UNIVERSITAT DE BARCELONA

LSNA

Virtual 3D Model of the Lumbar Spine

Alberto Prats-Galino[1], Miguel Angel Reina[2], Marija Mavar Haramija[1], Anna Puigdellivol-Sánchez[1], Joan San Molina[3] and José Antonio De Andrés[4].

[1] Laboratory of Surgical NeuroAnatomy (LSNA), Human Anatomy and Embryology Unit, Faculty of Medicine, Universitat de Barcelona, Barcelona, Spain.
[2] Department of Clinical Medical Sciences and Applied Molecular Medicine Institute, CEU San Pablo University School of Medicine, Department of Anaesthesiology, Madrid-Montepríncipe University Hospital, Madrid, Spain.
[3] Department of Medical Sciences, Faculty of Medicine. Universitat de Girona, Spain.
[4] Department of Critical Care and Multidisciplinary Pain Management, General University Hospital, Valencia, Spain.

Table of Contents

1 Introduction

1.1 About the document

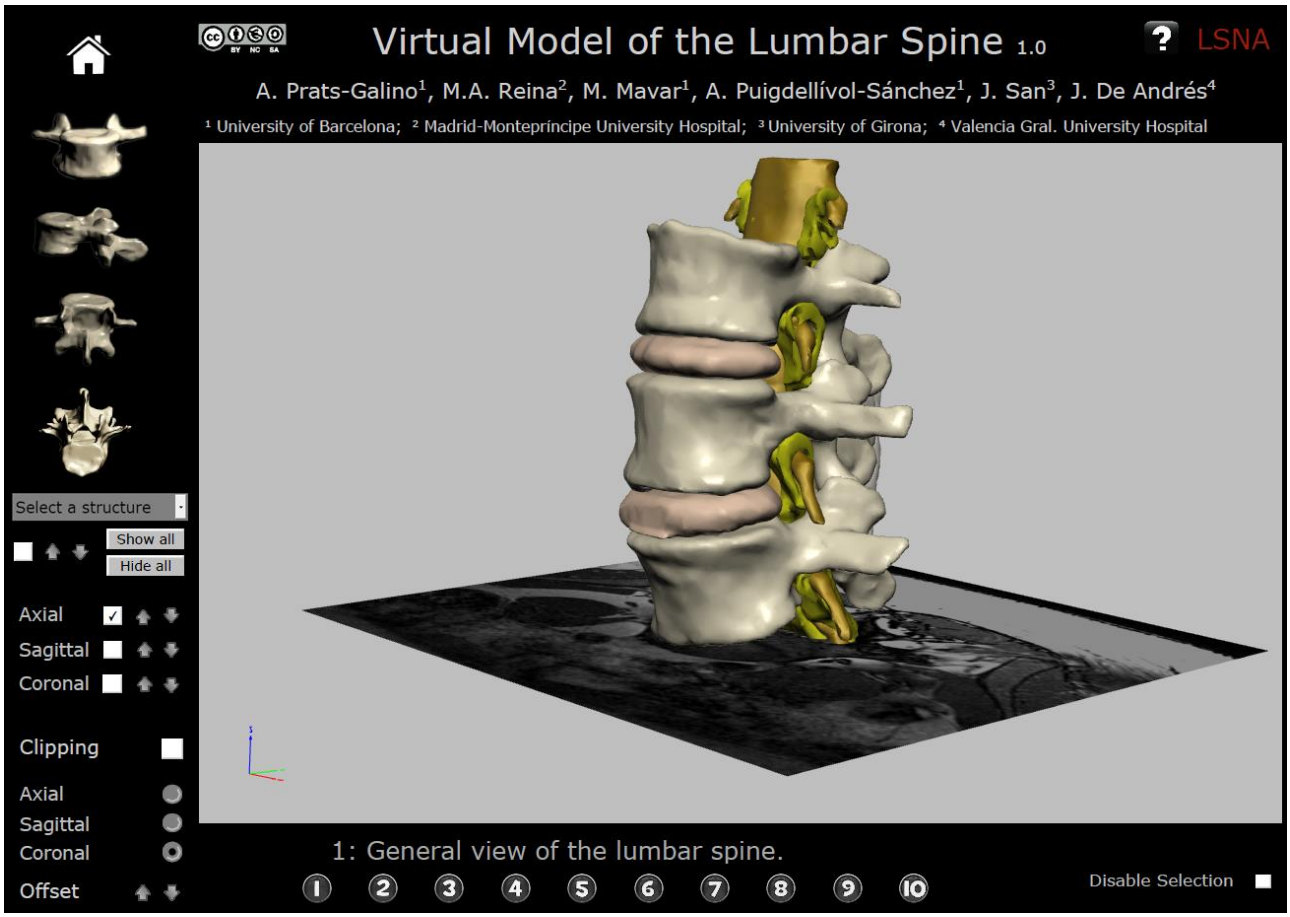


Figure 1 Interactive 3D PDF document

Authors

Alberto Prats-Galino[1], Miguel Angel Reina[2], Marija Mavar Haramija[1], Anna Puigdellivol-Sánchez[1], Joan San Molina[3] and José Antonio De Andrés[4].

[1] Laboratory of Surgical NeuroAnatomy (LSNA), Human Anatomy and Embryology Unit, Faculty of Medicine, Universitat de Barcelona, Barcelona, Spain.
[2] Department of Clinical Medical Sciences and Applied Molecular Medicine Institute, CEU San Pablo University School of Medicine, Department of Anaesthesiology, Madrid-Montepríncipe University Hospital, Madrid, Spain.
[3] Department of Medical Sciences, Faculty of Medicine. Universitat de Girona, Spain.
[4] Department of Critical Care and Multidisciplinary Pain Management, General University Hospital, Valencia, Spain.

Mail address for correspondence:
Alberto Prats-Galino: aprats@ub.edu
Miguel Angel Reina: miguelangel@perticone.e.telefonica.net

This interactive model has been developed from 3D reconstructions of human magnetic resonance (MR) images.
The authors have no conflict of interest to declare.

1.2 Objectives

The PDF format enclosing this three dimensional (3D) interactive anatomical model greatly simplifies its use, portability, compatibility and storage as the file size can be compressed and transferred across multiple platforms. The main fields of interest in regard to this specific 3D anatomical model include:

Educational programs

Real 3D imaging support for teaching neuroaxial anatomy and regional anesthesia
Visual aid in the development of new approaches in regional anesthetic techniques

Research programs

Review of patient data and analysis of anesthetic techniques
Image inspection techniques of complications in regional anesthesia

Patient information

Complementary visual aid to instrumental techniques and surgical procedures relevant to patients
This project allows users to examine 3D reconstructions from human MR images. We present a 3D interactive anatomical model of interest in regional anesthesia and pain medicine (e.g. Figure 2 shows spinal medial approach illustrated by our model).

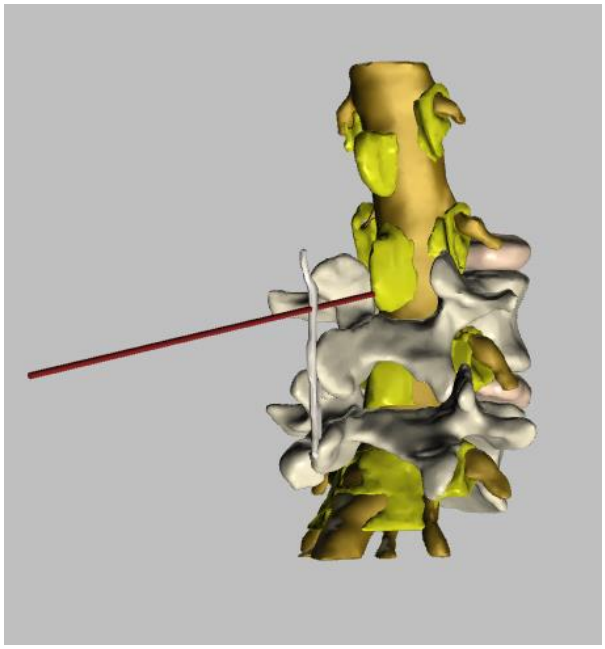


Figure 2 Example: Spinal medial approach

The technology used to support this interactive model has recently being applied in medicine, and enables us to produce interactive 3D models by means of a complex and strenuous technique of 3D image reconstruction from 2D images thanks to specific software (Amira 5.4.0 ©). The outcome is a simple and useful teaching, working and research tool. The use of this type of model is straightforward and does not

require previous experience, as it is an intuitive product, supported in PDF file format and can be opened in Windows and Mac computers. But above all, it may be used free of charge by every physician.

