



**Islamic Azad University**  
**Tehran Medical sciences**

## Utilization of Artificial Intelligence in Pre-operative Planning of Complex Spine Surgery

**Payman Vahedi, MD**

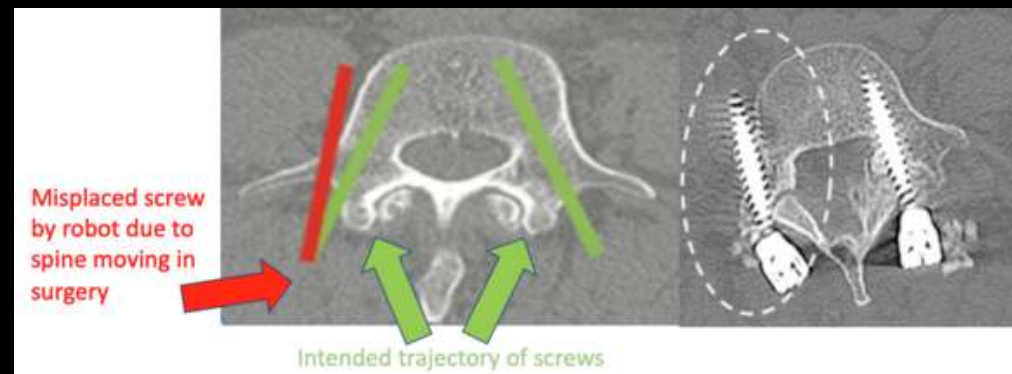
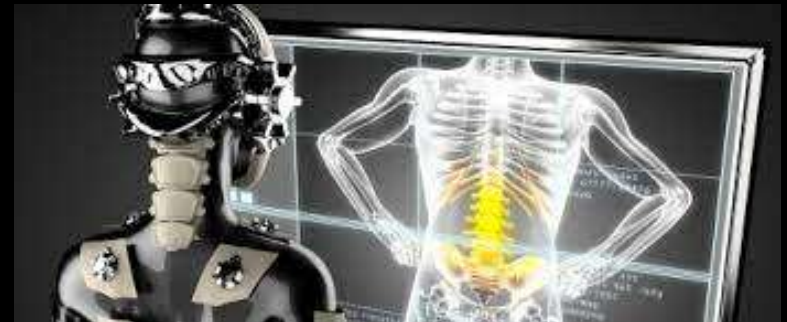
**Assistant Professor of Neurosurgery**  
**Fellowship in Spine Surgery**  
**Dept of Neurosurgery**  
**IAU**



# Intro

Digital technology : A new armamentarium in spine deformity surgery

Multiple pre-operative planning software systems are available to assist in deformity assessment and surgical planning for correction



# Intro

Using software analysis of X-ray, CT and MRI, surgeons have more tools than ever before to provide precise measurement of deformity and facilitate preoperative planning

Inadequate pre-operative planning can lead to continued sagittal imbalance and poor surgical outcomes



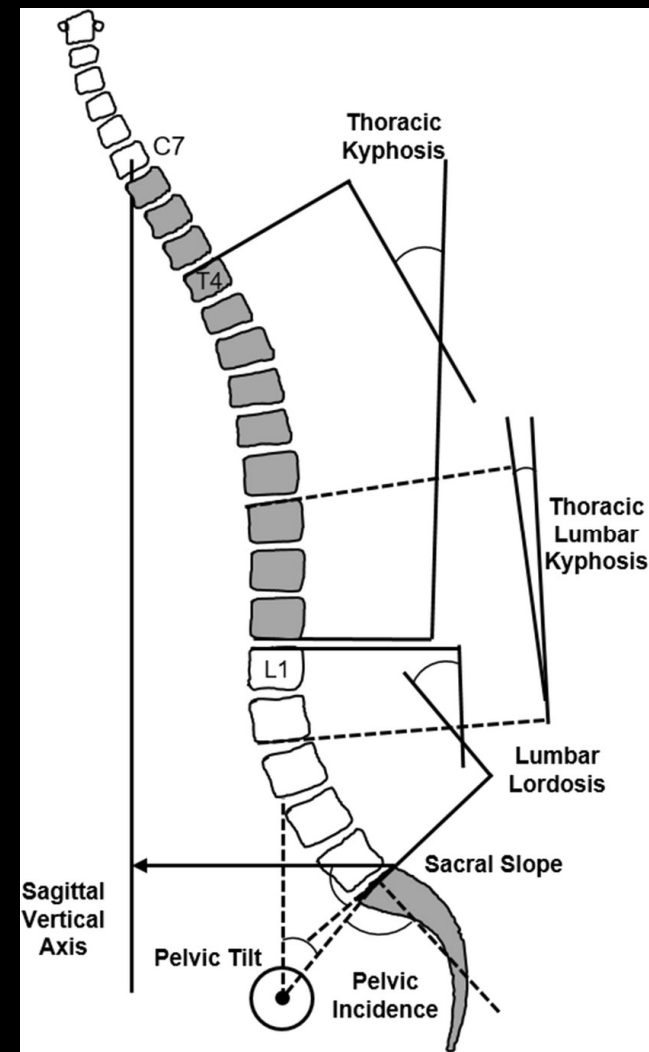
# Basic Concepts in Deformity Surgery

Prerequisite: A knowledge of relationship between spinal and pelvic parameters

Ultimate goal:

