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Novel Approach to Teach Veterinary Orthopedic Surgery in Dogs

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Abstract

As a delicate discipline, orthopedic surgery requires a mastery of the Topographic anatomy in order to get a quick access to the bone structure with the least risk and non-altering the vascular and nerve structures. Actually, 3D modeling offers a good representation of anatomical structures with a perfect transparency. The animal's organs can be reconstructed in 3D anatomical forms from the anatomical 2D charts, or rebuilt from radiological imaging with Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and ultrasound 3D.

This study is interested with the training of the orthopedic surgery. In addition, the synthesis of 3D models allows creating an interactive system between learners and the computer ensured by an intermediary device which is in our case the mouse as an input device controller.

This article can be considered as a contribution to the simulation of the orthopedic surgery in dogs by showing a 3D reconstruction of the osteosynthesis of the long bones with two methods; the intramedullary pining and the ordinary screwed plate as realized in our reel experiment.

Certainly, because of the very significant similarities between simulation and clinical scenario of the orthopedic surgery, the used software can be recommended as an alternative tool for surgery teaching, especially in the developing countries wherein the deficiency of learning resources. Moreover, it is important to ensure the animal's welfare and useful to minimize the rate of the euthanized animals after surgery training.

Keywords: Orthopedic surgery; Blender 3D; Intramedullary pining; Simulation

Introduction

Surgical simulation in veterinary medicine offers a space for learning and training of the orthopedic surgery and gives an access to the basic surgery techniques in a simple and fast method. In addition, this simulation removes the risk and gives learners the chance to adlibitum practices [1].

Actually, the development of a surgical simulator by integrating a simulation model in 3D environment in the real time is a technique of a virtual reality and a geometric modeling that provides a virtual prototyping of surgical tools; the design of implants (the screw plate, the Steinmann pin) and surgical site design.

In the simulation of the surgical synthesis of Intramedullary Pining (IMP) and Ordinary Plate Screwed (OP) in to the femur of the dog, using 3D computer graphics offers an opportunity to define the basic principles of the orthopedic surgery.

In the educational purposes and in order to test the various osteosynthesis, the use of simulation models of osteosynthesis in the operation planned before performing the actual surgery has allowed, us to get a better planning with a minimal invasive, obtain an optimal correction and bring a new look on bone surgery training, especially in the delicate surgical maneuvers [2].

Review of simulation projects in veterinary and human medicine

Simulating an interactive virtual environment for training takes a very important place in any field such as automobile simulator, flight simulator, etc. For example, in the medical field, surgical simulation knew a great progression following the development of laparoscopic and robotic surgery like the surgical simulator with Haptic Feedback (Figure 1) [1].

Moreover , this technology begins to emerge in the veterinary medicine such as the use of haptic cow for palpating the cow's uterus and being directed to feel for increased softness associated with pregnancy [3], (Figure 2), also the creation of Robot of animal like Robo-pets for dogs clinical simulation [4] (Figure 3).

Simulation of orthopedic surgery

Actually, the training in the orthopedic surgery is done either directly on the living animals and cadavers, or with simulation methods using synthetic fractured bones or computer-assisted simulation. For the simulation in the first method, students must fix the fractures on fractured synthetic bone (Figure 4) by using surgical tools and implants (typical fracture plastic bones are presented). These synthetic bones differ in quality and cost, good synthetic bones quality is not simple plastic mannequins, they are made from materials of different densities and textures on the inside surface and to simulate the real bone as closely as possible. Normally, students work with the bone placed in front of them, in the typical position of the respective actual operation. They reduce the fracture and secure inside using implants selected from hundreds of plates, screws, nails and son. For the insertion of implants, students use various surgical instruments to drill holes, measure length, and insert the implants [2].

The second method uses the graphics computer to create a 3D virtual environment and simulate the real technical gestures of surgery. For that, the object of this study is to add a contribution to the basic design of surgical simulation and modeling of the surgical scene.