The present project includes reconstructions of vertebrae, vertebral disks, vertebral arches, ligamentum flavum, supraspinous ligaments, interspinous ligaments, epidural fat, foraminal fat, dural sac, nerve root cuffs, sensory and motor nerve roots.
It has a dynamic 360º view including partial or total views of each and all structures, including zoom function.

2 Basic Instructions

The PDF document runs under Adobe Acrobat 11 or superior.
Navigation may be started from different points. One or more structures may be selected initially, as well as selecting preset options of 3D reconstruction images. Interaction with the screen is performed by mouse, allowing the model to move, offering views of the structures from different perspectives. It includes axial, sagittal and coronal MRI slices as reference.
This interactive anatomical model allows cutting in axial, sagittal and coronal planes. Clipping may include all the structures reconstructed in the model. The other options are intuitive and easy to grasp.

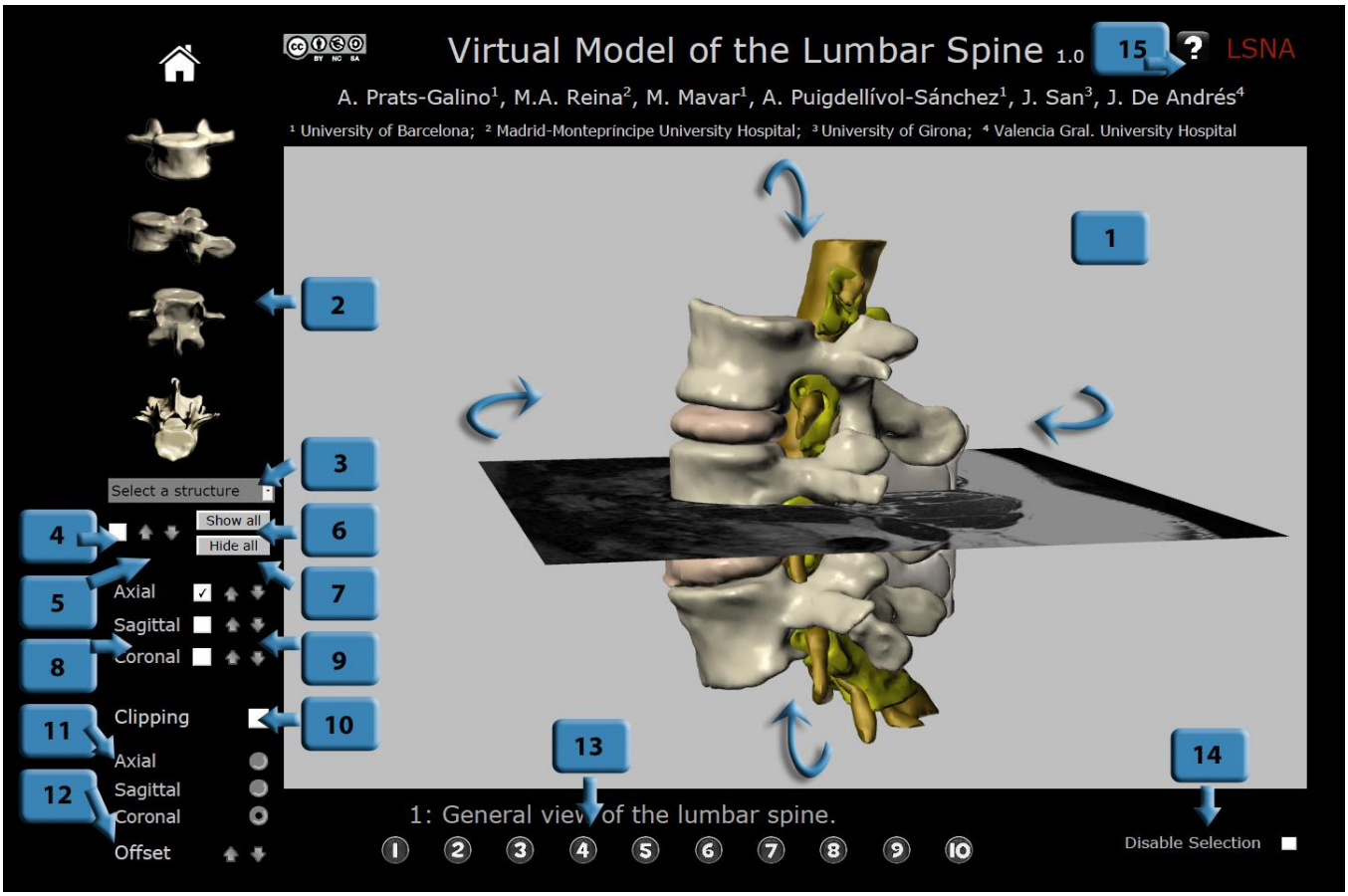


Figure 3 Function description: click on a numbered button to jump to a corresponding chapter

The functionality of this pdf document is described in 15 short instructions, each one explaining a concrete function/button. You can click on the blue numbered buttons on the Figure 3 to jump to a chapter describing the corresponding function.

2.1 Screen Working Area

Full screen mode is invoked by Control + L key combination and exited by the ESC key.

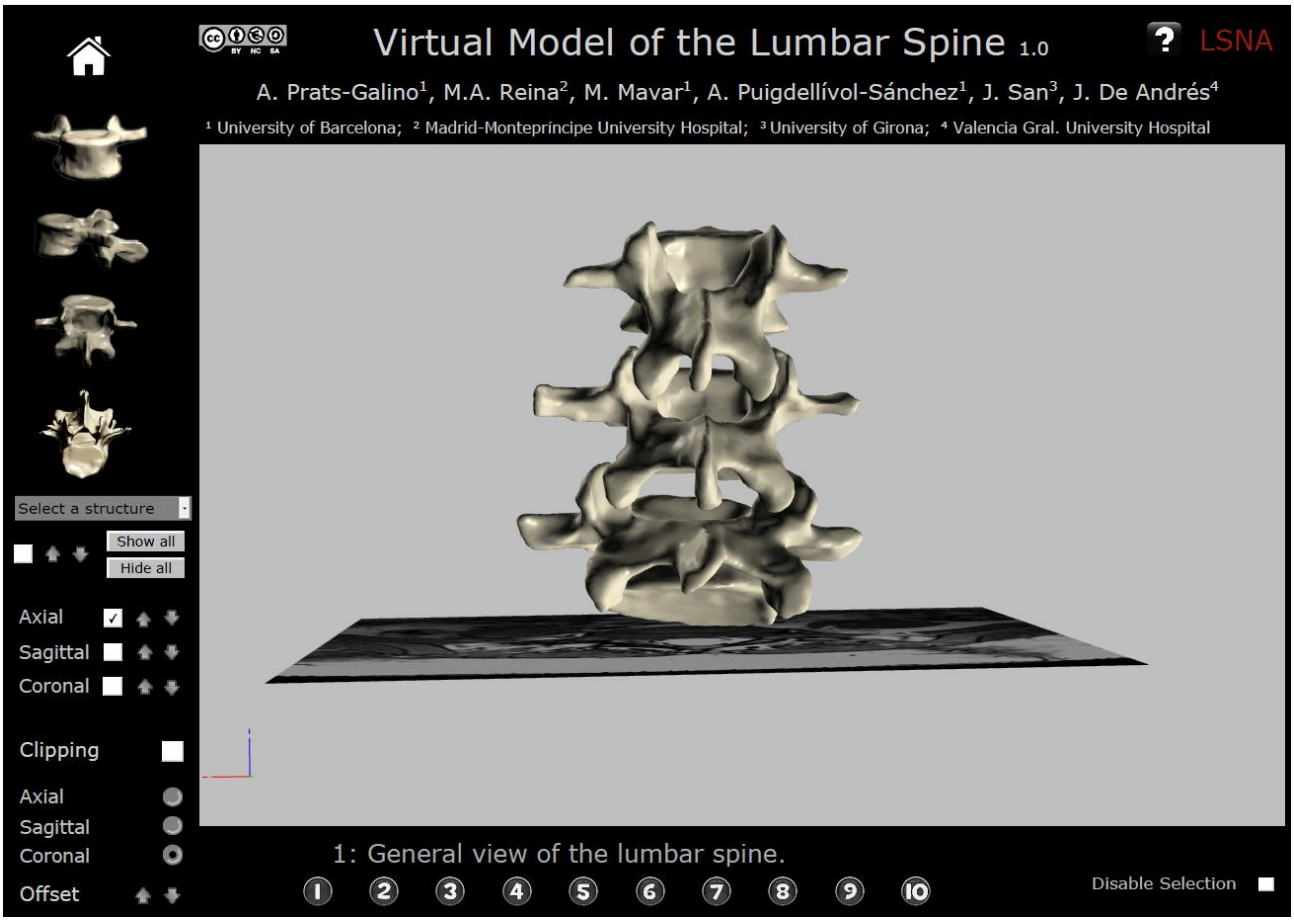


Figure 4 Working area

Dynamic 360º view is obtained by mouse motion while holding down left mouse button.

