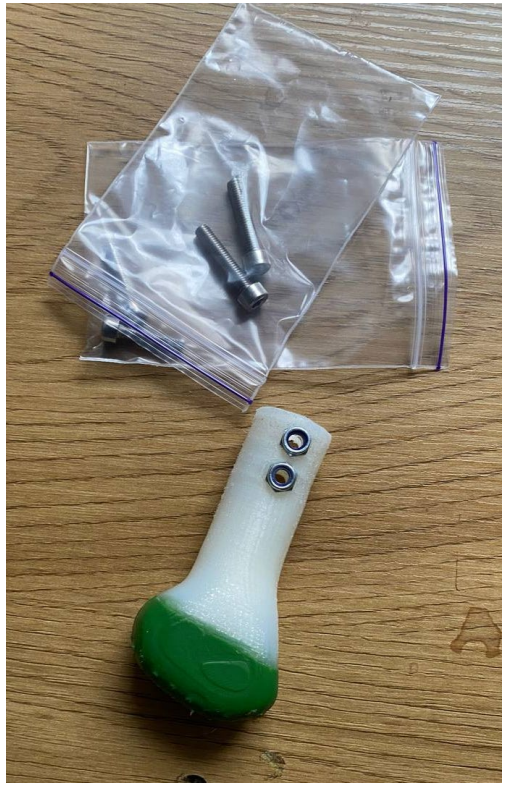


Healing process

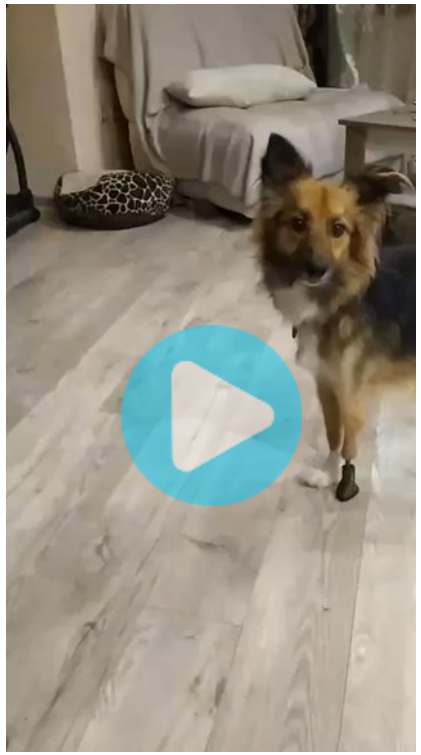


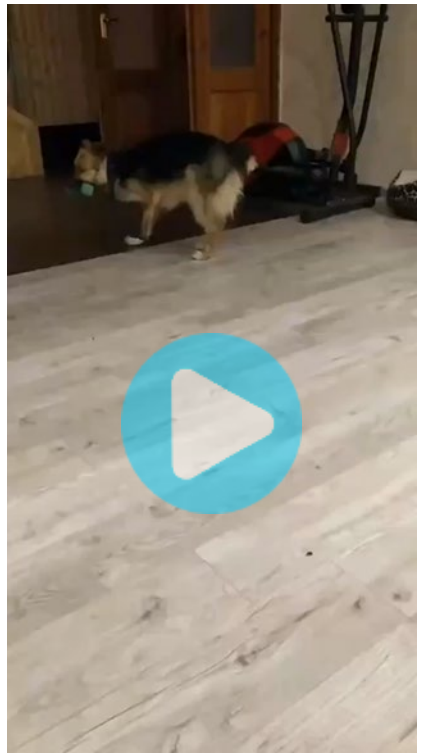
Limb Prosthetic Replacement

The “boot” was replaced due to excessive impact during walking.



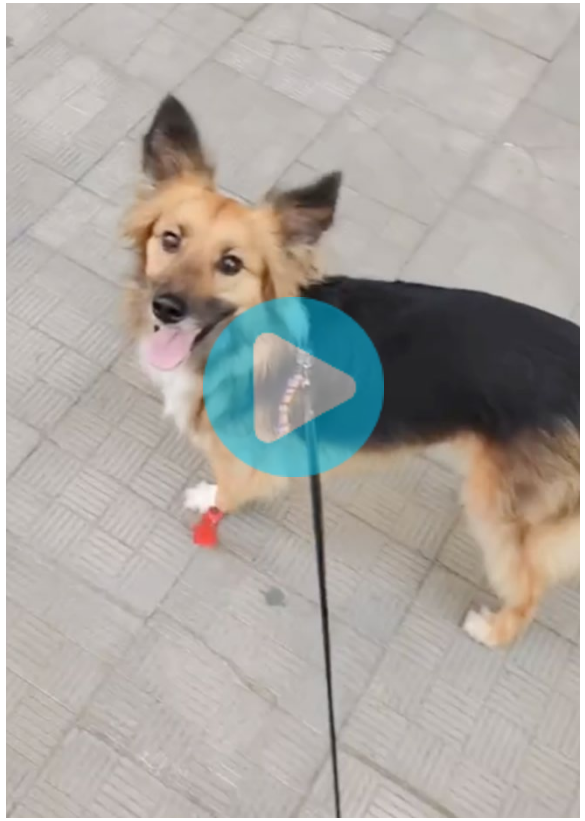
Videos of the dog before the boot replacement



