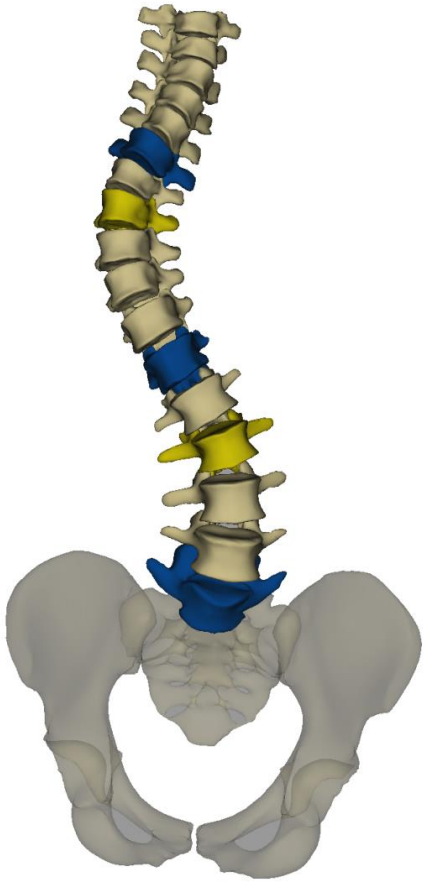
QUICK USER GUIDE

Spine



sterEOS 1.6

Table of Contents

I. General

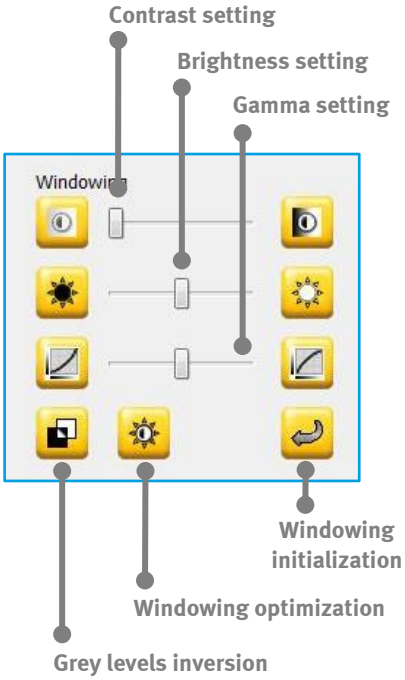
1.1 Tips

General help:

- At every step, the question landmark is available through the icon:

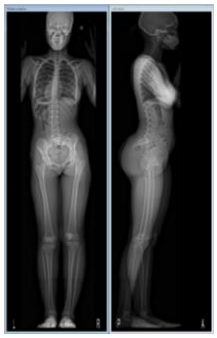
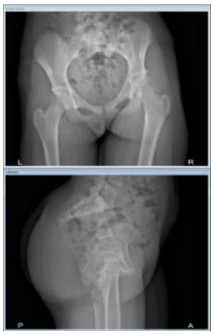
Windowing panel:

Use the windowing panel to adjust the image display settings.

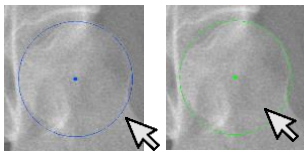


Keyboard shortcuts:

Key		Description
	Grey levels optimization	Set the optimal brightness and contrast for the area of the image that is visible in the active window.
	Initial grey levels	Return to the initial levels of brightness and contrast in the active window.
	Hide annotation and model	Use “M” at every step to mask the tools and the model.

Vertical images	Horizontal images
	
	

Mouse actions:

Actions	Description
	Move the images
	Magnification
	Selection of images
 Double-click	Display only the selected image
	Modify an object: move the cursor on the object, it will then turn green
	Reset the zoom of the image

1.2 Indications and Limits

Indications

- For adult patients as well as pediatric patients 7 years and older
- To get the position and orientation of bone structures of one level regarding other levels

3D measurements independent from patient positioning during acquisition
Compatible with EOS Micro Dose images as part of pediatric patients follow-up

Note

The 3D model does not highlight bone alterations (such as postoperative geometry changes, fractures/fibrocartilage calluses, osteophytes)

Might not be possible in the following cases

- Implant or orthopedic material hiding anatomical landmarks
- Pathological condition altering the bone density such as osteoporosis
- X-ray images with insufficient information (bariatric patient, …)

Contraindications

- Patient under 7 years old
- Extra or missing vertebra
- Vertebrae with congenital deformities (such as hemivertebraes, spina bifida)
- Spondylolisthesis

Pelvic parameters

Pelvic parameters workflow is an option of the Spine 3D workflow.

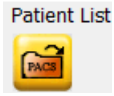
In order to calculate pelvic parameters, it is necessary to:

- Visualize the sacral plate on the lateral view
- Visualize the sacroiliac joints on the frontal view
- Distinguish the left and right acetabula on frontal and lateral views

These structures must be visible in order to obtain an accurate 3D model.