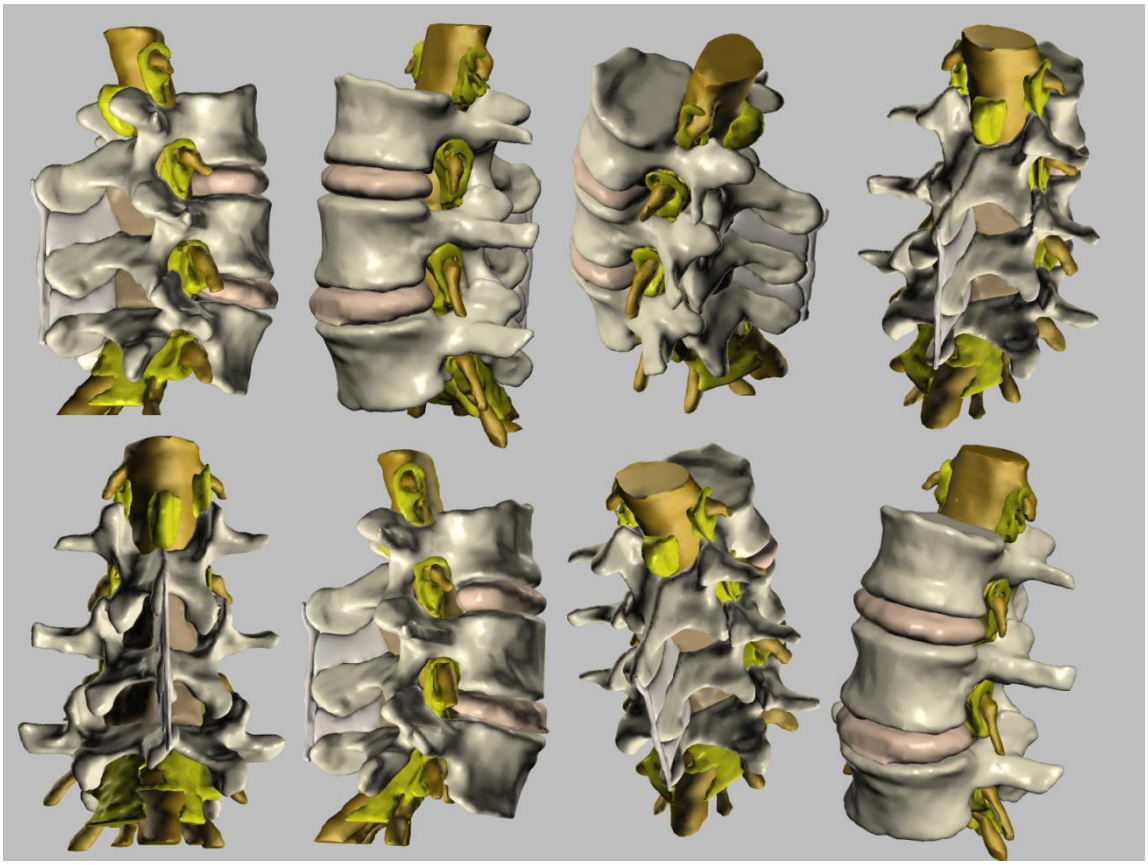


Figure 5 360º rotation of the model

2.2 Default Views

Selects among four default positions in which the model can be displayed (anterior, lateral, posterior and superior view).