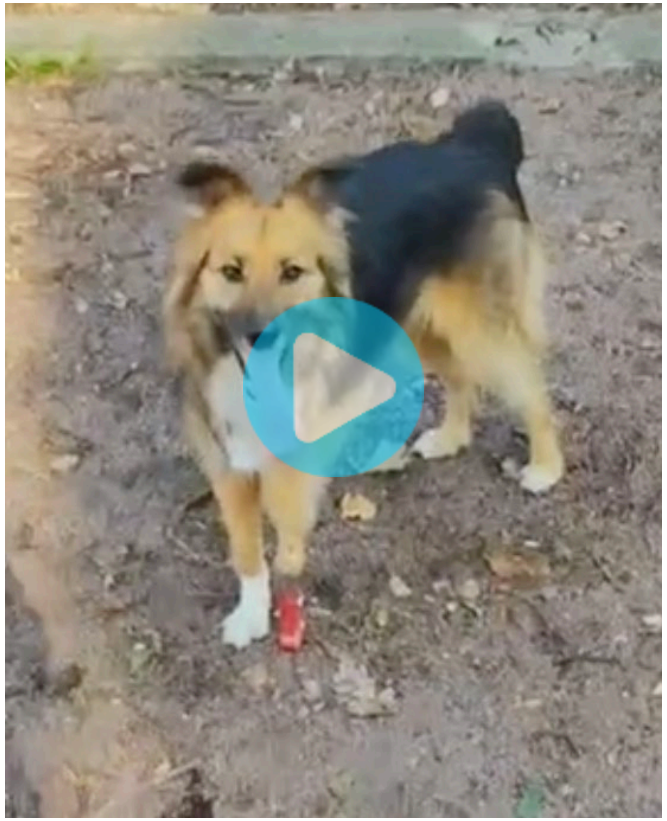


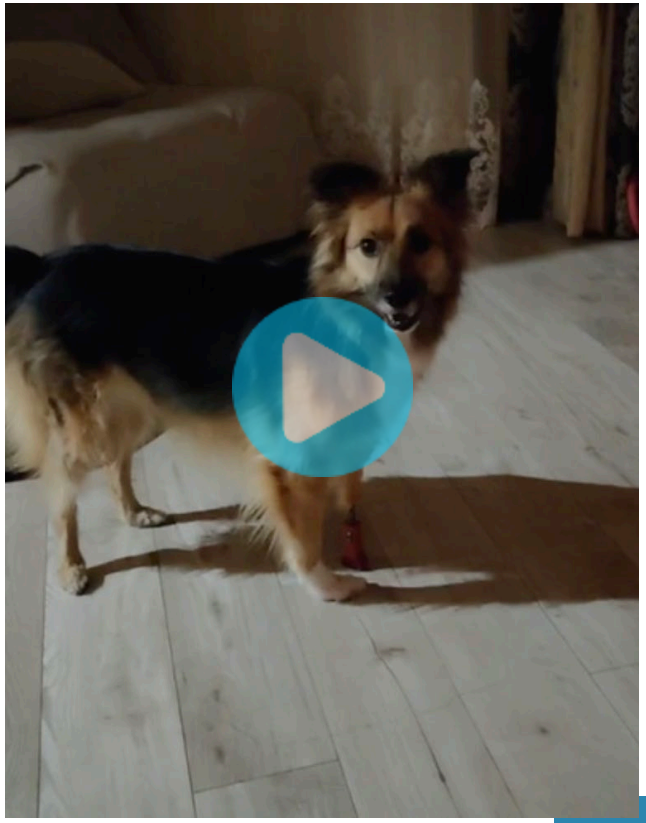
Final Results: A Success Story

This is after the final boot replacement.

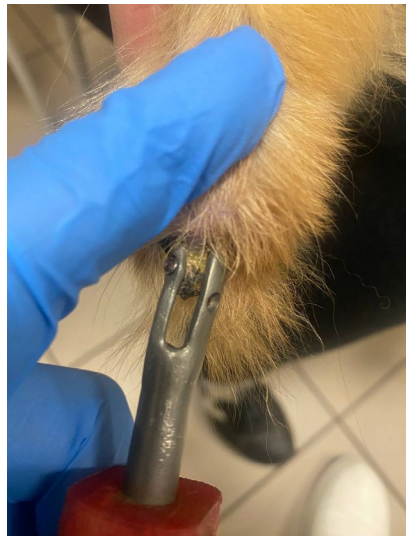


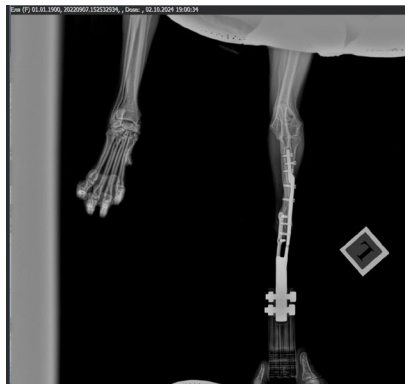
This is how the dog walks now





Current Condition

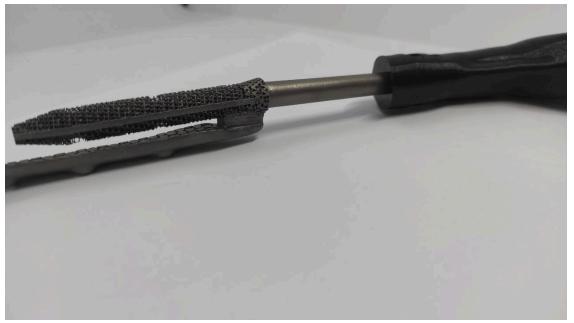




Case Study: Prosthetic Installation for a 56 kg Patient

Black Terrier Tor, 2 years old

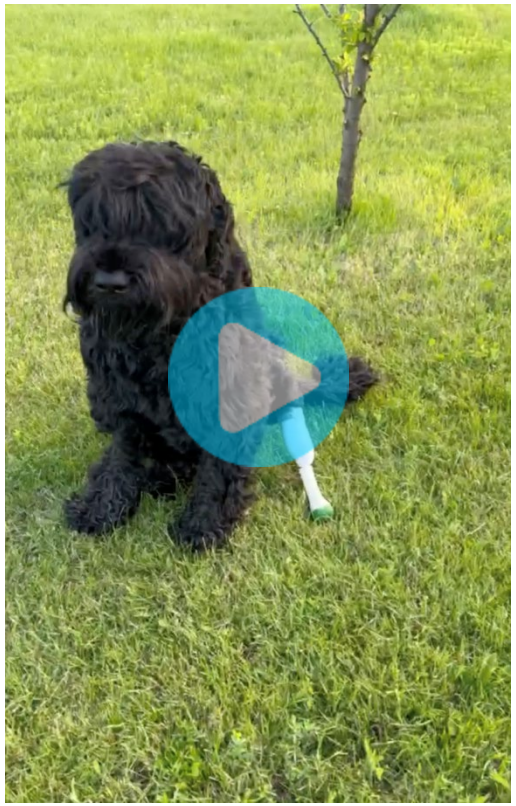
The dog was caught in a cluster bomb attack.