Preventing fatigue

↑ Bio-mechanical efficiency of the spinal muscles and their relationship to the pelvis



# Current Status of DSS

Digital measuring systems have become widely accepted

Decreased planning time

Improved accuracy

Reduced human measuring error



# Available Softwares

NuVasive'sPulse

Hectec GmbH's mediCAD

K2M's Balance ACS

EOS

Surgimap

Measure pre-operative parameters

Planning osteotomies

Improving the accuracy of screw placement

Tracking outcomes of surgery

Generation of 3D models

Customized instrumentation and implants through 3D printing

Pre-cut rods



# Surgimap®

The Physician Driven Imaging Solution®

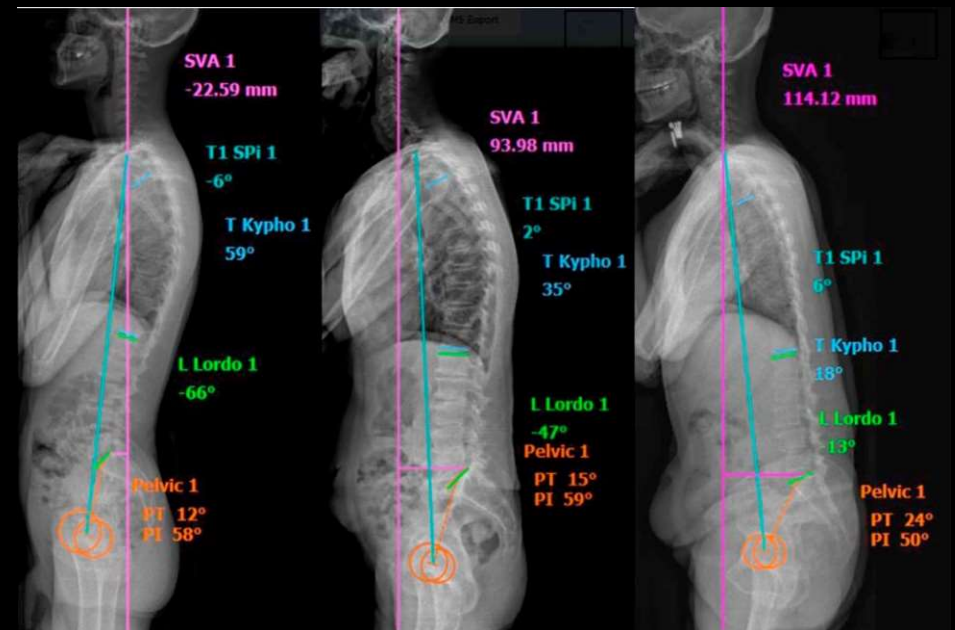
Surgimap(Nemaris, Inc.,  
NewYork,USA)

Uploads images from any  
database

**Measures** parameters  
relevant for preoperative  
deformity correction

Planning of **pedicle screws**,  
**cages**, and **osteotomies** to  
restore sagittal and coronal  
balance