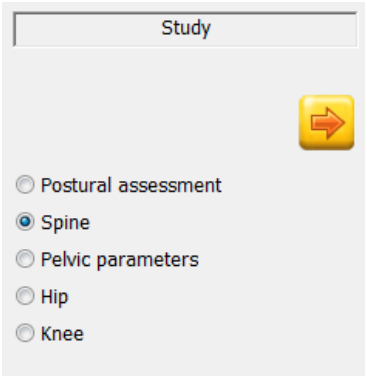
II. Start

2.1 Launching an Exam in sterEOS

- Double-click on  to launch the sterEOS application
- Click on  to open the patient list
- Select an exam and double-click to open it in sterEOS 2D

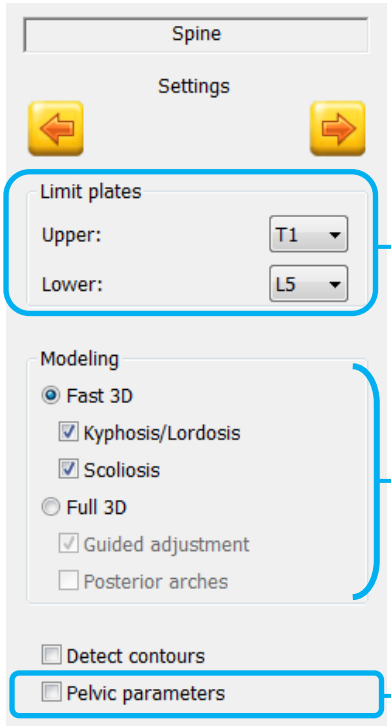
2.2 Workflow Selection

Once the images are loaded in sterEOS 2D, click on the sterEOS 3D icon and select the spine workflow from the sterEOS 3D interface.



2.3 Spine Settings

Objective: Select the vertebrae levels, the type of modeling and the options.



Selection of the spine segment to model
The longest segment is T1 – L5

Selection of the workflow

In order to calculate vertebral orientations in the pelvic plane, this option should be selected

There are two workflows for the 3D modeling of the spine:

- The fast 3D mode is a modeling process featuring fast overall adjustment of the vertebrae and fine adjustment of **a few points only**.

  ⇒ It is used when vertebral orientations are needed only for the junctional and apical vertebrae of the Cobb angles. It is often used in follow-up cases.

  Options:

  ☑ **Kyphosis/Lordosis:** to measure sagittal angles
  ☑ **Scoliosis:** to measure Cobb angles

- The full 3D mode is a modeling process featuring fast overall adjustment and fine adjustment of **all vertebral bodies and pedicles**.

  ⇒ It is used when vertebra orientations are needed on every vertebra.

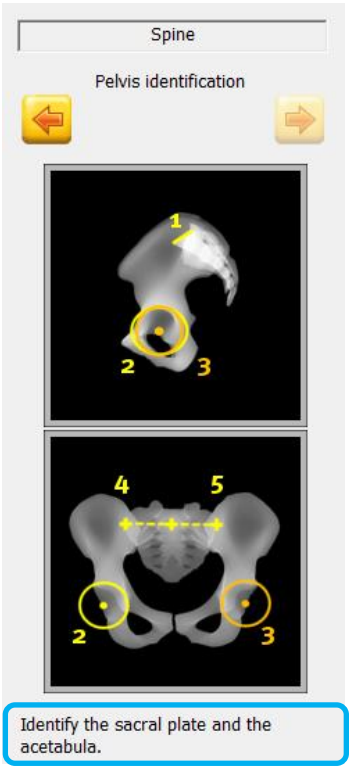
  Options:

  ☑ **Guided adjustment:** to facilitate the modeling process
  ☑ **Posterior arches:** for clinical research only

III. Full 3D Modeling of the Spine

3.1 Pelvic Parameters

Objective: Identify the sacral plate, the sacro-iliac joints and the acetabula



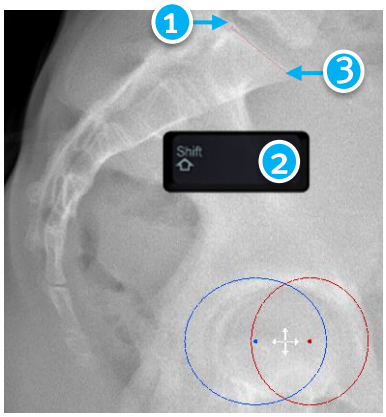
Identify the following landmarks on the radiographic images, as shown on the help illustrations:

- Sacral plate 1
- Acetabula 2 – 3
- Sacro-iliac joints 4 – 5

Help message labeling the landmarks to be identified on the lateral and frontal views

Method:

1 On the **lateral** view, trace the sacral plate.



1. Left-click on the posterior corner of the sacral plate
2. Press and hold down the shift key
3. Left-click on the anterior corner of the sacral plate to complete the identification

2 – 3 Left-click on one of the images to pre-position the acetabula. Then select the circles one by one (left-click) to correctly position them on the acetabula on the frontal and lateral views. Use the mouse wheel to adjust the diameters of the circles.

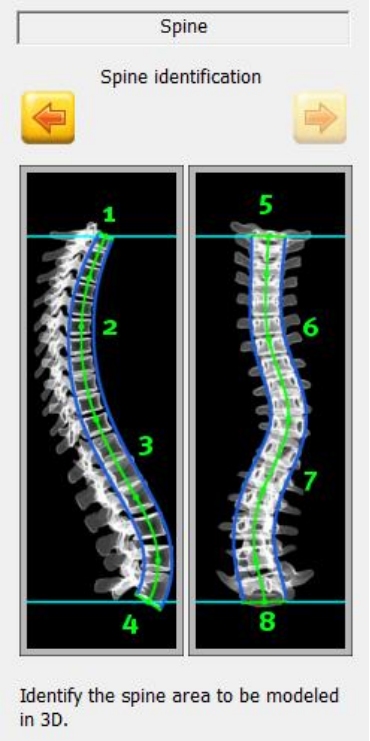
The **blue** circle represents the **right** acetabulum

The **red** circle represents the **left** acetabulum

4 – 5 On the **frontal** view, right-click and adjust the position of the crosses on the sacroiliac joints (left-click).