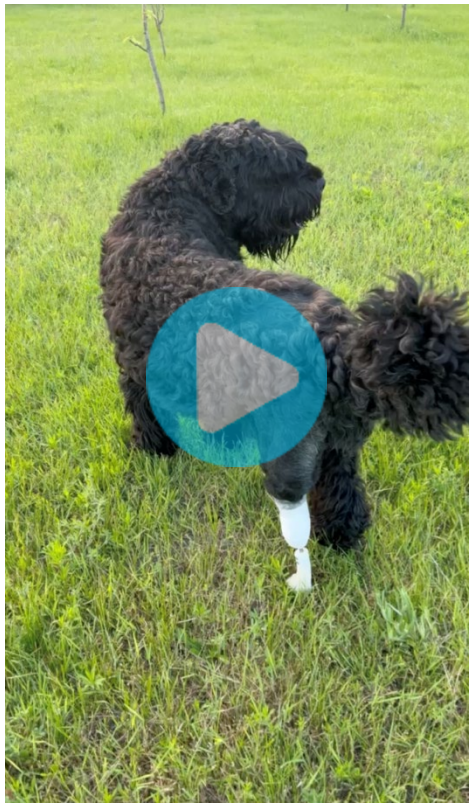


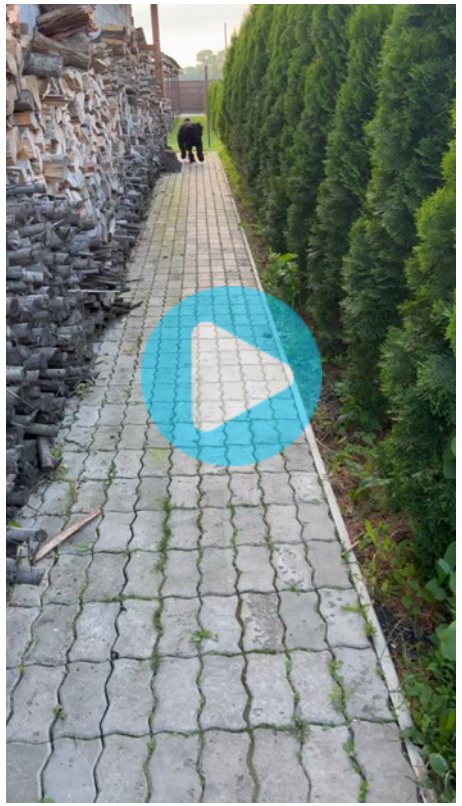
Control X-rays

The Surgical Team at Work

Rehabilitation

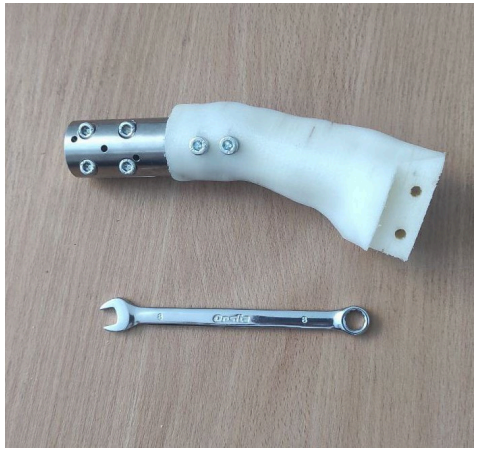