**Simulates** postop images



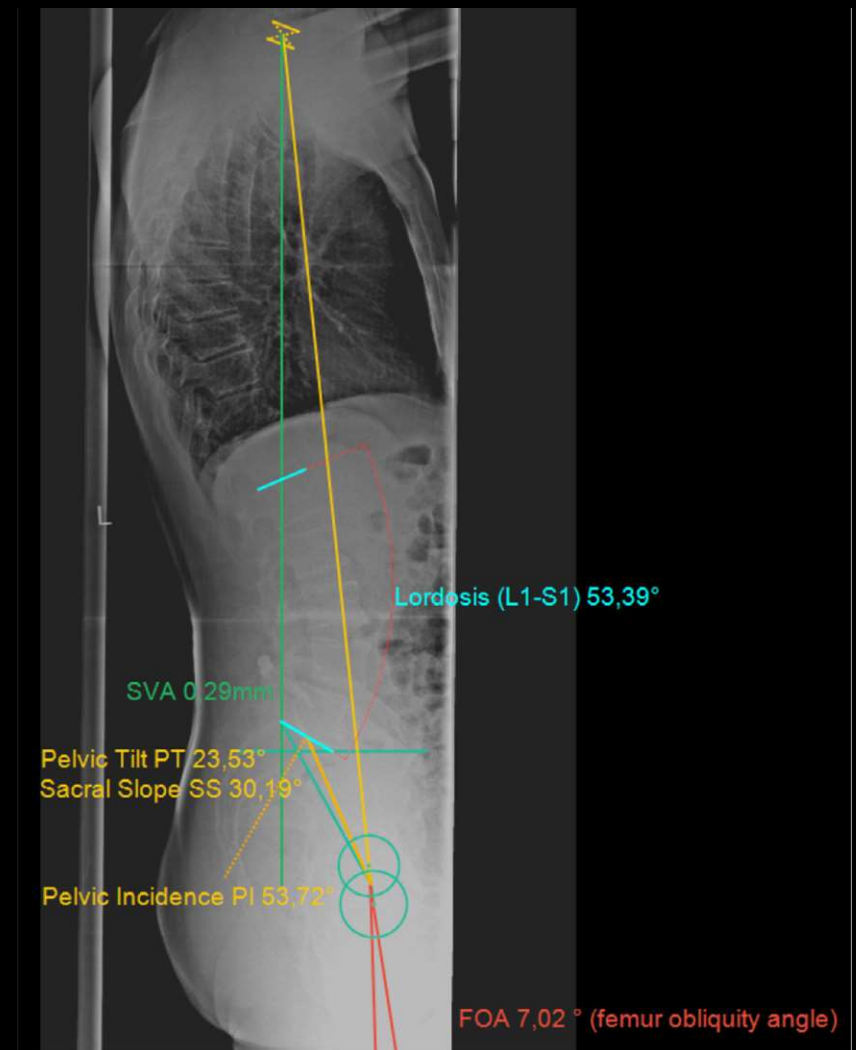
# Hectec GmbH's MediCad

Provides suggested **osteotomy angles**

Can be adjusted intraoperatively to reflect the course of the surgery

**Simulates** different approaches and hardware types

Rod lengths, contouring and insertion can be modelled and adjusted intraoperatively





# Pulse (Nuvasive)

Combines multiple technologies including pre-operative planning software, **Intra-operative imaging** and **Navigation**, and **IONM** in to a single system

## Supporting 100% of spine

Procedure category	Pulse*	Standalone navigation	Standalone robotics
ACDF	●		
PCF	●	●	
PLIF	●	○	○
TLIF	●	○	○
ALIF	●		
XLIF	●	○	
TL posterior fusion	●	●	●
Deformity	●	●	●
Revision	●	●	●
Trauma	●	●	●
Decompression	●		
Microdiscectomy	●		
Spinal cord stim	●		
Spine cord (tumors, untethering, rhizotomy)	●		
Corpectomy (tumors, infection)	●	●	●
Kyphoplasty, SI fusion	●	●	○

● Supports procedure      ○ May support procedure

\*The Pulse platform can be used in every spine procedure; however, not all modalities are cleared for every spine procedure. Refer to Pulse system instructions for use.

# K2M Balance ACS

Integrates Surgimap software to allow for preoperative planning for deformity correction

Allows screw placement

Cage placement

Rod placement

Wedge osteotomies

Predicts deformity correction in the sagittal, coronal and axial planes

Offers 3D printed anatomical models from CT imaging and 3D printed, customizable implants

# Spine EOS( EOS imaging, Paris, France)

**Pioneer** in spine digital technology

Unique Features:

Focus of study on **AIS**

Use of **low-dose xray modality**

Advantages

**Creates 3D images from 2D**  
stereoradiographic input

No need for high radiation doses of CT  
imaging

Uses low-dose X-rays to assemble the 3D  
reconstruction using sterEOS, a  
software platform available through  
EOS.