3.2 Spine Identification

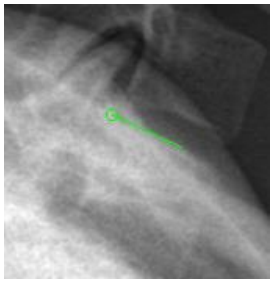
Objective: Identify the spine segment to be modeled



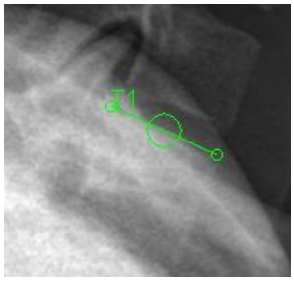
Start with the **lateral** view:

1 Identification of the upper plate of the first vertebra of the segment to be modeled:

- **Left-click** on the posterior corner of the upper plate of the first vertebra to be modeled

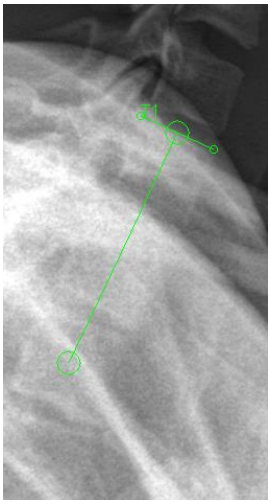


- **Hold the left-click** and drag the cursor to the anterior corner of the upper plate, then release the left-click



❷ – ❸ Identification of the spinal curve passing through the center of the vertebral bodies:

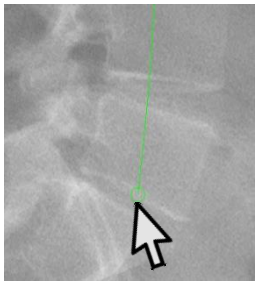
- Make several successive left-clicks to plot the curve.
- The control points should be placed at the center of the vertebral bodies.



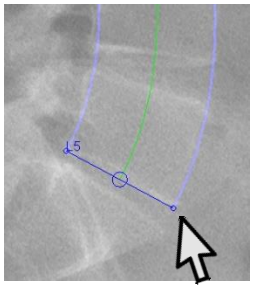
Note
When identifying the spinal curve, it is recommended to limit the number of control points (e.g. standard procedure = 4 or 5 points).

❹ Identification of the lower plate of the last vertebra of the segment to be modeled:

- Position the cursor at the center of the lower plate
- Hold down the shift key 

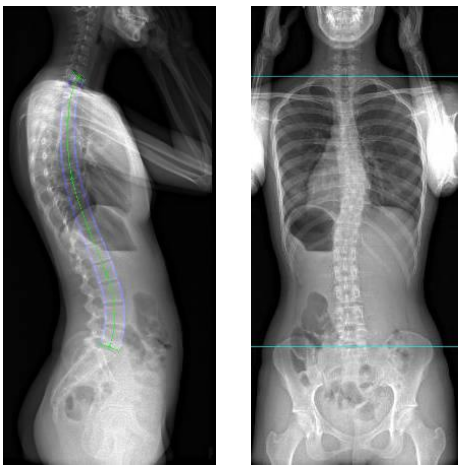


- Left-click and drag the mouse up to one edge of the plate
- Release the shift key and the left click
- Blue lines representing the spinal envelope are displayed



5 – 8 Proceed in the same way on the frontal view.

On the frontal view, the upper plate of the first vertebra to be modeled and the lower plate of the last one are set by epipolar lines.
The level of these plates can only be adjusted on the lateral view.



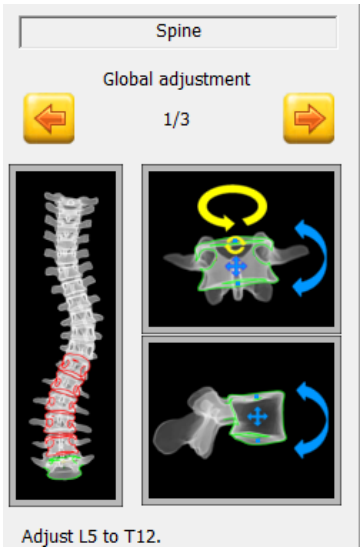
Adjustment of the position and width of the spinal envelope:

The spinal envelope is represented by two blue curves running along the vertebral bodies. It can be adjusted by modifying the control points positioned on the spine curve (green line):

- To modify the position of a point: left-click on it, hold the click and drag it to a new position
- To modify the width of the spinal curve: select a control point and adjust the width by scrolling the mouse wheel
- To add a new point: left-click on the spinal curve
- To delete a point: drag the point to merge it with an adjacent point

3.3 Global Adjustment

Objective: Adjust the position and orientation of vertebrae



Considering that the spine is modeled from T1 to L5, the global adjustment is divided in three sections: L5-T12, T11-T6 and T5-T1. For each section all the vertebrae models should be adjusted successively.
If the spine isn't modeled from T1 to L5, the limits of the three sections will be adjusted accordingly.

1. Start by moving vertebrae that are not correctly positioned:

   On the **lateral** view, left-click on the tool  at the center of the vertebra, hold the click and move the tool to position the vertebra.

Working vertebra by vertebra is now advised.

To display only one vertebra, click on 

Start working from the lowest to the highest vertebra. To display the next vertebra, right-click on it.