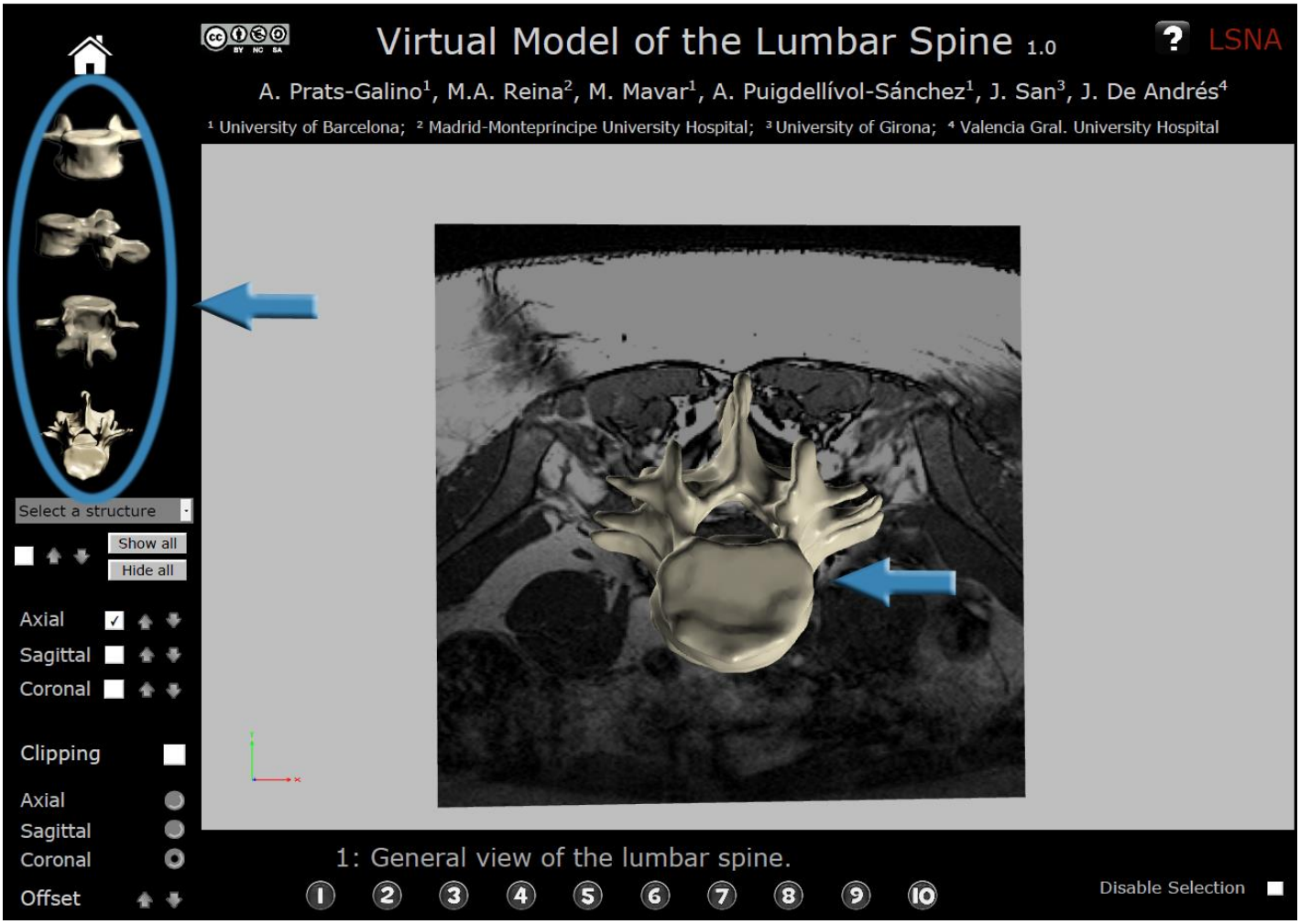


Figure 6 Default views example: superior view

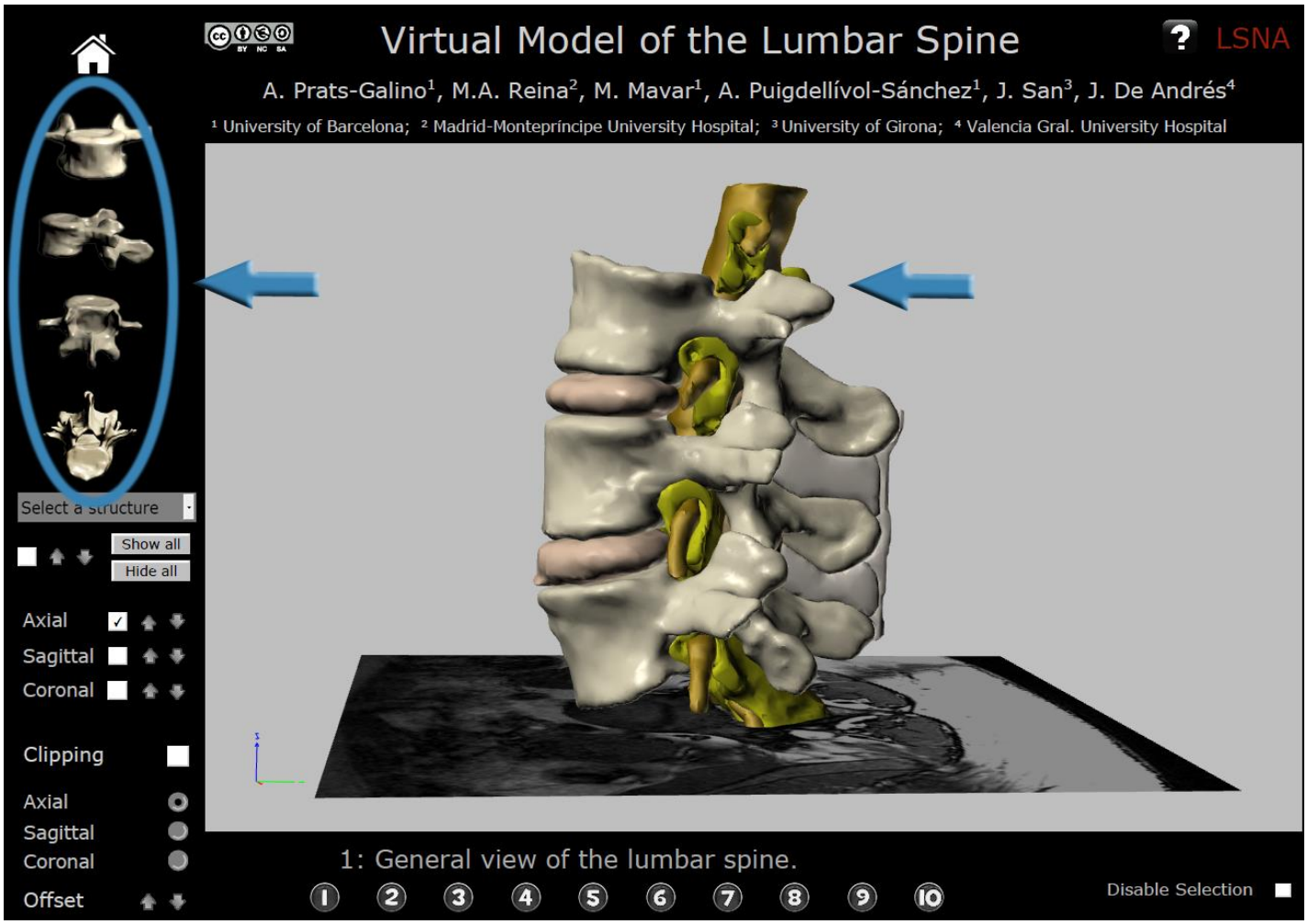


Figure 7 Default views example: lateral view

2.3 Structure Selection

Click on the structure of the drop-down menu to build the model up on the screen. Selection is validated by clicking on function Nº 4 (show/hide selected structure). Structures may be successively incorporated to the model on the screen.

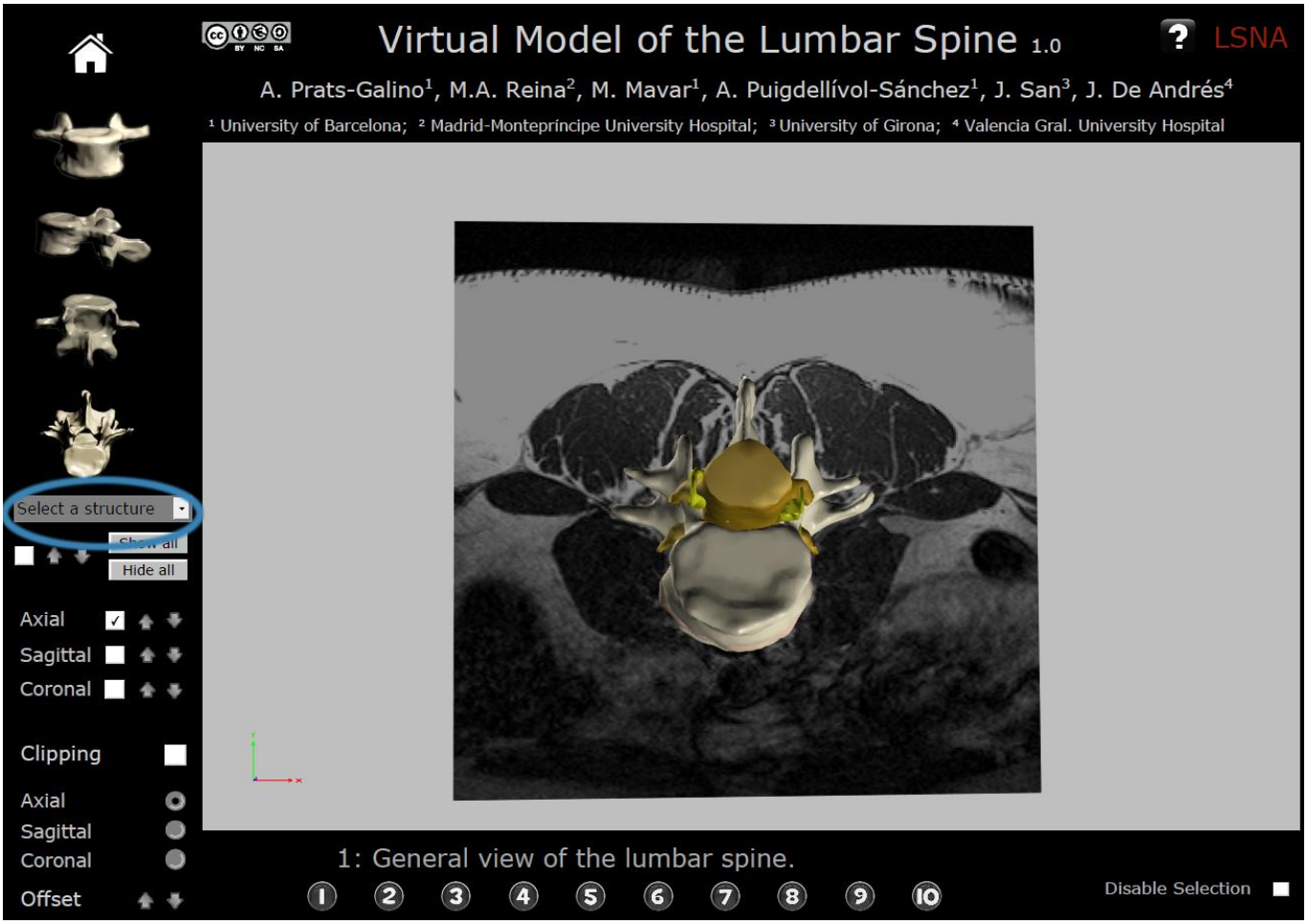


Figure 8 Structure selection function

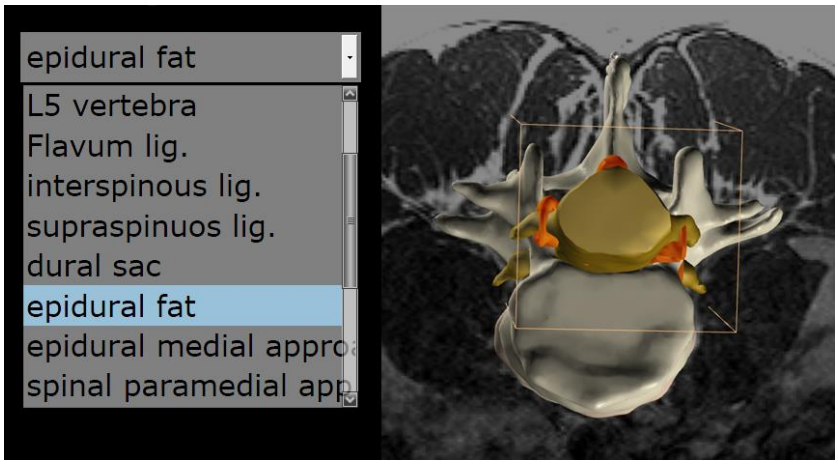


Figure 9 Structure selection example: epidural fat selected (in red)