# DSS at IAU Spine Section



2018-Now

64 ASD patients

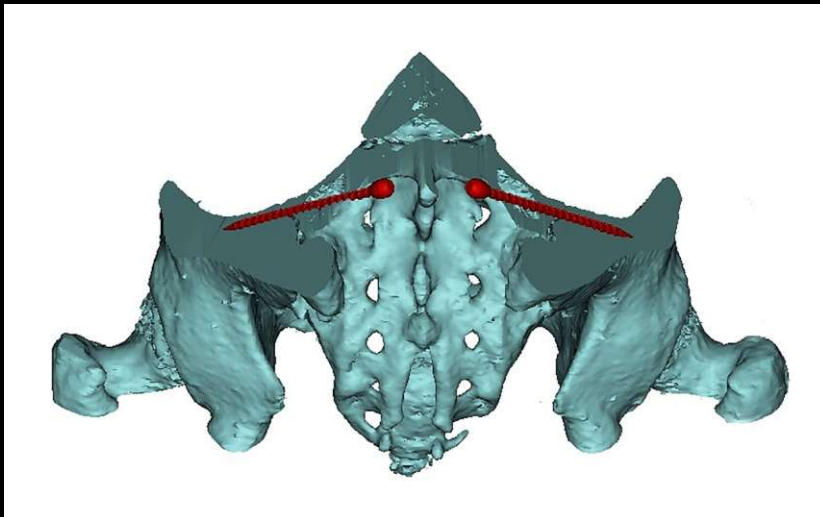
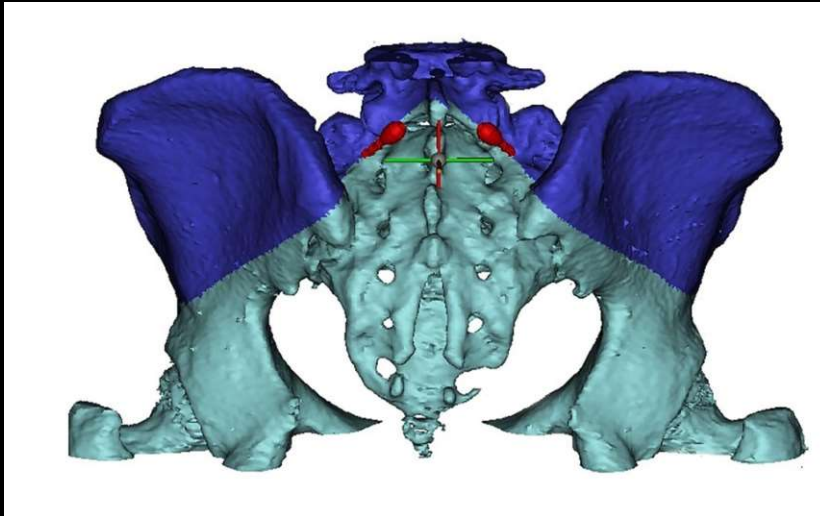
Preop planning (Surgimap)

3D Spinopelvic Models  
(Materialize MIMICS)

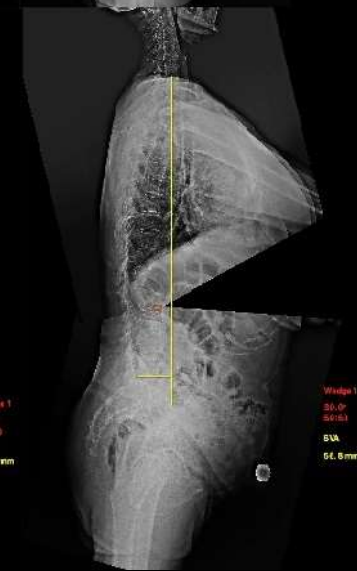
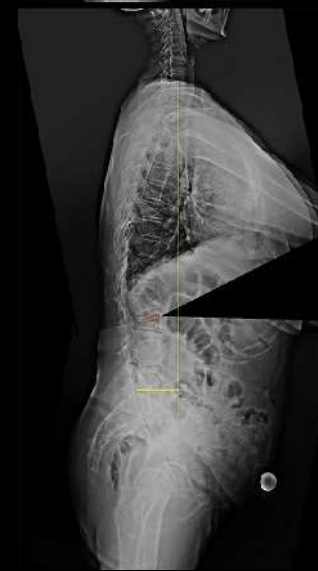
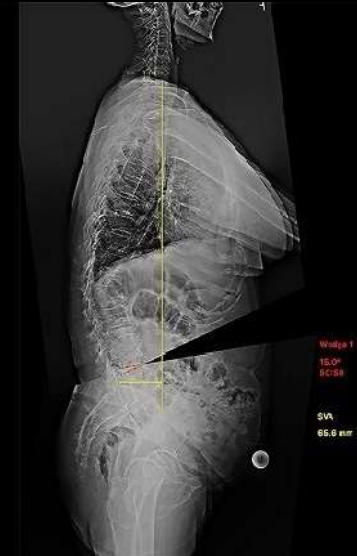
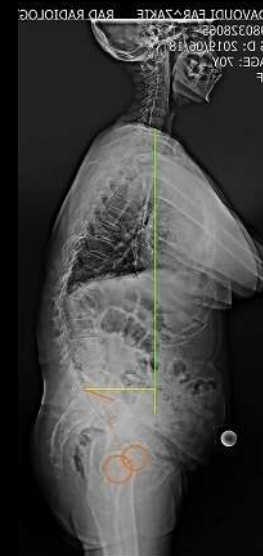
23 PSO