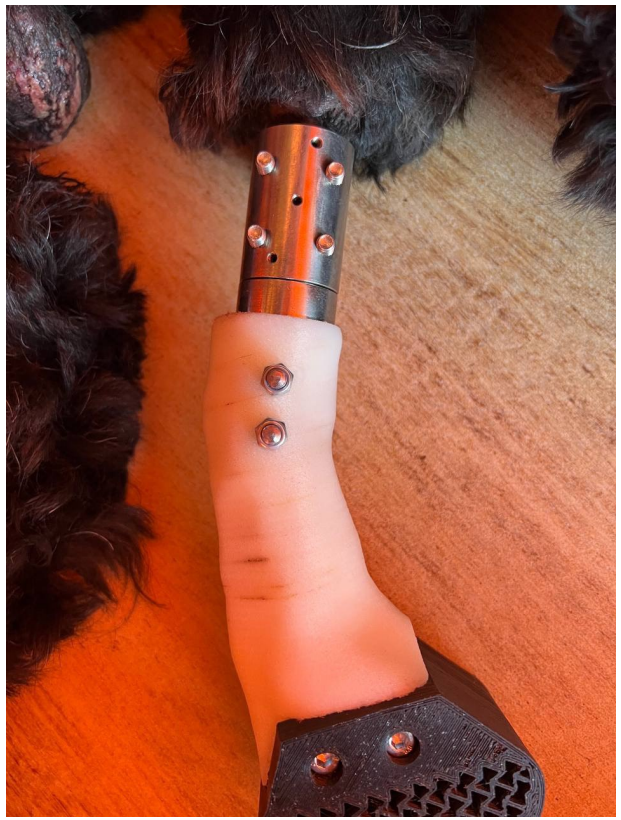




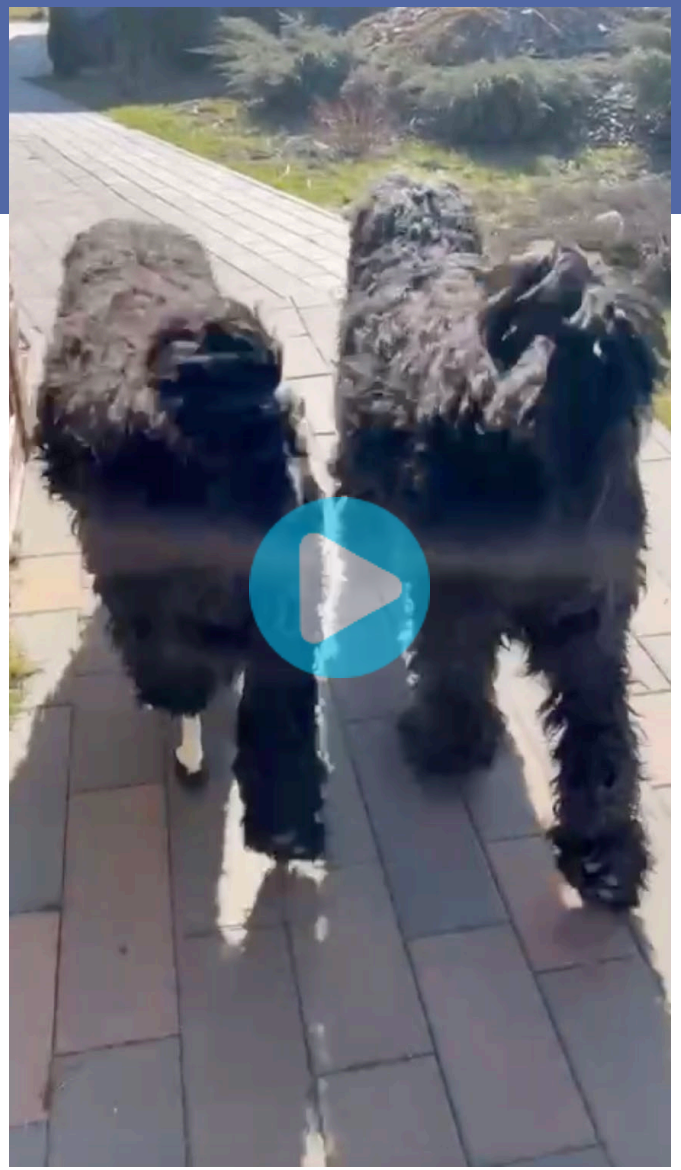
Complications We Encountered

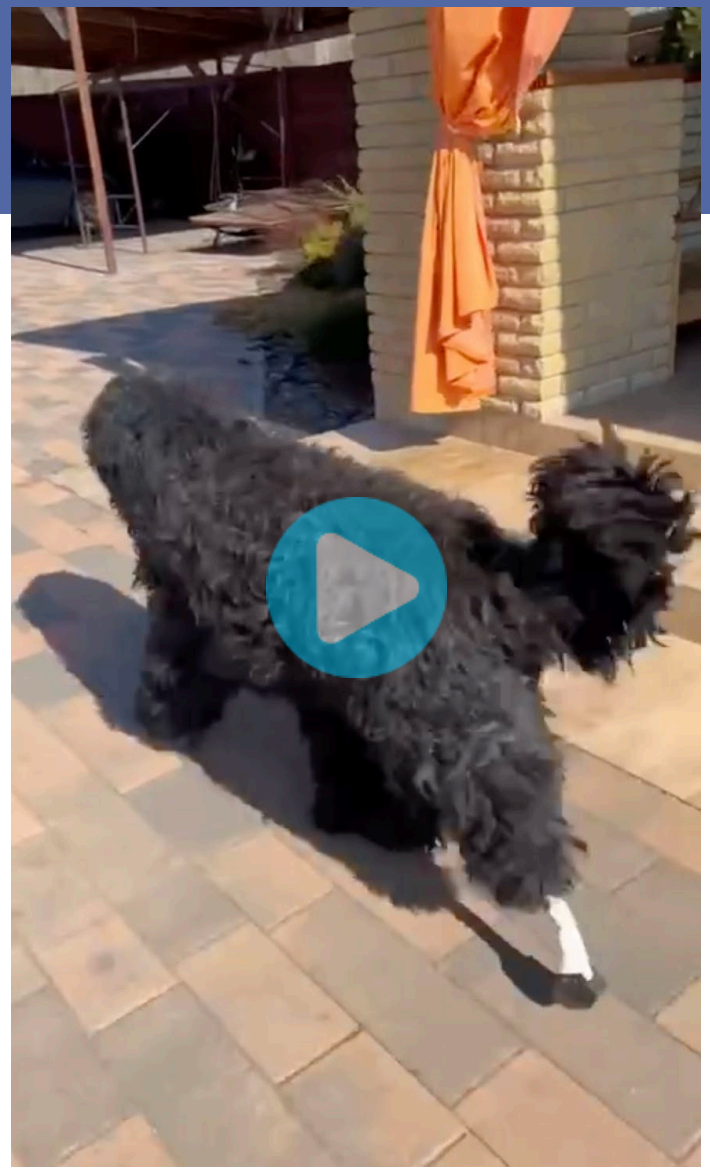
After 4 months, the central pin broke.