For each vertebra, if necessary:

2. On the **lateral** view, adjust the sagittal rotation of the vertebral body:

   Place the cursor on the blue cross at the center of the vertebra (it will then turn green) and scroll the mouse wheel. **Check that the vertebral plates on the model and on the image are parallel.**

3. On the **frontal** view, adjust the frontal rotation of the vertebral body:

   Click on the frontal view. Place the cursor on the blue cross at the center of the vertebra (it will then turn green) and scroll the mouse wheel. **Check that the vertebral plates on the model and on the image are parallel.**

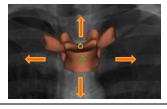
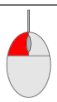
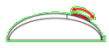
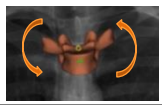
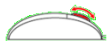
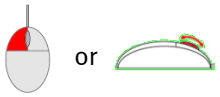
4. On the **frontal** view, adjust the axial rotation of the vertebral body:

   Either place the mouse on the yellow circle at the center of the vertebra and scroll the mouse wheel or hold the left-click and drag the mouse. **Check that the spinous processes on the model and the image are aligned.**

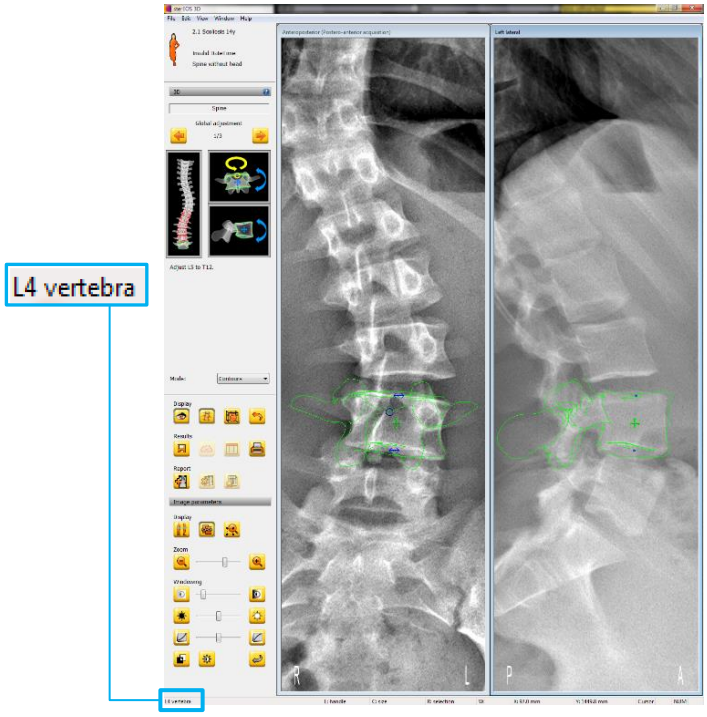
   Note: In the case of extremely deformed vertebrae, adjust the position and orientation of the vertebrae on the frontal and lateral views.
   Place the cursor on the blue point at the center of each plate and scroll the mouse wheel.

5. Once all the vertebrae of the section are adjusted, repeat the steps 1 to 5 for the adjustment of the sections T11-T6 and T5-T1.

The table below recaps the tools for the adjustment of the position and orientation of vertebrae:

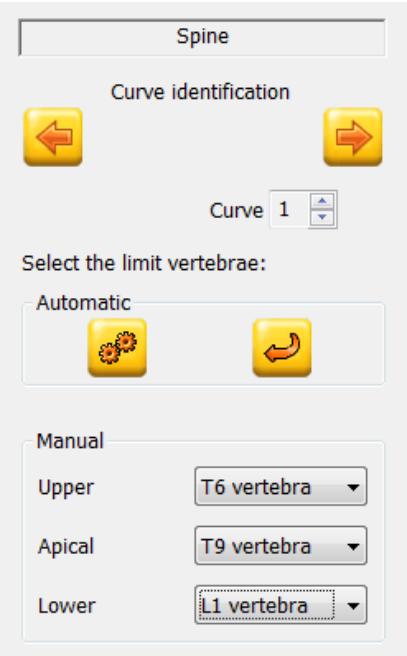
ACTION		SYMBOL	MOUSE
Translation (frontal/lateral views)			
Sagittal Rotation (lateral view)			
Frontal Rotation (frontal view)			
Axial Rotation (frontal view)			 or

Note: The name of the active vertebra is displayed at the bottom left corner of the interface



3.4 Curve Identification

Objective: Choose the vertebral levels for the Cobb angles



Up to three curves can be selected.

By default, curves are defined **automatically**: the software only displays curves with a Cobb angle over 10°. It is also possible to define curves **manually**. As an example, the manual method can be used for a follow-up exam since the Cobb levels have already been defined.

Automatic Method

Perform the automatic detection of the curves

Cancel the selected curve and the associated Cobb angle

Manual Method

For each curve:

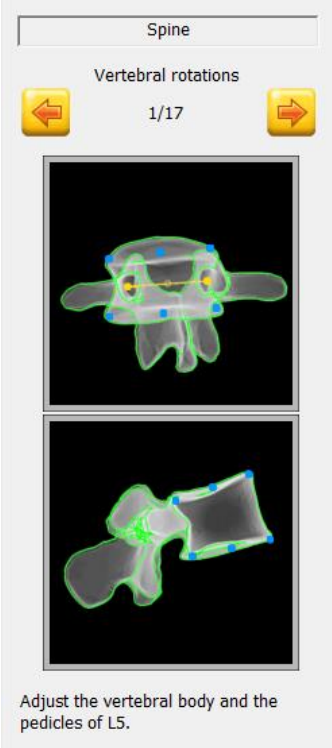
1. Select the curve from the drop-down list (1, 2 or 3)

2. Check that the selection of the limit vertebrae is correct or identify them manually. If necessary:

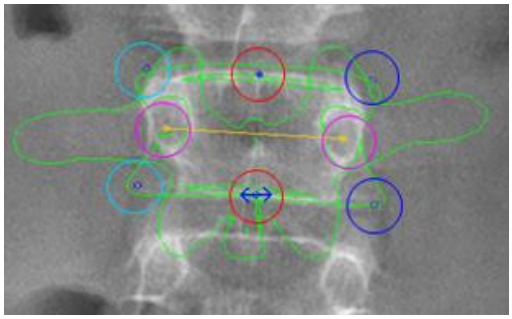
- Change the limit vertebrae in the drop-down list
  or
- Move the limit vertebrae directly on the frontal view by dragging them to the desired levels.