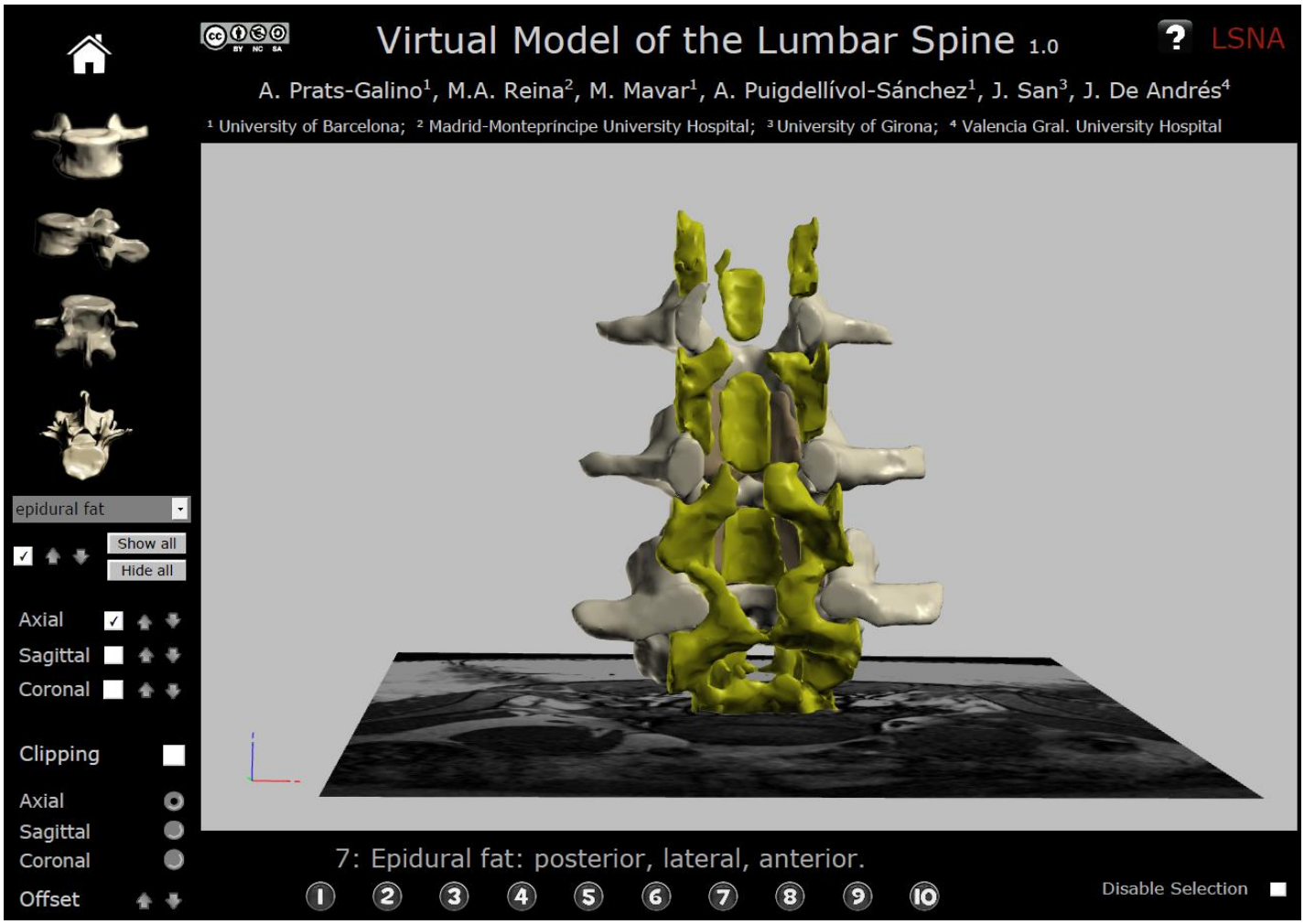


Figure 10 Structure selection example: Epidural fat selected

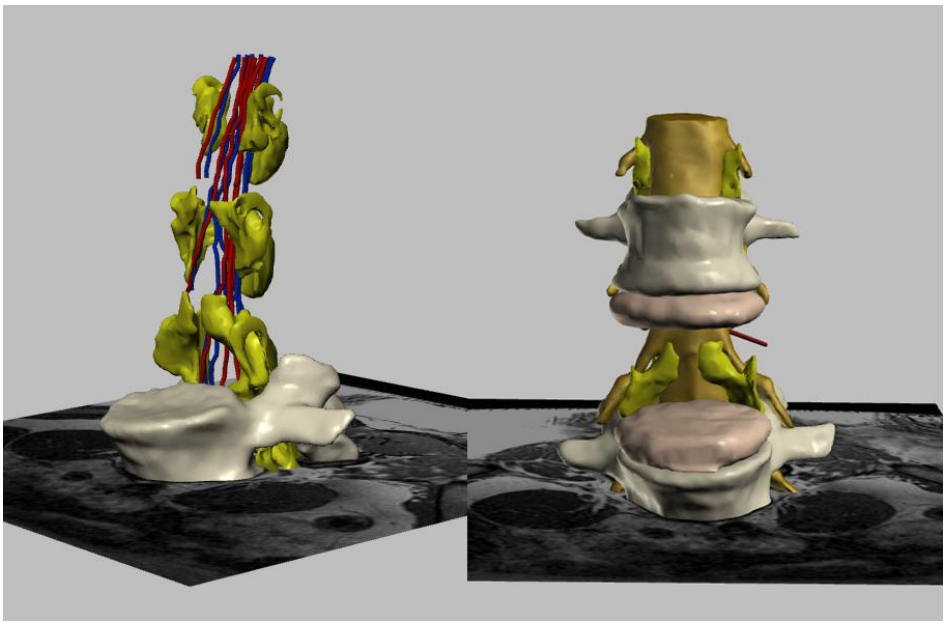


Figure 11 Examples of different structures shown/hidden

2.4 Structure Validation Function

Structure validation button, when checked, the selected structure is added to the model in the working area. When unchecked, the selected structure is hidden from the model.

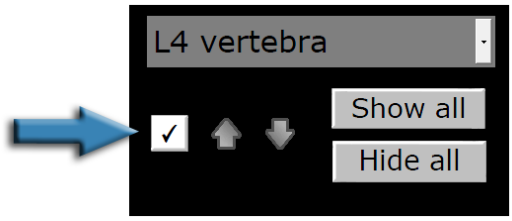


Figure 12 Structure validation: show/hide selected structure

2.5 Transparency Graduation

Arrows modify the degree of transparency, allowing the structure selected on the screen to disappear progressively as it changes its color.

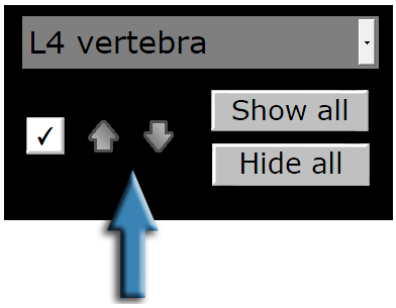


Figure 13 Gradual change of the selected structure's transparency

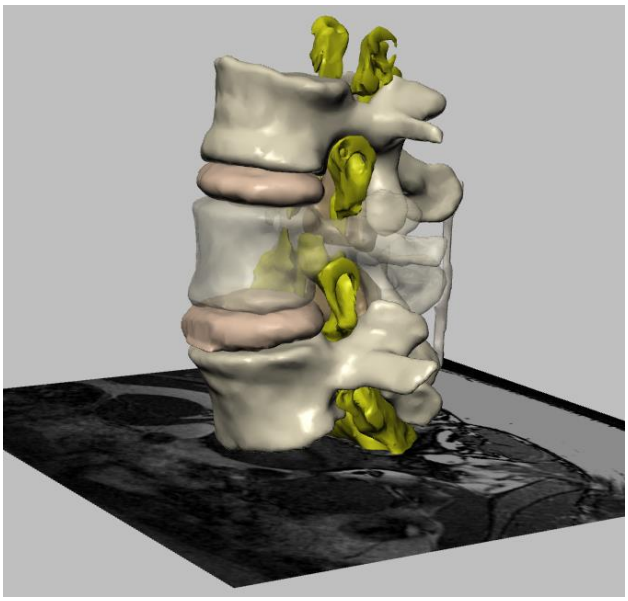


Figure 14 Transparency graduation example: Semi-transparent L4 vertebra

2.6 "Show all" Option

This button displays all of the structures of the 3D model on the screen. Each superficial structure may be selected and made transparent, allowing internal ones to appear on the screen. To remove structures from the screen, select each structure by clicking on it and pressing on *validation-function* (2.4).