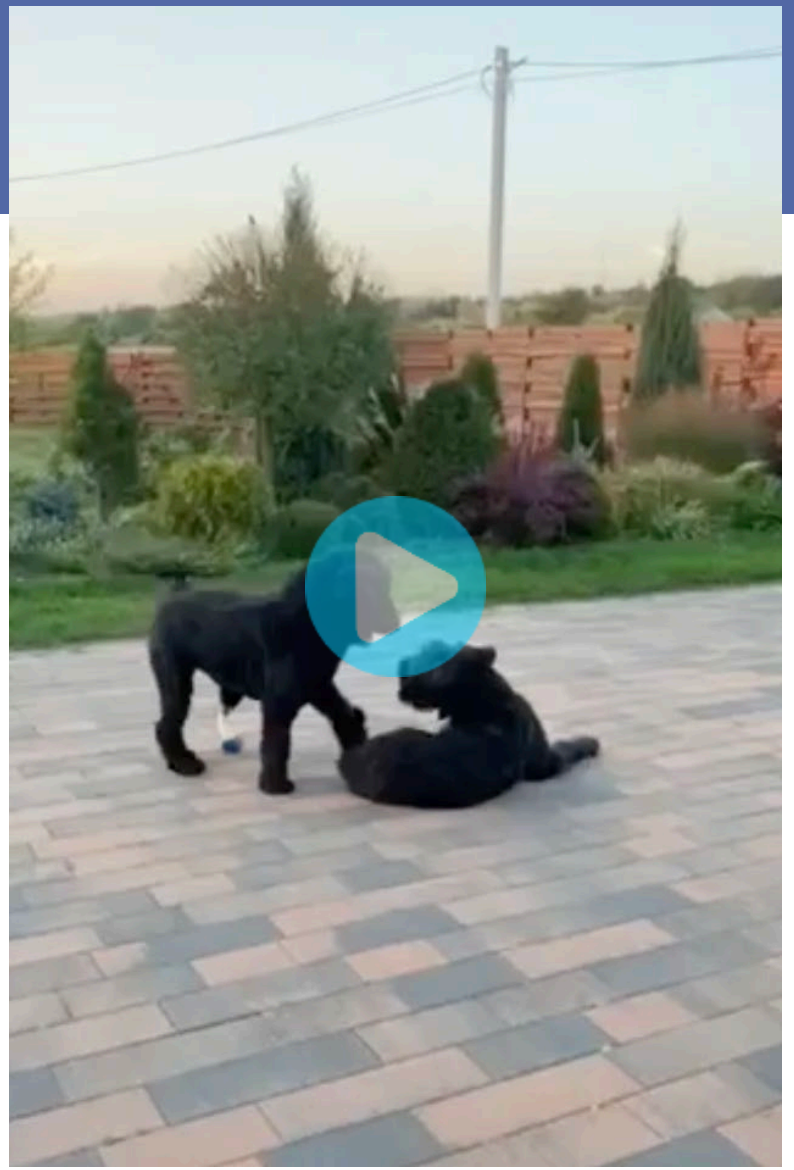


Dog’s Condition after 1 year





Dog’s Condition after 1.5 years

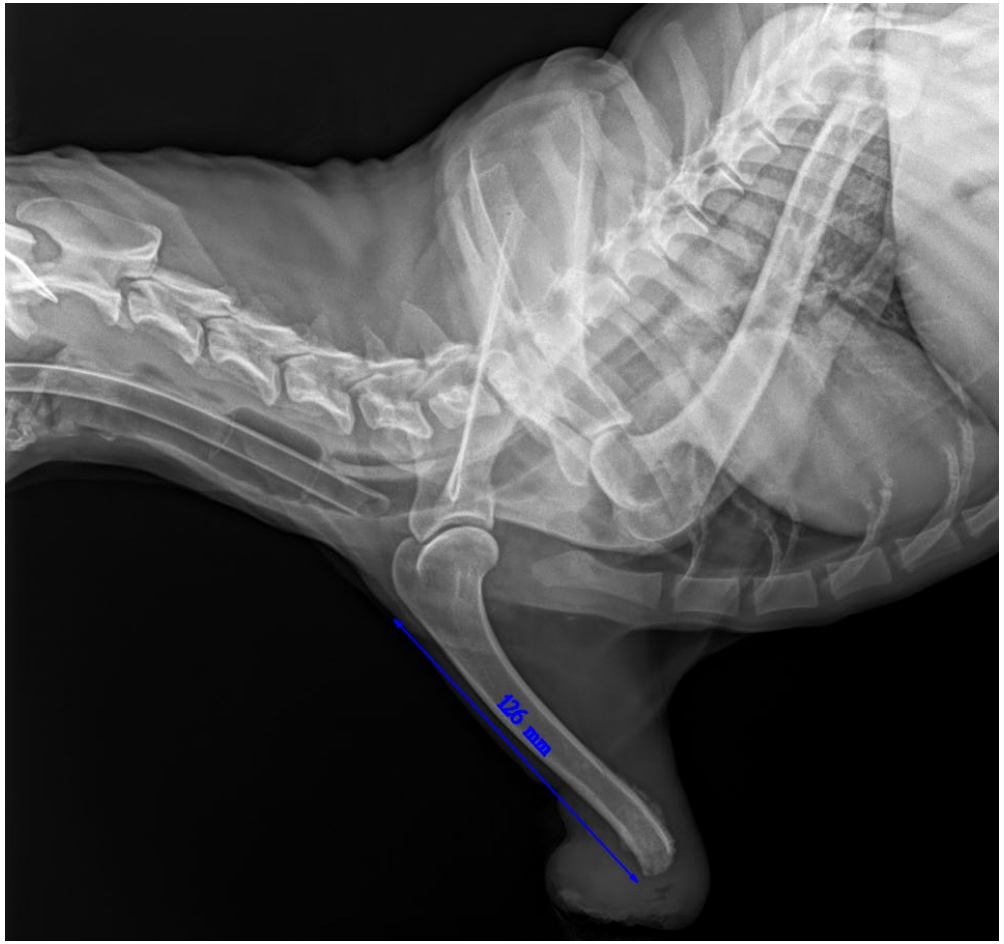


Case Study: Prosthetic Limb Installation for Forelimb Absence