47 combined S1AI & S2AI  
screws

## MIMICS Materialize 3D Spinopelvic Model



## Surgimap PSO Simulation







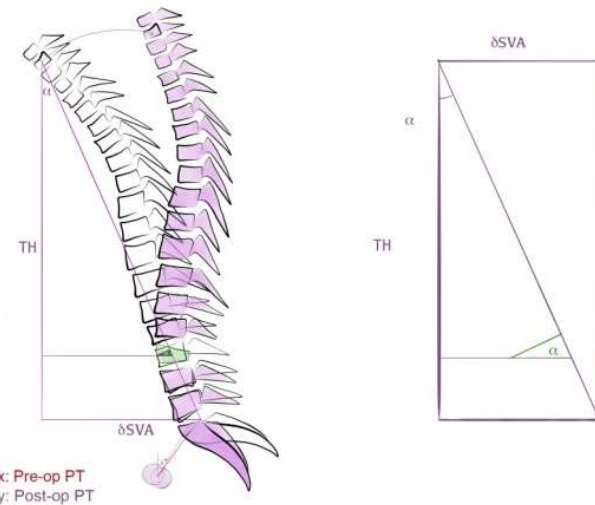
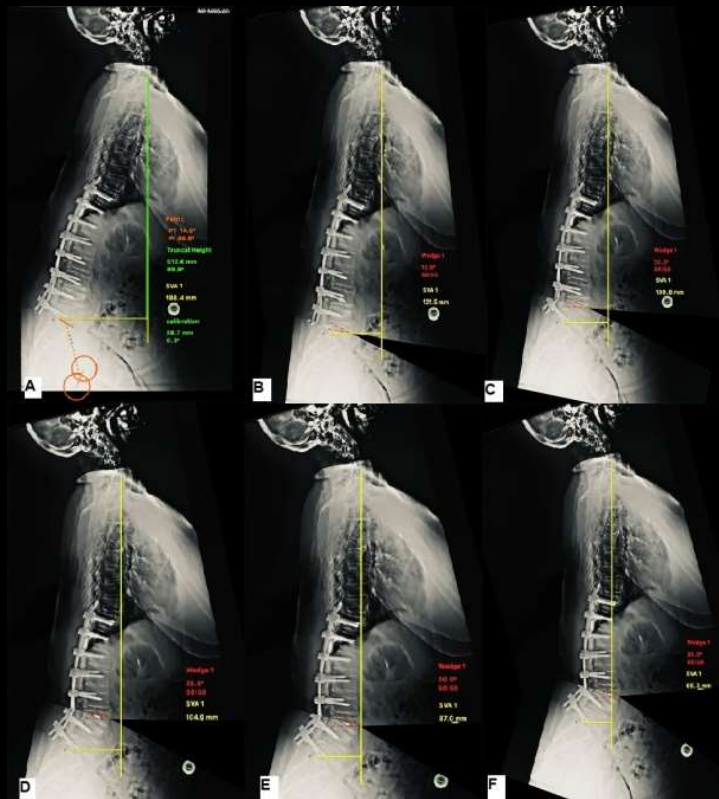
Turkish Neurosurgery

Modified Ondra's Formula to Predict Post-Op SVA after Lumbar PSO: A Preliminary Report Verified by Simulated Post-op Images Via Surgimap Software

Ghazal Shahbakhsh<sup>1</sup>, Zahra Vahedi<sup>1</sup>, Payman Vahedi<sup>1</sup>

<sup>1</sup>BouAli Hopsital of Islamic Azad University of Medical Sciences, Neurosurgery, Tehran,