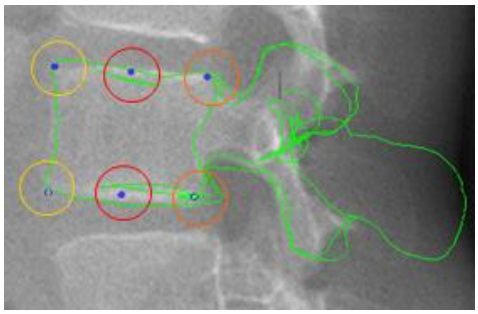
3.5 Vertebral Rotations

Objective: Finely adjust the position and the shape of each vertebra



Control points are associated with the vertebral plates and pedicles and have to be adjusted to better fit the image.

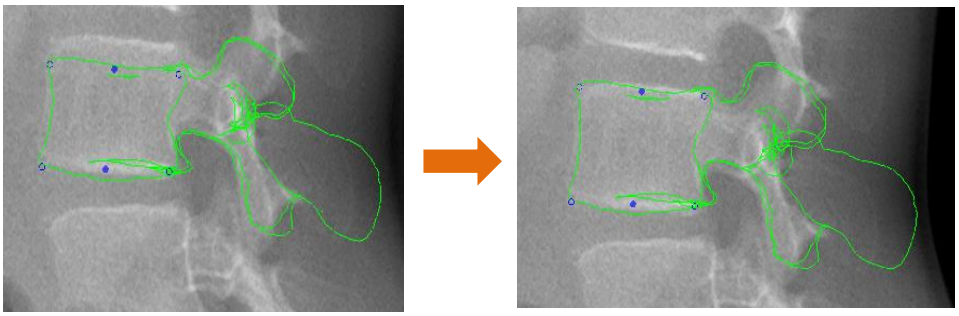




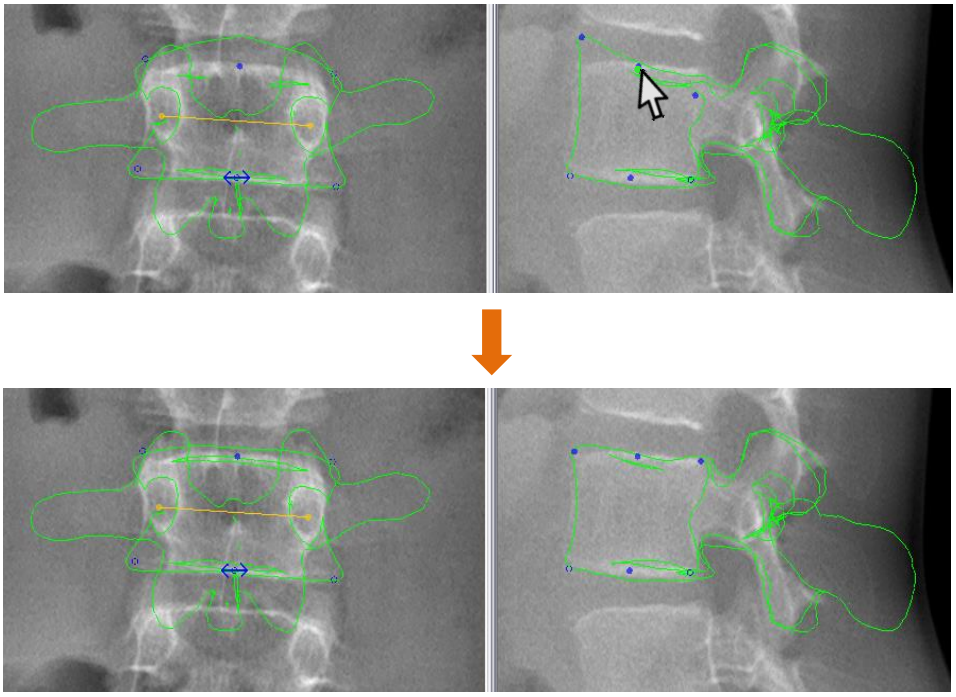
- Centers of pedicles
- Centers of vertebral plates
- Right lateral points of vertebral plates
- Left lateral points of vertebral plates
- Anterior points of vertebral plates
- Posterior points of vertebral plates

For each vertebra, simultaneously work on the **frontal** and **lateral** views:

1 Move the blue control points (left-click) to fit the contour of the vertebral model to the radiographic contour



2 If necessary, modify the orientation of the plates: left-click on the central control point of the vertebral plate and scroll the mouse wheel



3 Position the yellow control points in order to adapt the pedicules of the model to the ones on the radiographic image.

Notes

To ensure a consistent and accurate orientation of the model, for each vertebra, check that:

- On the frontal view, the spinous processes on the model and the image are aligned
- On the frontal view, the lines representing the vertebral plates are parallel to each other and to the ones representing the pedicles
- On the lateral view, the lines representing the vertebral plates are parallel

IV. Fast 3D Modeling of the Spine

The Fast Spine 3D workflow (see 2.3 Spine Settings) is particularly adapted to follow-up exams.

In this workflow, the following steps will be similar to the full 3D workflow:

3.2 Spine Identification
3.3 Global Adjustment

The fine adjustment will only concern the vertebrae involved in the lordosis, kyphosis and in the Cobb angles calculation.

4.1 Lordosis/Kyphosis

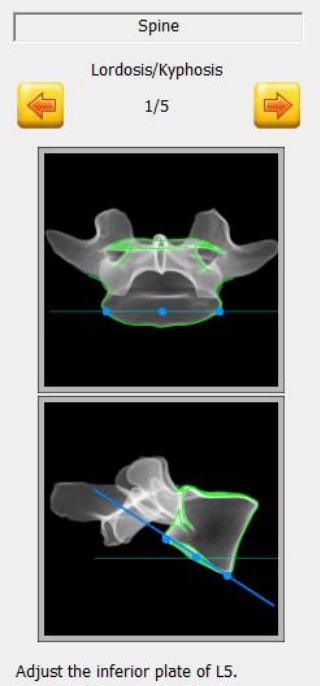
Objective: Adjust the orientation of the vertebral plates involved in the calculation of the lordosis/kyphosis angles

Simultaneously work on the **frontal** and **lateral** views:

1. Adapt the contour of the vertebral model to the radiographic contour: left-click on a control point, hold the click and drag the point to the desired location.