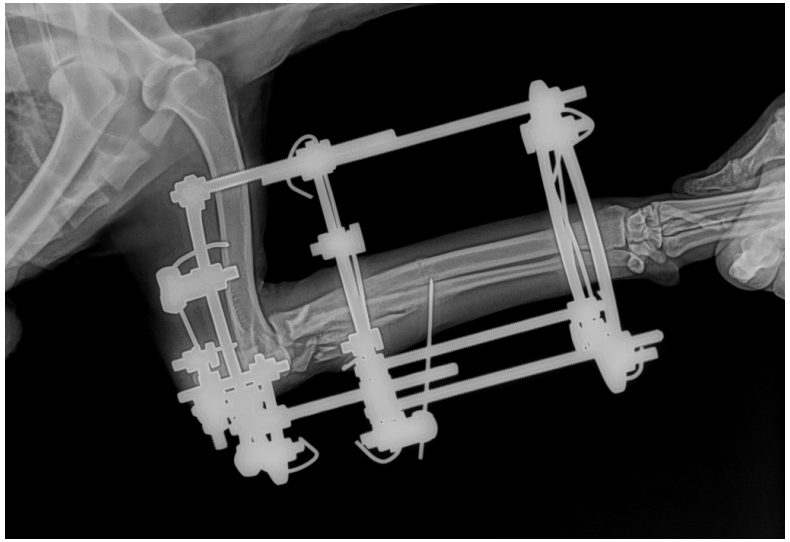
Patient: mixed-breed dog, 2 years old.

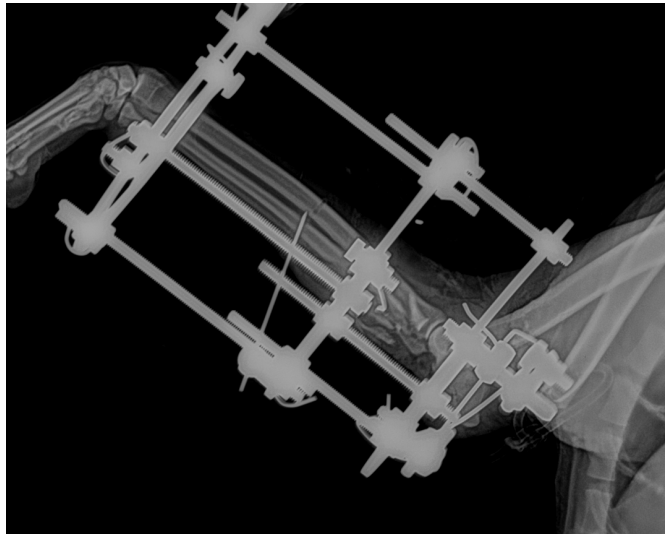
The dog was caught in an artillery attack.

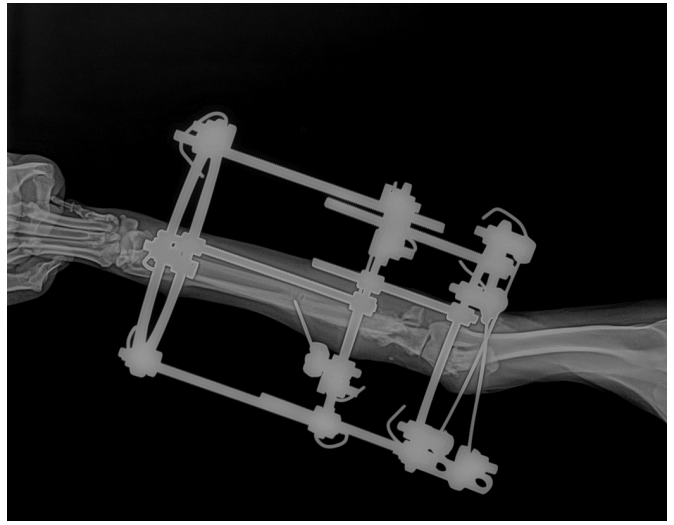
First Stage: Amputation and Surgical Treatment