Alternatively, structures can be removed from the screen by selecting their name in the *drop-down menu* (2.3) and clicking the *structure validation* function (2.4).

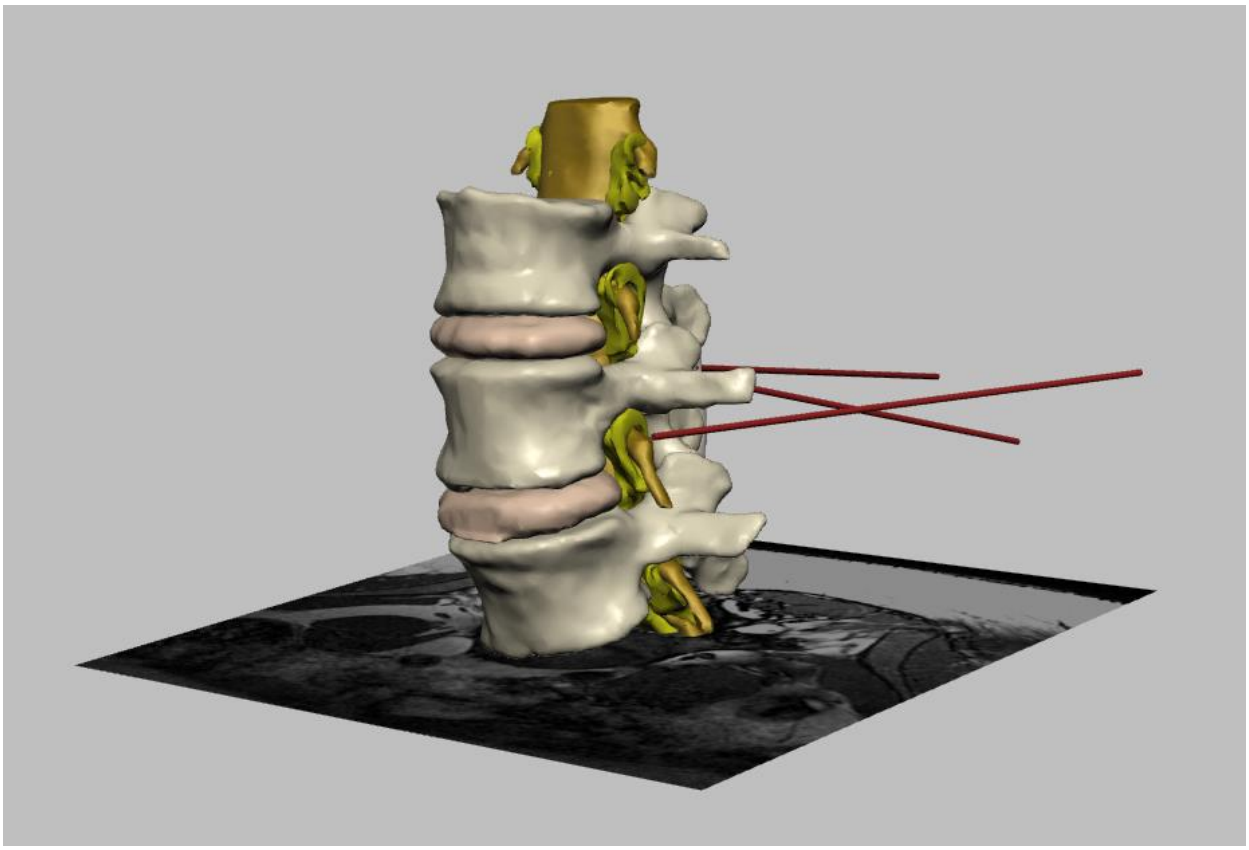


Figure 15 Show all: All structures of the model are made visible

2.7 "Hide all" Option

"Hide all" button removes all structures displayed in the working area of the screen.

2.8 MRI Slices

This functionality shows or hides MRI slices from the working area.

Axial, sagittal, and coronal options may be selected either independently or in combination.

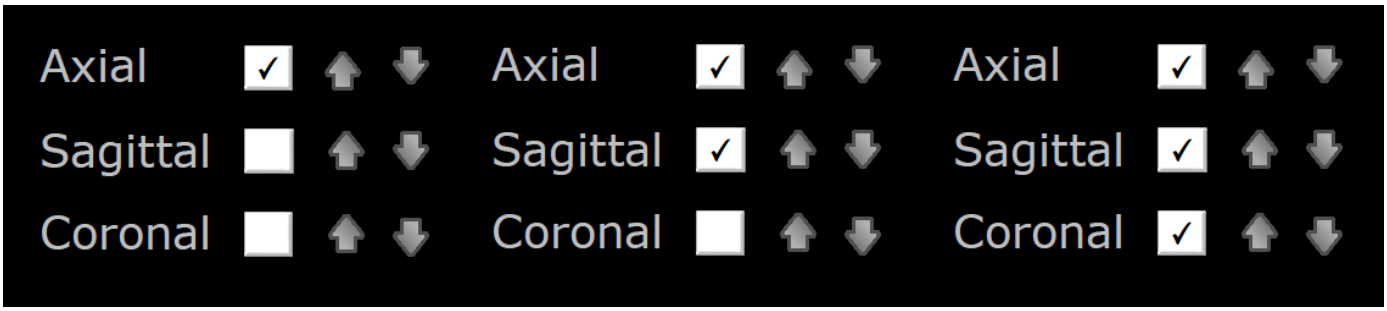
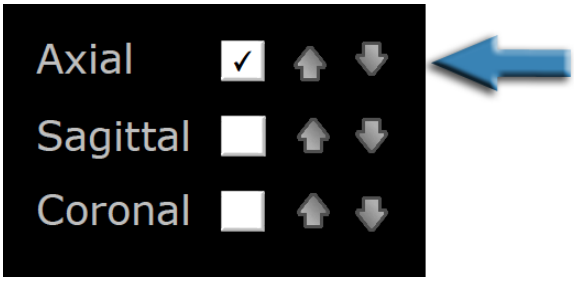


Figure 16 Showing MRI slices in the working area

2.9 MRI Slice Navigation

Arrows allow navigating from one MRI slice to the next. There are coupled arrows for each of the orientations: there are nine axial, seven sagittal and six coronal slices.