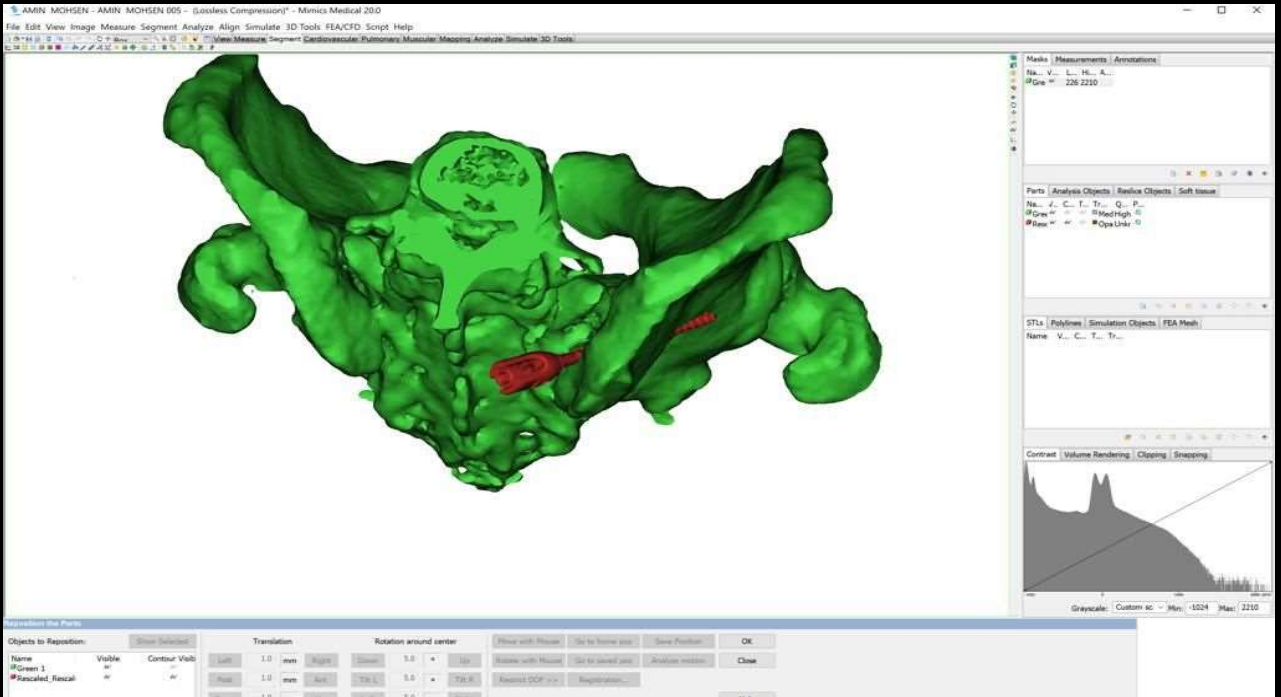
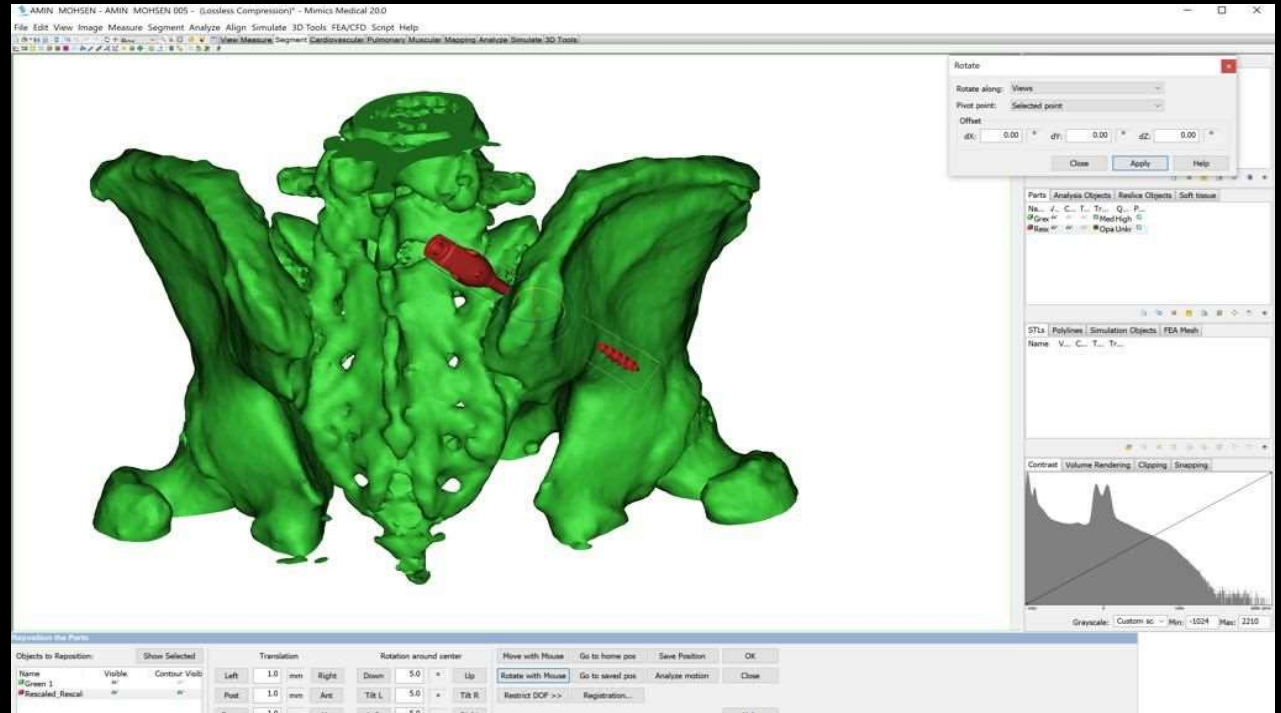
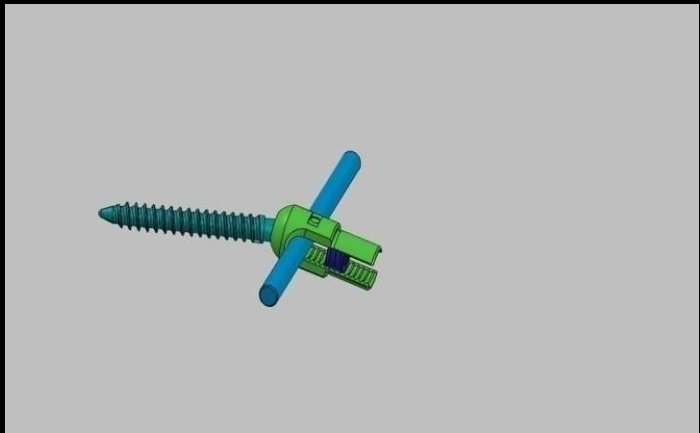