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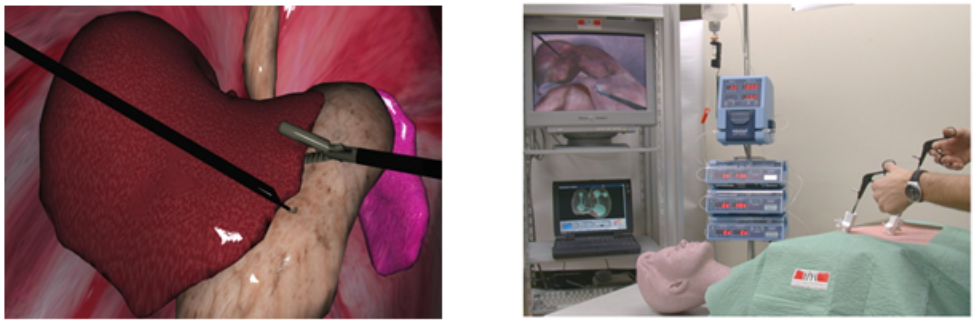

Figure 1: Surgical simulator with haptic feedback (Robotic Systems Laboratory LSRO).

Figure 2: The haptic cow, Royal Veterinary College's (RVC).

Figure 3: Robo-pets (simulation vet care center at Cornell University).

Figure 4: Fractured synthetic bone (*Sawbones® veterinary products)*.

The Assisted Orthopedic Surgery by Computer Using 3D Modeling Software

Material and methods

Blender 3D: For 3D design, we have used Blender 3D, is free software for modeling, animation and rendering in 3D. It has advanced features for modeling, 3D sculpture, UV unwrapping, texturing, rigging of armature, 3D animation and rendering. It also manages the non-linear video editing, composition, nodal creating materials, creating interactive 3D applications and various physical simulations such as

particles, rigid bodies, soft bodies (Figure 5) and fluids. As it is available in many languages, Blender is also available on multiple platforms such as Microsoft Windows, Mac OS X, GNU/Linux. In addition, this program is an extensible (adding scripts) using the Python language [5].

This software has proven its effectiveness in the medical field; this capability has given very satisfactory results in graphics quality anatomical models. It was found that the software is applicable in two recent studies; the first is in teaching ocular ultrasound [6], and the second is in the simulation of cardiac surgery [7]. Therefore, Blender can be used as a powerful tool in the development of medical simulators.

Reconstruction of Intramedulary Pinning (IMP) and Ordinary Bone Plate (OBP): The graphics capability of the computer is used to reconstruct the clinical scenario by 3D free software (Blender 3D), by the creation of animal body and anatomical shapes like the bone (Figures 6 and 7), muscle, joints…, and implants: screw, plate and Steinmann pin (Figure 8).

To have a 3D model with perfect resemblance, it must rebuild from the results of Computed Tomography (CT), and the results obtained in DICOM files will be converted to 3D objects.

Figure 5: Collision detection and object deformation in *Blender 3D*.

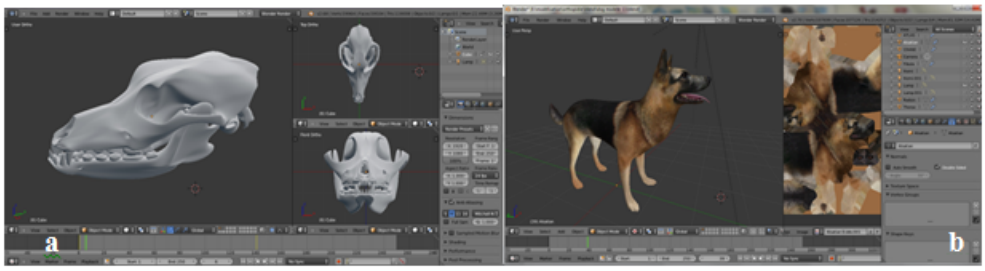

Figure 6: a) modeling of the skull of the dog, b) textured dog model.

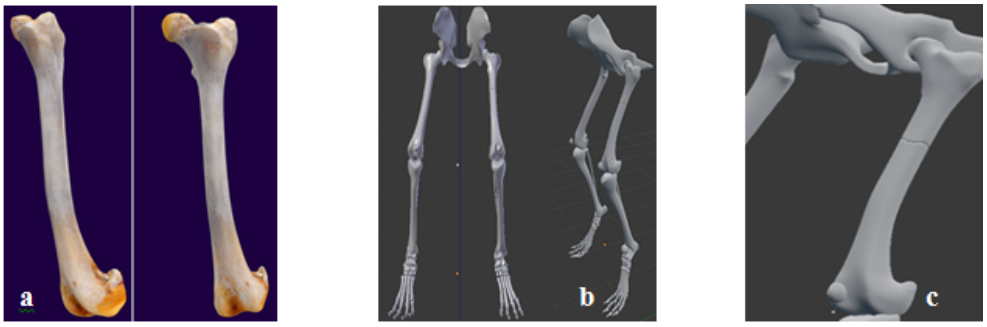

Figure 7: a) Modeling realistic femur bone of dog rendered with real texture b) modeling skeletal posterior limbs in the dog, c) simulation of the femoral bone fracture.