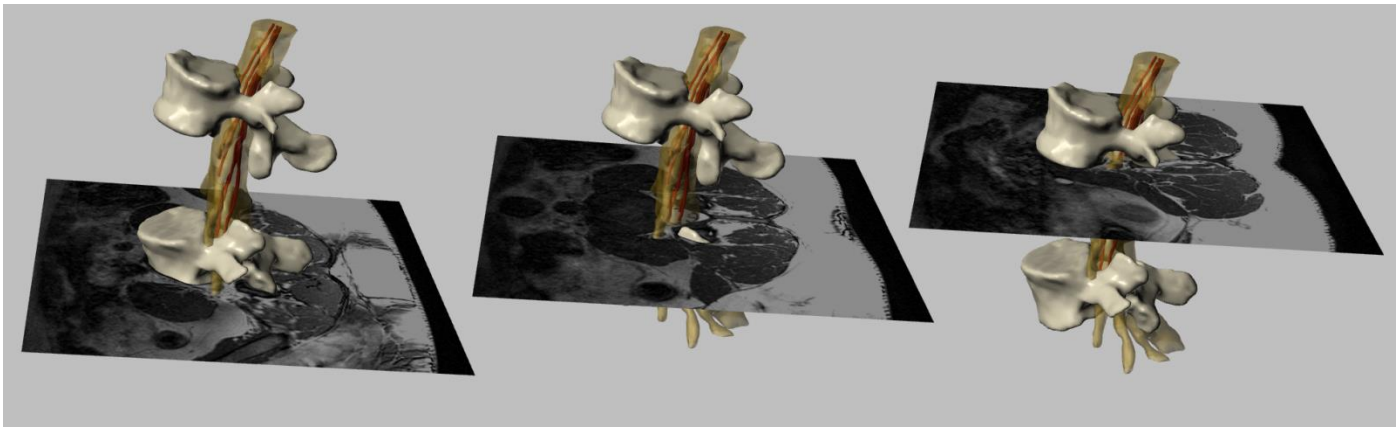


Figure 17 Axial MRI slices

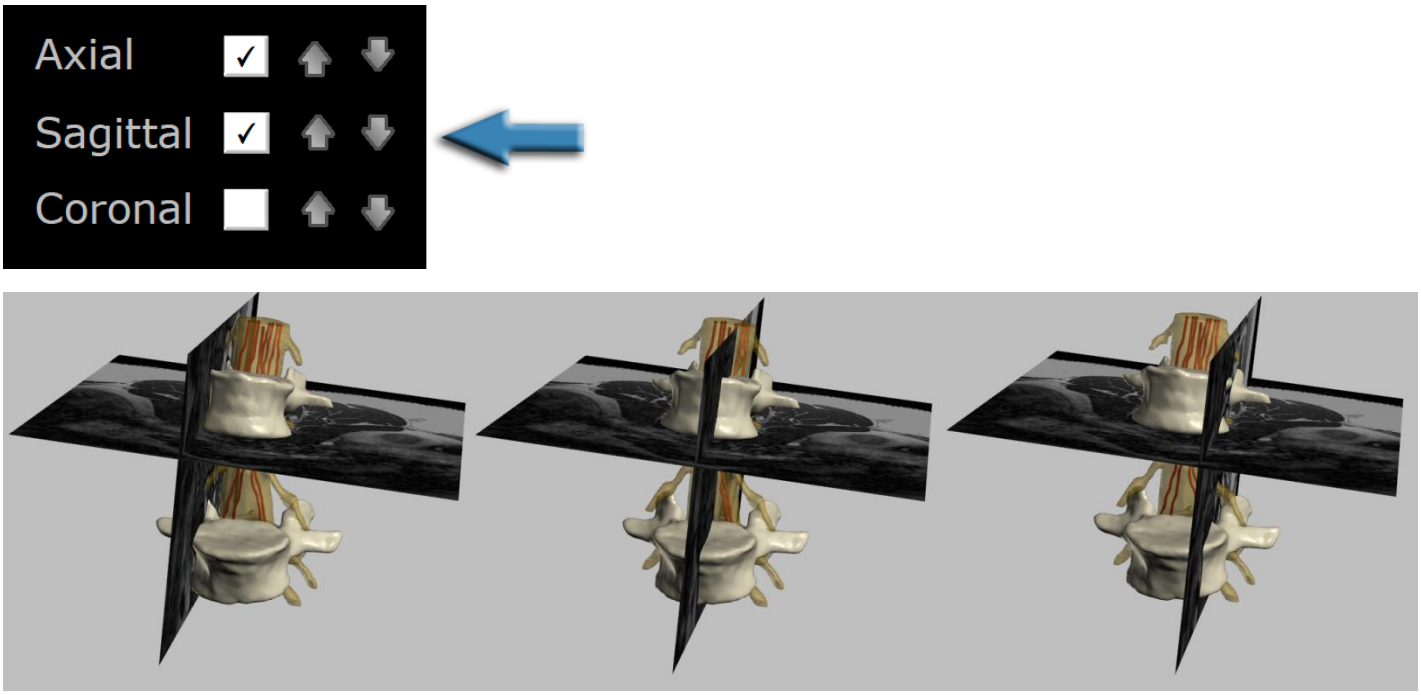


Figure 18 Sagittal MRI slices

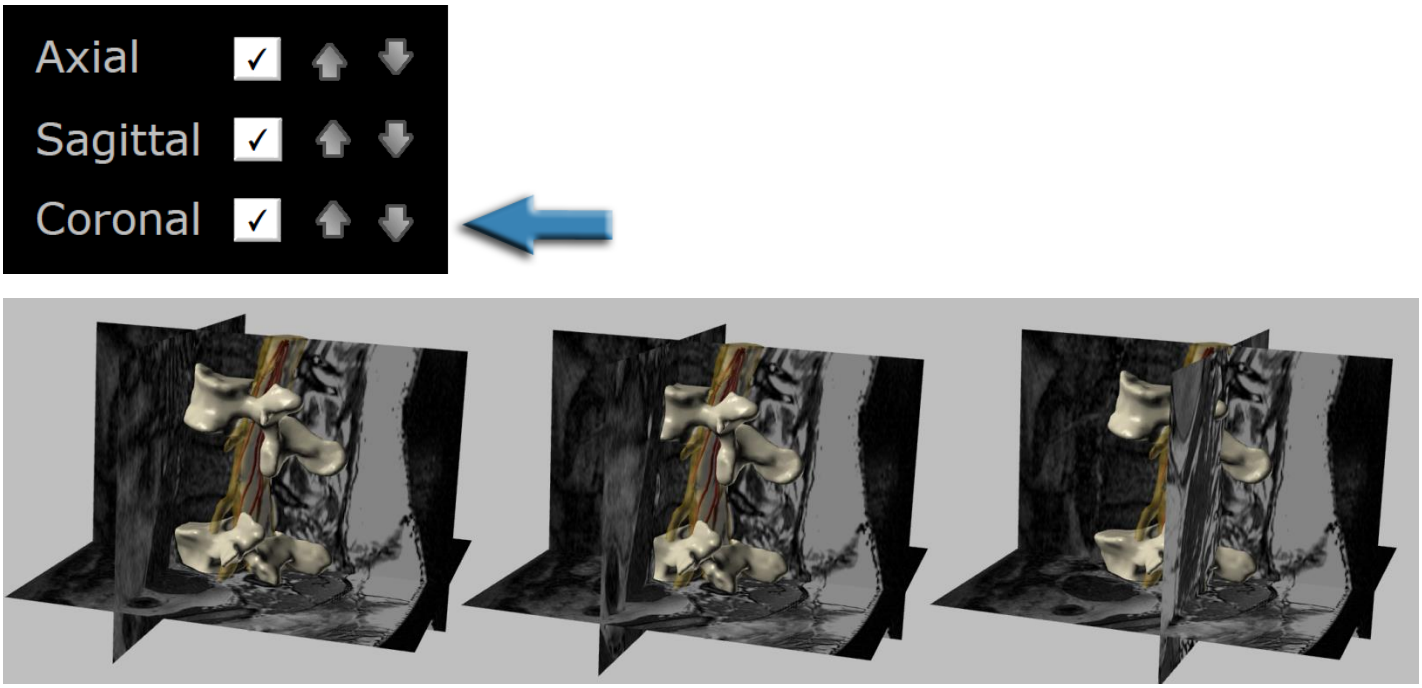


Figure 19 Coronal MRI slices

2.10 Clipping Function

This function displays cuts of the original 3D model, including the MRI slices selected by function 11.

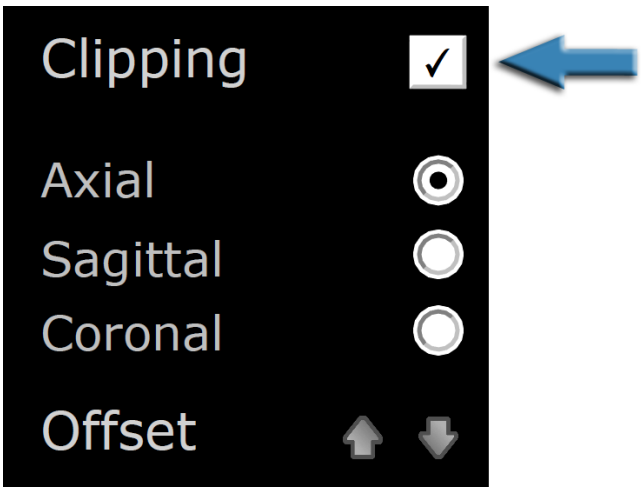


Figure 20 Clipping: cutting the model by a clipping plane

2.11 Clipping Plane Orientation

This function selects different clipping plane orientations: axial, sagittal or coronal.

Figure 21 Clipping plane orientations

2.12 Clipping Plane Offset

This functionality allows navigating along successive cuts of the model (by moving the clipping plane).