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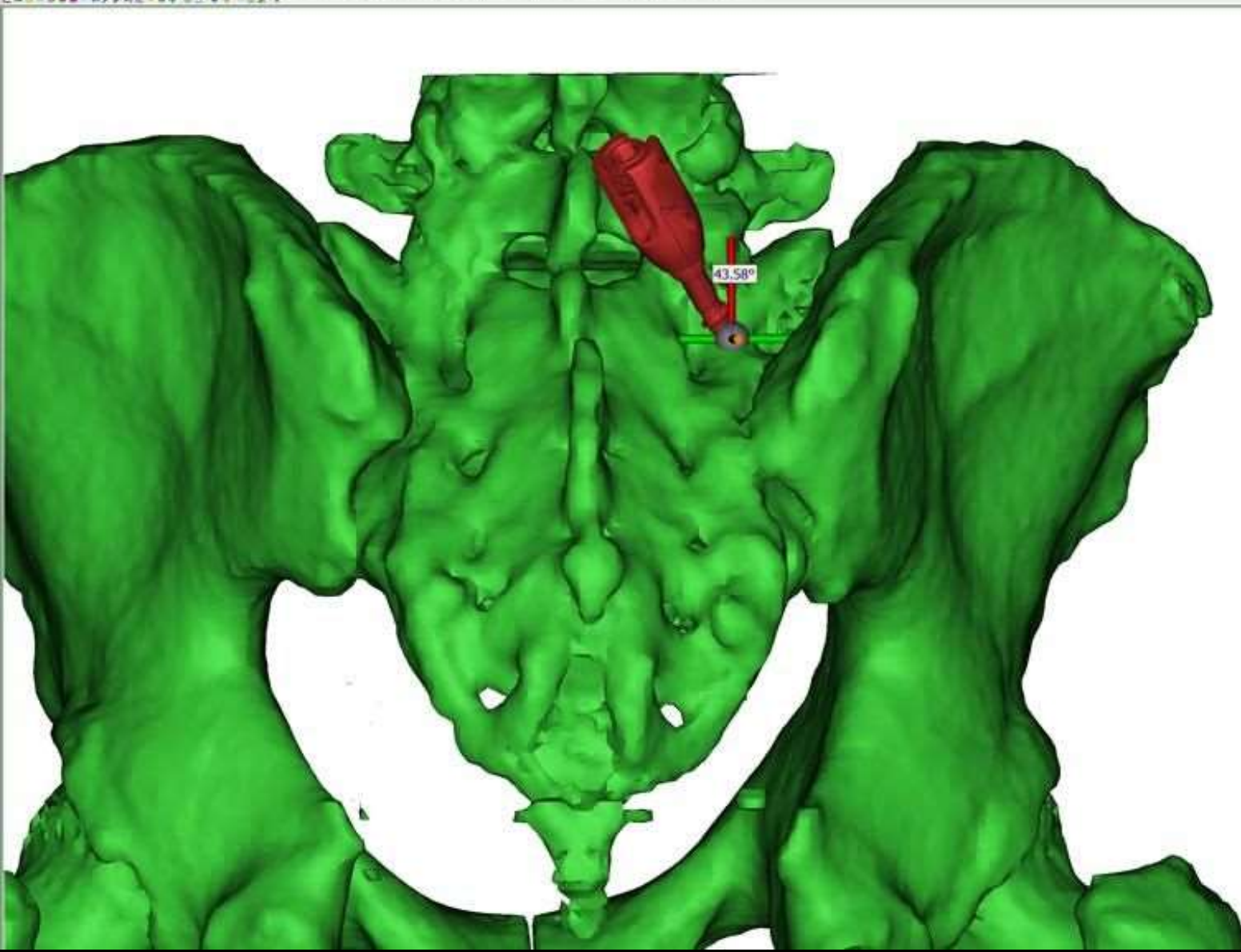