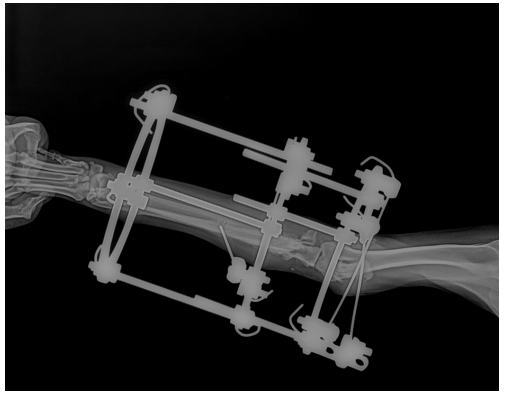


Temporary Stabilization with Ilizarov Apparatus

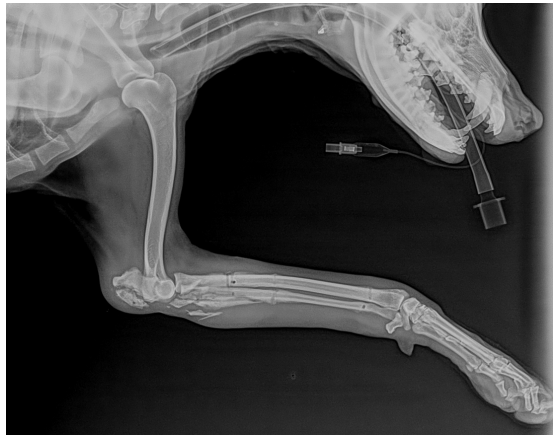


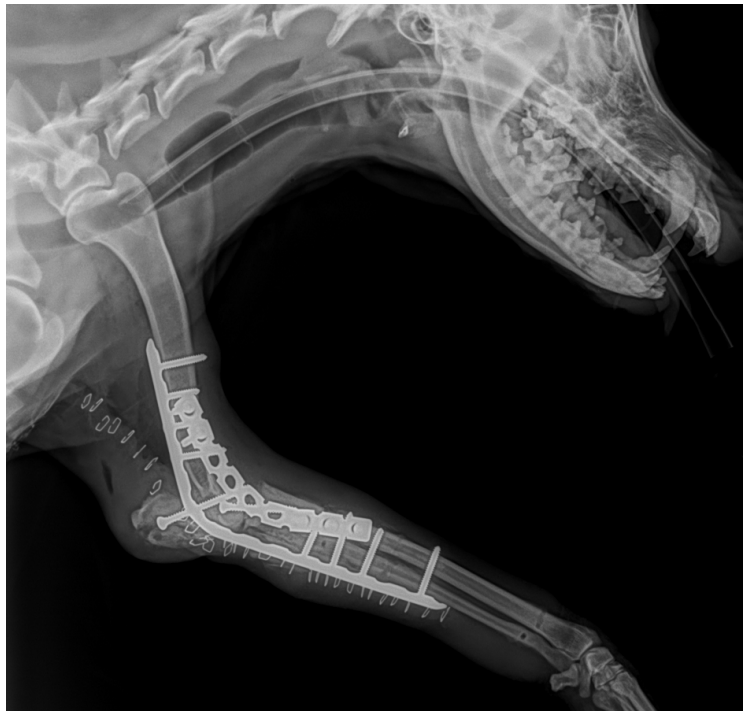


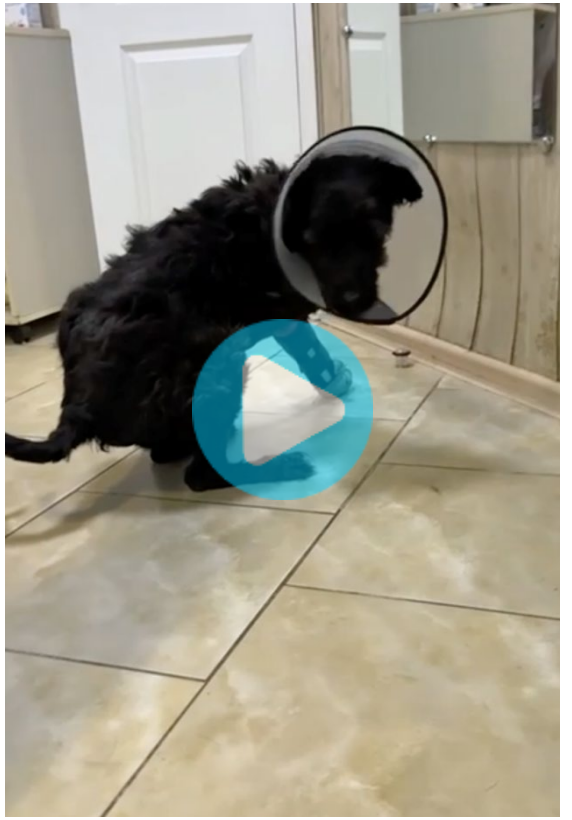




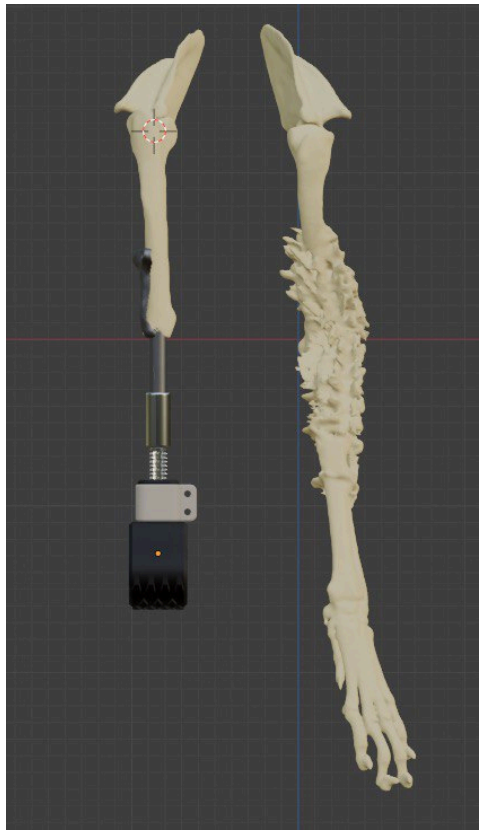
After Healing, Arthrodesis was Performed