Figure 22 Clipping plane offset: moving along the model

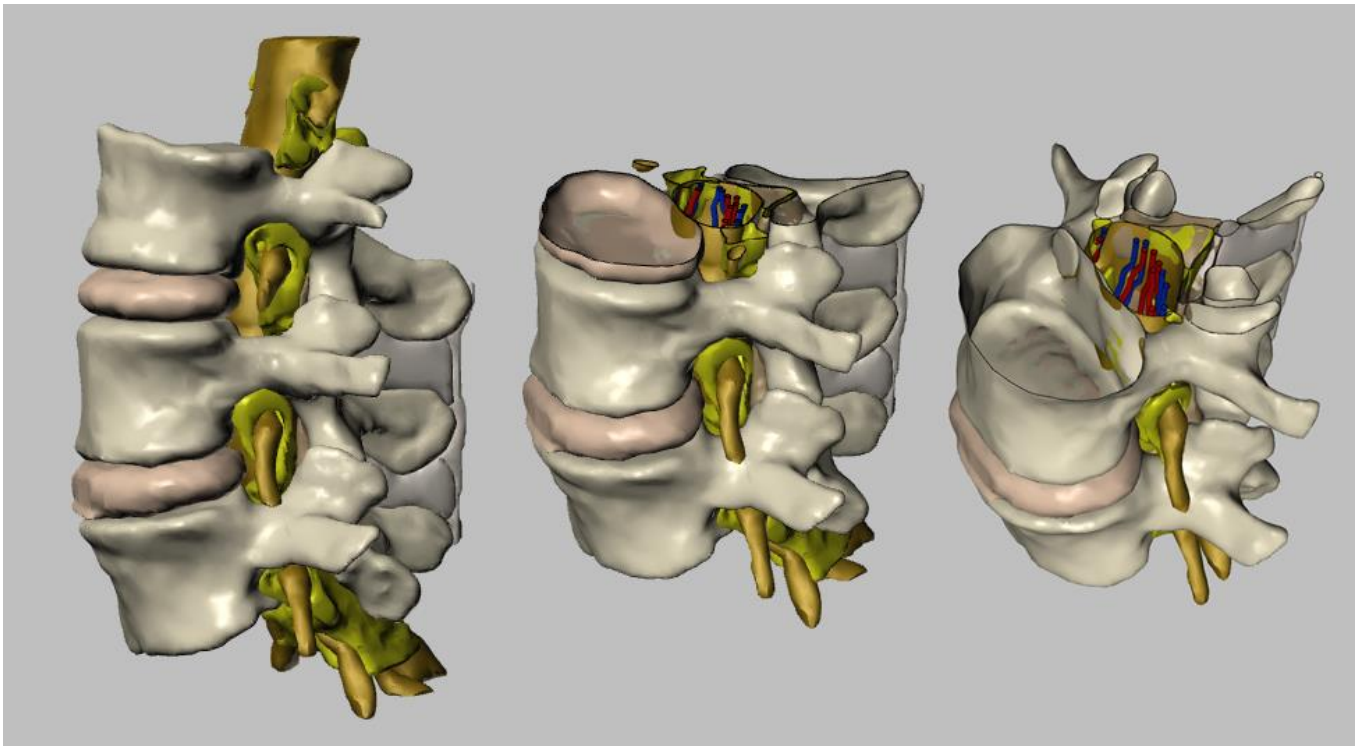


Figure 23 Clipping example: Axial clipping

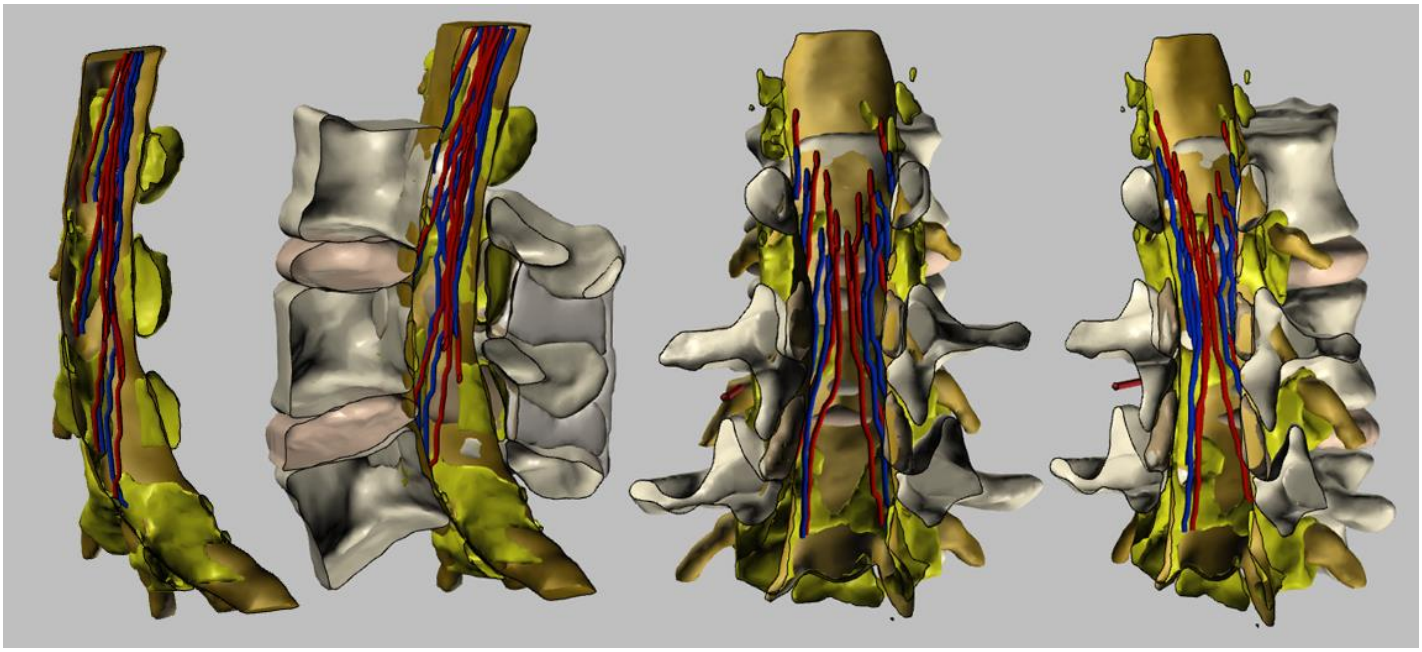


Figure 24 Clipping example: Sagittal and coronal clipping

2.13 Predetermined Custom Views and Short Explanations

Different predetermined views are available, together with a short explanation of the current view. All above mentioned functions may be applied to each view.

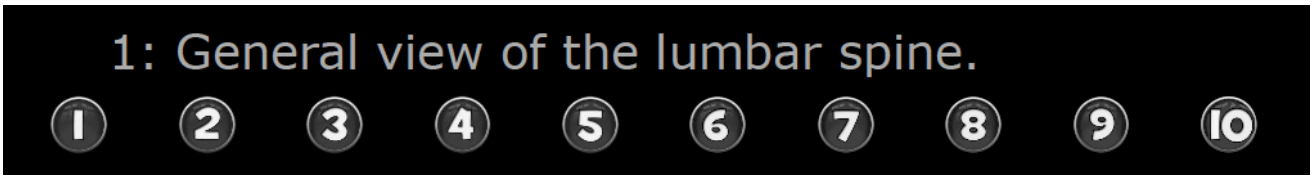


Figure 25 Custom views and comments

2.14 "Disable selection" Option

This option disables user from selecting structures by a mouse click.

It can be useful in different occasions: in presence of problems regarding performance of screen area due to problems with graphical properties of a computer or similar, or simply if we want to rotate the model without accidently highlighting the structures causing them to appear in color red.

Figure 26 Disable selection of the model

2.15 Access the Instructions

Instructions on how to use interactive PDF file can be accessed by clicking on a question mark button on the top right.

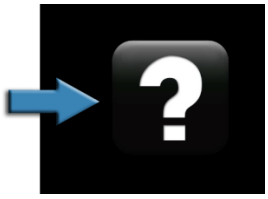


Figure 27 Accessing instructions

3 Table of Figures

4 Acknowledgements

This work has been partly supported by the grants "Marató TV3 Project" [411/U/2011 - TITLE: Quantitative analysis and computer aided simulation of minimally invasive approaches for intracranial vascular lesions.] and "2012PID-UB/002 Project" [Grupo de Anatomía Virtual y de Simulación, Universitat de Barcelona].

We also thank Olga Fuentes[1] for her technical assistance.

5 Licensing

The 3D Interactive Spine Virtual Model PDF file is distributed under CC BY-NC-SA 2.0[2] license, which requires attribution to the authors, but allows derivate works without commercial use, provided that it is shared under the same license as the original document.

JavaScript source code and original surface model geometry are not public and cannot be accessed or modified.

In case of using any part of the mentioned document (e.g. image capture of the anatomical model) according to CC BY-NC-SA 2.0 license please reference this work by the following citation:

- Prats-Galino A, Mavar M, Reina MA, Puigdellívol-Sánchez A, San-Molina J, De Andrés JA. Three-dimensional interactive model of lumbar spinal structures. Anaesthesia 2014; 69:521.

The original 3D PDF document, together with the instructions and the license file, is freely available at `http://diposit.ub.edu/dspace/handle/2445/44844?locale=en`.

[1] Laboratory of Surgical NeuroAnatomy (LSNA), Human Anatomy and Embryology Unit, Faculty of Medicine, Universitat de Barcelona, Barcelona.

[2] http://creativecommons.org/licenses/by-nc-sa/2.0/