2. If necessary, modify the orientation of the plate: place the cursor on the central control point of the vertebral plate and scroll the mouse wheel.

It is essential to verify that the blue bars correctly reflect the orientation of the concerned vertebral plate.



Adjust the inferior plate of L5.

4.2 Scoliosis

Objective: Adjust the position and orientation of the vertebrae involved in the calculation of the Cobb angles

Cobb angles will be identified in the same way as 3.4 Curve Identification. Fine adjustment (as in 3.5 Vertebral Rotations) is only needed on the vertebrae involved in the Cobb angles.

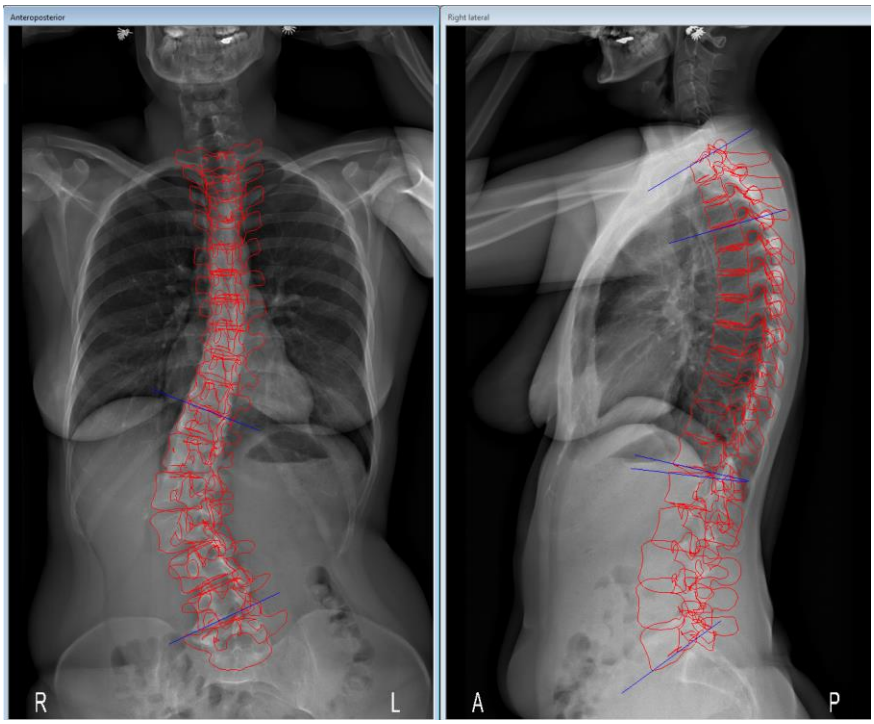
V. Validation Step

Validation is the final step of the modeling. The whole spine model is displayed and has to be validated by the user. If corrections are needed, right-click on the model to display the control points.

For a precise calculation of the Cobb angles and the lordosis/kyphosis parameters, it is essential to ensure that:

- **Blue bars** (lines representing the vertebral plates for the Cobb angles or kyphosis/lordosis angles) correctly reflect the orientation of the plates on both views
- **Spinous processes** follow each other along a coherent curve
- **Vertebral anterior and posterior walls** continuously follow each other on the lateral view

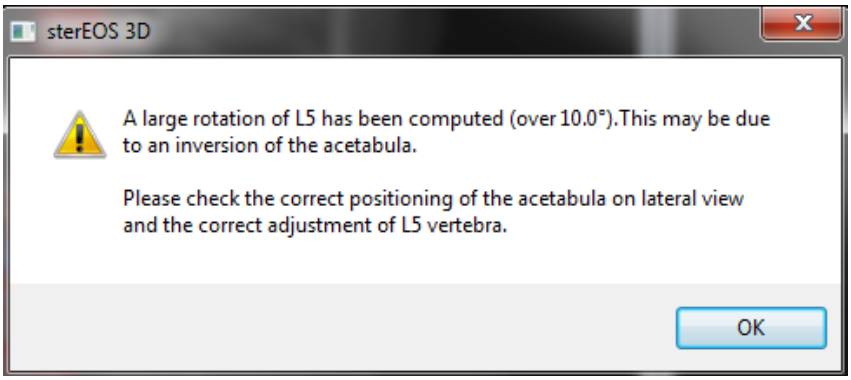
Note: If the Fast 3D workflow was selected, only the vertebrae involved in the Cobb angles or kyphosis/lordosis angle calculation should be modified.



VI. Results Step

At this step, the computed clinical parameters are displayed on the radiographic images.

If a strong vertebral rotation of L5 has been detected, a pop-up opens. This may be due to an inversion of the acetabula on the lateral view. This can be corrected by going back to the identification of the pelvic parameters. Skip the steps until the results.



On the radiographic images, clinical results annotations can be moved:

- Right-click to select them (they turn green)
- Left-click and drag them to change their position

The result step gives access to a 3D model and a clinical parameters sheet.