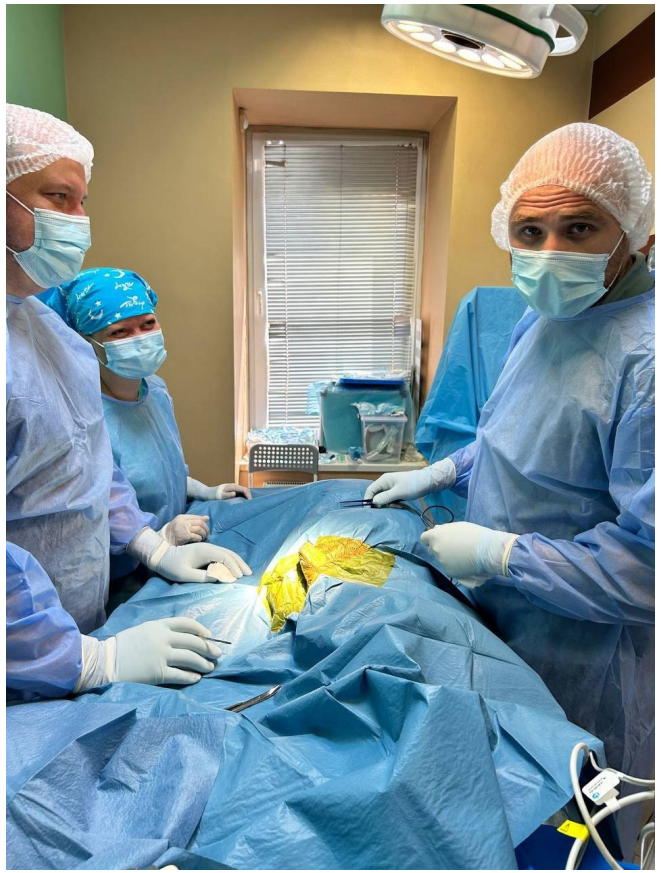


Planning and Developing the Prosthetic

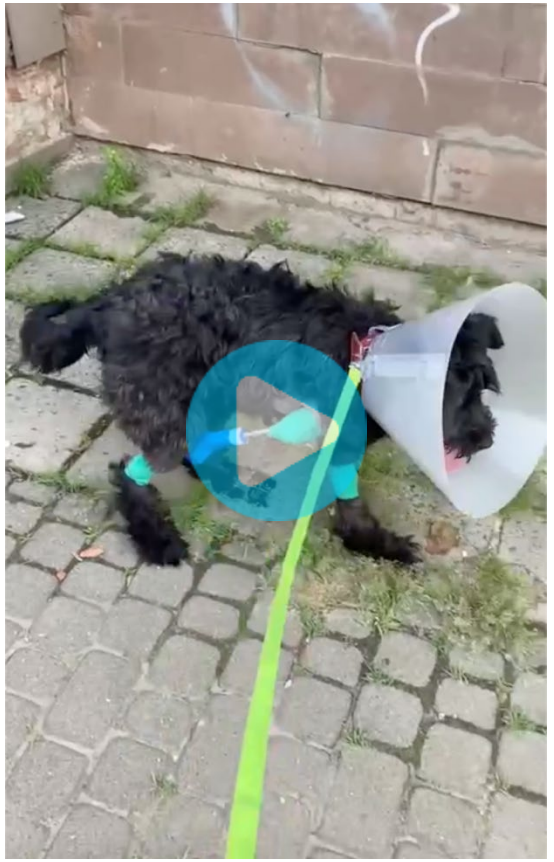


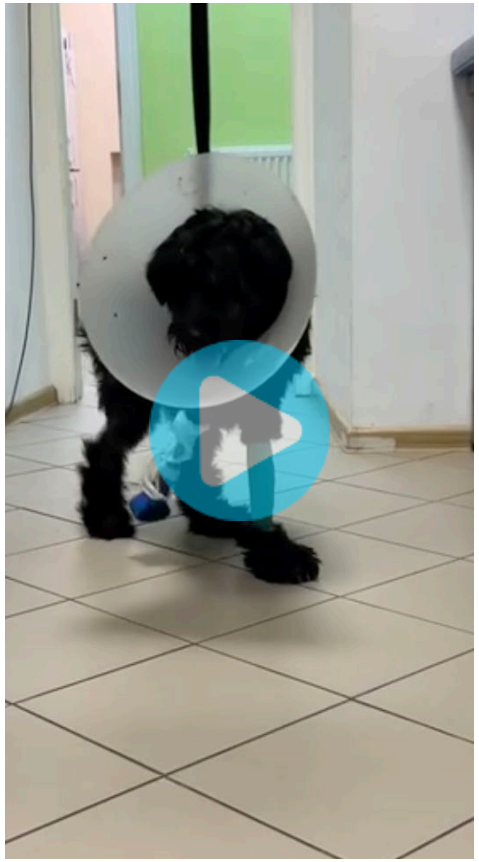
Developed by our Prosthetic Designer, Kateryna

Implant Installation

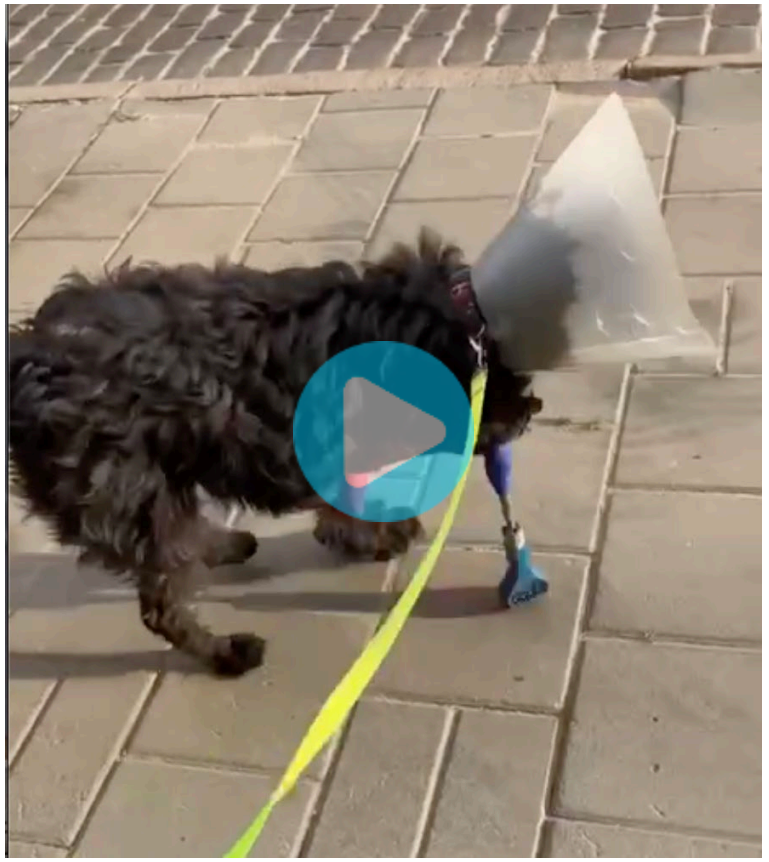


First Steps





Appearance of the Stump after 3 Months



Thank You for Your Attention!

Coordinated by Dr Vitalii Kluban