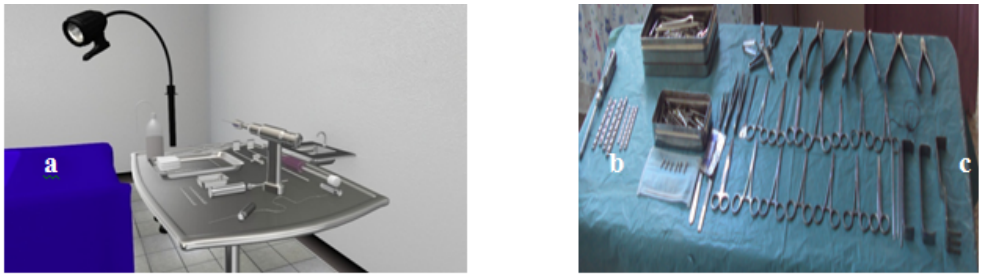

Figure 8: Prototyping and rendering of surgical equipment.

Results and Discussion

After the reproduction of two types of osteosynthesis, the results showed that Blender 3D gives very significant similarities between simulation and clinical scenario [7].The simulation was done step by step following the clinical course of the practice of osteosynthesis [8] (Figures 9 and 10). For the being time, the simulation results are presented in the form of video recording and image rendering, resulted from the passage of OpenGL to pixel mode. However, there is always the possibility of the integration of device for manipulation in real time like Haptic Feedback.

Possible hardware integration

The creation of 3D scenes in Blender 3D is a real contribution to the realization of interactive orthopedic surgery software. Obviously, there is a significant similarity between pictures of simulation and realistic photos.

In our case, the mouse and the key board are the input control devices, in addition other devices can be used like cyber glove or Haptic Feedback; interaction with the haptic requires the intervention of another software H3D [7] which is an open source haptic graphic API based on X3D. So, after the export of X3D scene in H3D with

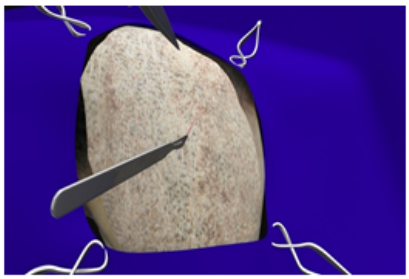
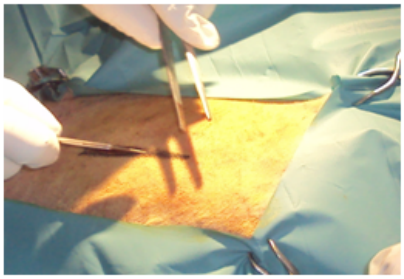

Figure 9A: The skin incision.

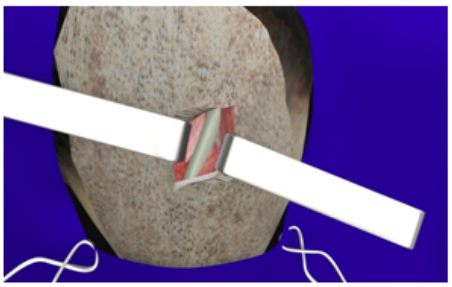
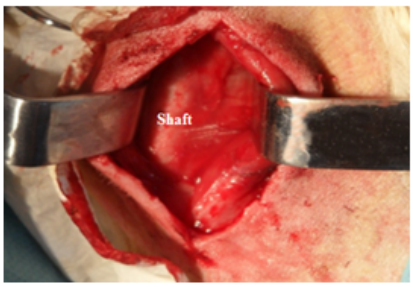

Figure 9B: Exploration of the femoral shaft in dog.

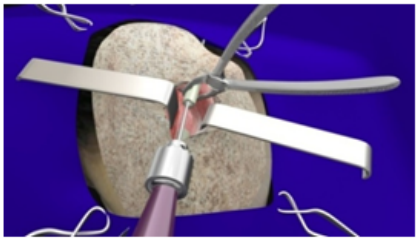


Figure 9C: insertion of Steinmann pin into the medullary canal.