- To open the 3D model viewer, click on 
- To display the clinical sheet, click on 

The 3D model and clinical parameters may be exported in a patient report (see VII. Patient Report)

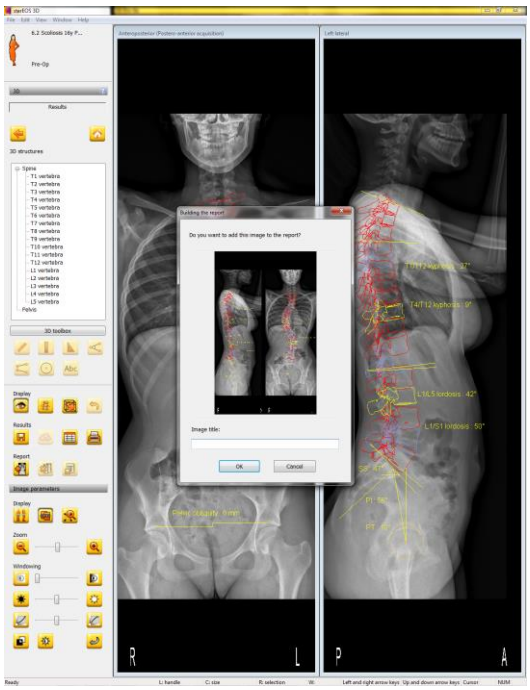
VII. Patient Report

To create a report:

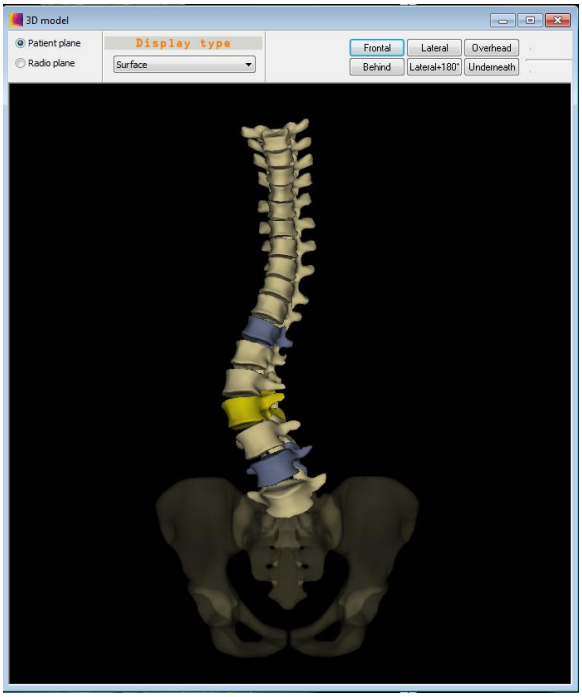
1. **Save the 3D Secondary Capture (3D SCPT)** by clicking on 

2. Add data to the report:

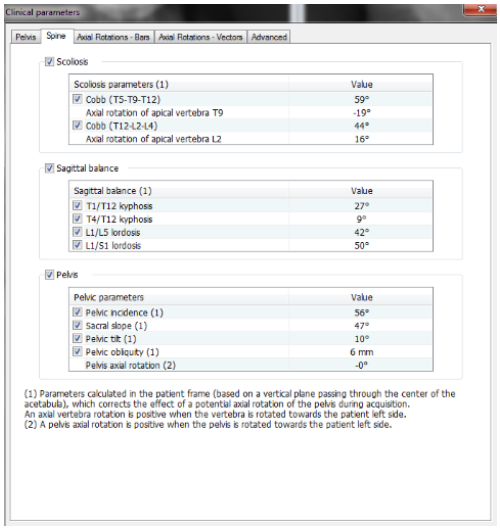
   - To add a screenshot of frontal and lateral views, click on 



   - To add a **3D model** to the report, open the 3D viewer  and click on  . Different views (frontal, lateral, overhead…) can be added.

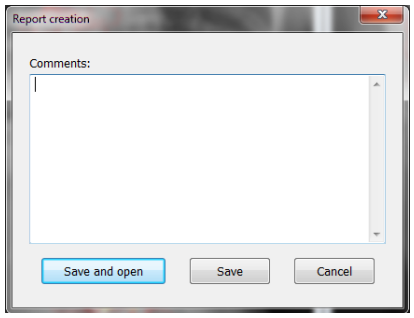


- To add the **clinical parameters** to the report, open the clinical sheet  and click on 



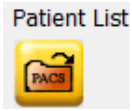
3. Save the report by clicking on 

- Add comments in the report creation window if needed. They will appear on the last page of the patient report

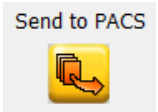


- Click on **Save** to create a report in **DICOM** format.
- Click on **Save and Open** to create a report in **.rtf** format. The report will automatically open in Microsoft Word®. It can be converted in DICOM format by clicking on 

4. The 3D SCPT and the patient report in DICOM format will be automatically saved in the patient list in sterEOS 2D.

- Click on 

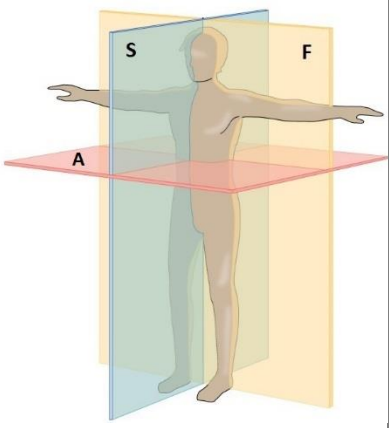
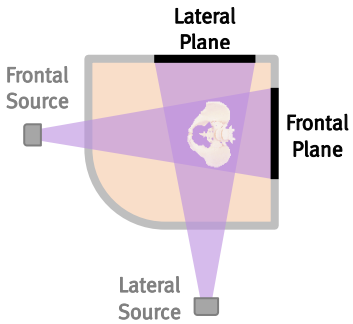
- Select and open the 3D SCPT and the patient report.

5. Click on 

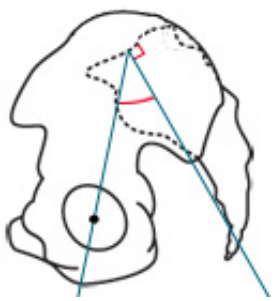
VIII. Clinical Parameters

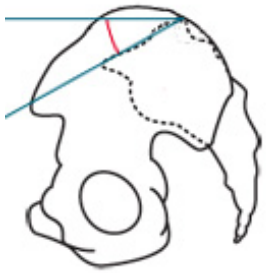
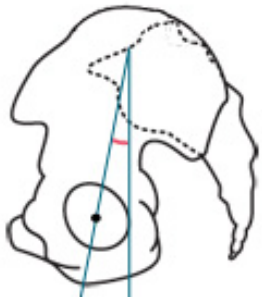
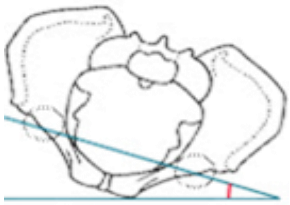
Note:
If the **pelvic parameters** were computed, the spinal parameters are calculated in the **patient's reference planes** which correct the effect of a potential axial rotation of the pelvis during the acquisition.
If the pelvic parameters were not computed, the spinal parameters are calculated in the **radio planes** (planes of the image).

- **Reference planes**

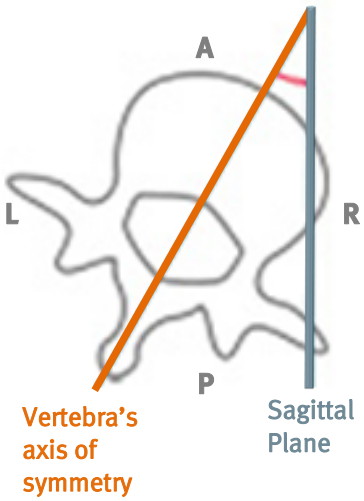
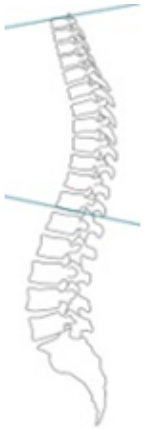
Category	Name	Description	Illustration
Patient's Reference Frame	Patient's Frontal Plane	Vertical plane containing the line connecting the centers of the acetabula (acetabular axis).	
	Patient's Sagittal Plane	Vertical plane passing through the midpoint of the acetabular axis. **Note:** This plane is perpendicular to the patient's frontal plane. This plane allows for PI, SS and PT measurements not to be impacted by an axial rotation of the pelvis during the acquisition.	
	Patient's Axial Plane	Horizontal plane	
Radiographic Reference Planes	Frontal Radio Plane	Acquisition plane of the frontal detector	
	Lateral Radio Plane	Acquisition plane of the lateral detector	

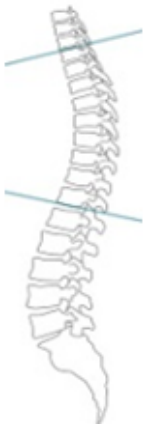
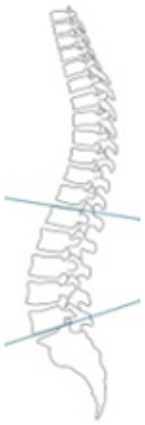
- **Pelvic parameters**

Category	Name	Description	Illustration
Pelvis	Pelvic incidence (PI)	Angle defined in the patient's sagittal plane between the: • Line perpendicular to the sacral plate at its midpoint. • Line connecting the midpoint of the sacral plate and the midpoint of the acetabular axis. **Pelvic incidence = sacral slope + sagittal pelvic tilt**	

Category	Name	Description	Illustration
	Sacral Slope (SS)	Angle defined in the patient's sagittal plane between the: • Sacral plate • Horizontal axis **Note:** When the pelvis is rotated backwards, the sagittal pelvic tilt increases and the sacral slope decreases. When the pelvis is rotated forward, the sagittal pelvic tilt decreases and the sacral slope increases.	
	Sagittal pelvic tilt (PT)	Angle defined in the patient's sagittal plane between the: • Line connecting the midpoint of the sacral plate and midpoint of the acetabular axis • Vertical axis **Note:** When the pelvis is rotated backwards, the sagittal pelvic tilt increases and the sacral slope decreases. When the pelvis is rotated forward, sagittal pelvic tilt decreases and sacral slope increases.	
	Pelvic Obliquity	In the patient's frontal plane, distance between the highest point of each acetabulum, calculated along the vertical axis.	
	Pelvis Axial Rotation	In the axial plane, angle defined between the: • Acetabular axis • Frontal radio plane **Note:** This parameter is the only one that is not calculated in the patient's reference frame	

- **Spinal parameters**

Category	Name	Description	Illustration
Scoliosis	Vertebra's Axial Rotation	Angle defined by: • The patient's sagittal plane, • The vertebra's axis of symmetry **Note:** The axial rotation is positive when the vertebra is oriented toward the left side of the patient viewed from the top.	
	Cobb Angle	Angle defined in the patient's frontal plane between: • The upper plate of the upper junctional vertebra • The lower plate of the lower junctional vertebra **Note:** This value is always positive.	
Sagittal Balance	Kyphosis T1-T12	Angle defined in the patient's sagittal plane between the: • Upper T1 plate • Lower T12 plate	

Category	Name	Description	Illustration
	Kyphosis T4-T12	Angle defined in the patient's sagittal plane between the: • Upper T4 plate • Lower T12 plate	
	Lordosis L1-L5	Angle defined in the patient's sagittal plane between the: • Upper L1 plate • Lower L5 plate	
	Lordosis L1-S1	Angle defined in the patient's sagittal plane between the: • Upper L1 plate • Tangent to the sacral plate