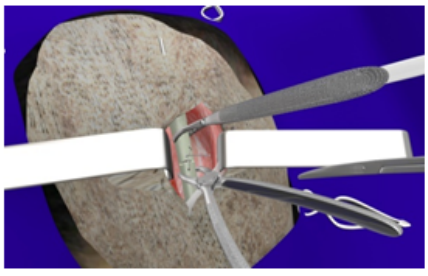
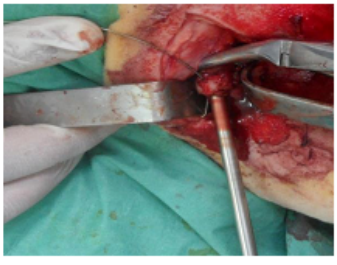

Figure 9D: Perforation by the drill and attachment by wire.

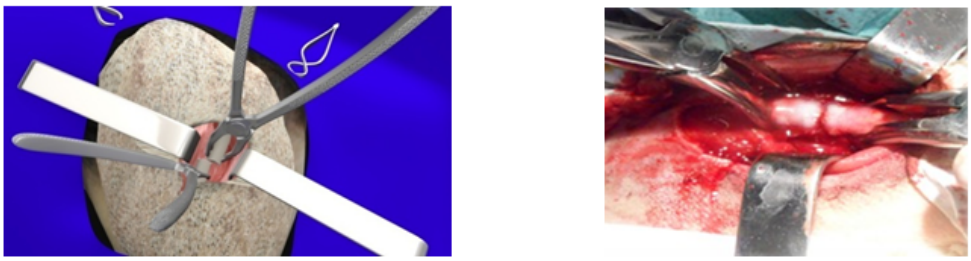

Figure 10A: femur fracture reduced by bone's reduction forceps.

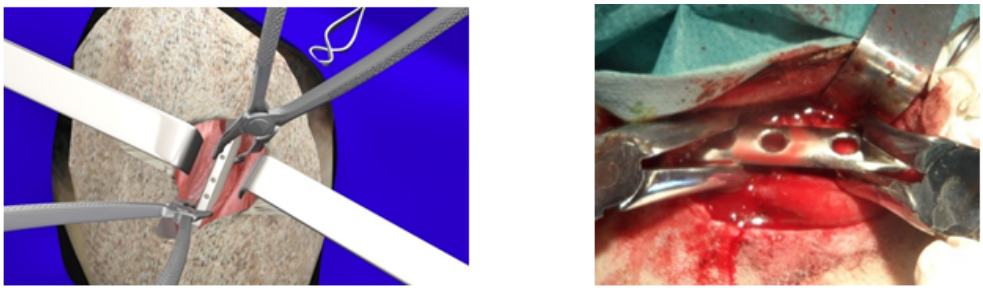

Figure 10B: insertion of the plate.

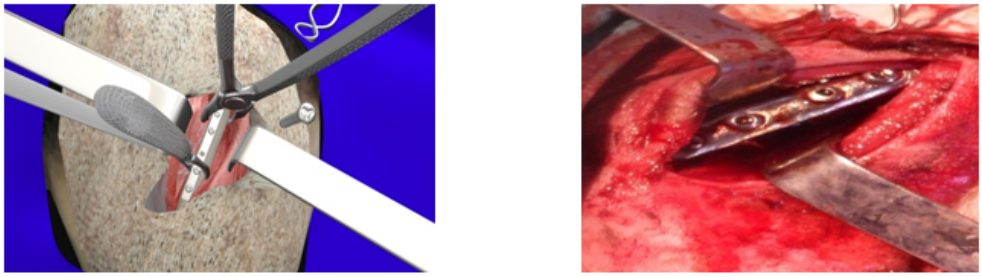

Figure 10C: attaching of plate to bone.

Blender exporter, H3D API gives collision detection between the material of the surgery and the organs of the animal which takes place in real time.

Conclusion

As a conclusion, certainly, the use of simulation models is very effective in the interactive learning orthopedic surgery system. The development of these models by integrating the appropriate equipment will allow us to develop a drawing tool ties in favor of teaching orthopedic surgery.

It is important for us to further develop this technology for an ethical alternative purpose that preserves and protects the living animal. Moreover this system gives an opportunity to master the skills that allow the veterinarian to enter the professional environment although the use of live animals for research still necessary in some cases.

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