x: Pre-op PT  
y: Post-op PT

$$\Delta SVA = TH \times 0.017 \times PSO \text{ Angle}^\circ \times K$$







Measures | Measurements | Annotations

No...	V...	L...	H...	A...
#Gre				226 2210

Parts | Analysis Objects | Realistic Objects | Soft tissue

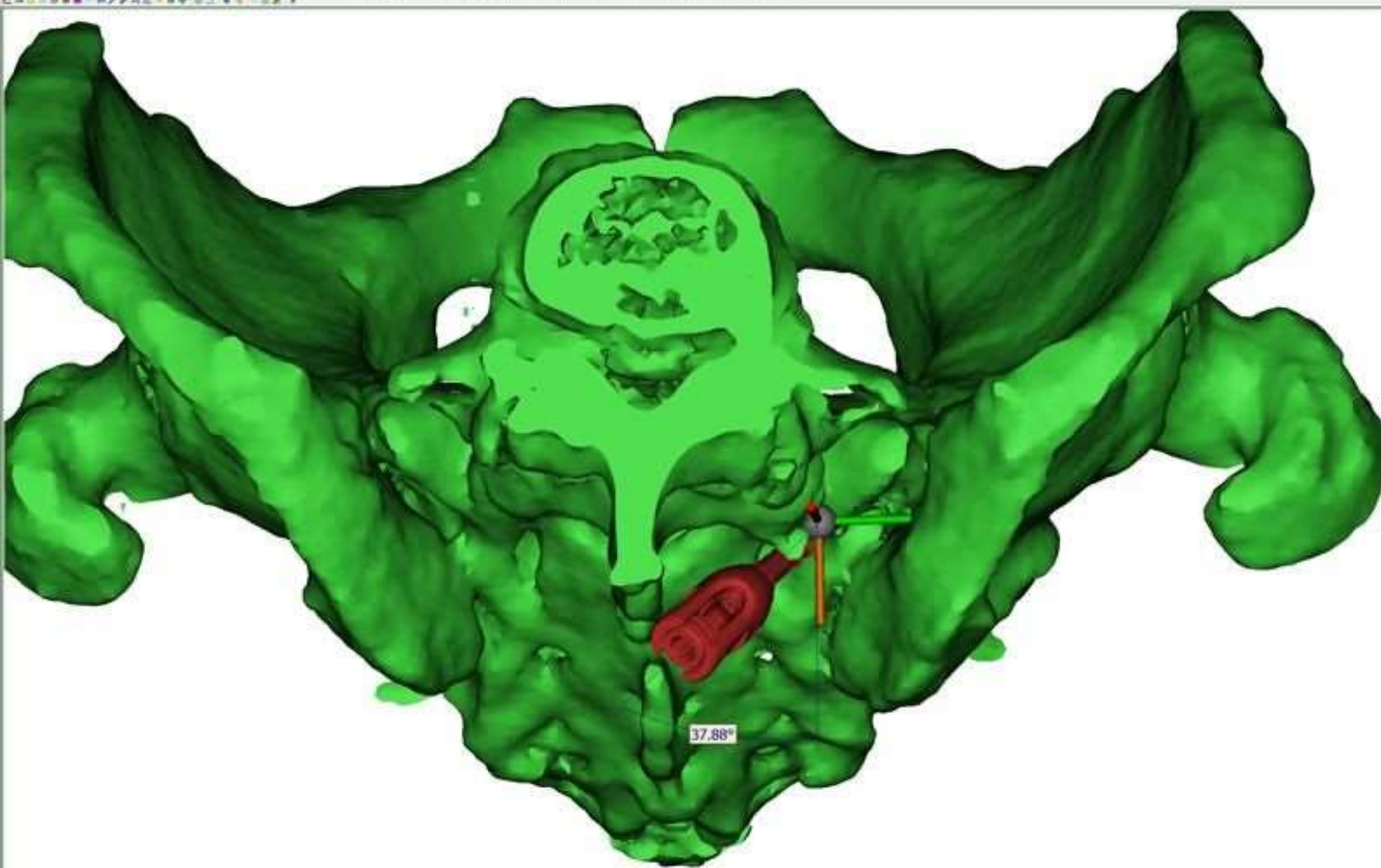
No...	V...	C...	T...	Q...	P...
#Gre				Med High	
#Rau				Ops Unk	

STIs | Polylines | Simulation Objects | FEA Mesh

Name	V...	C...	T...	Tr...
------	------	------	------	-------

Contrast | Volume Rendering | Clipping | Snapping

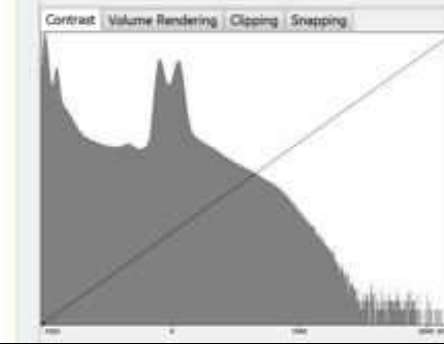
A histogram showing the distribution of volume data. The x-axis ranges from 0 to 2000, and the y-axis represents frequency. The distribution is skewed to the right, with a peak around 1000.



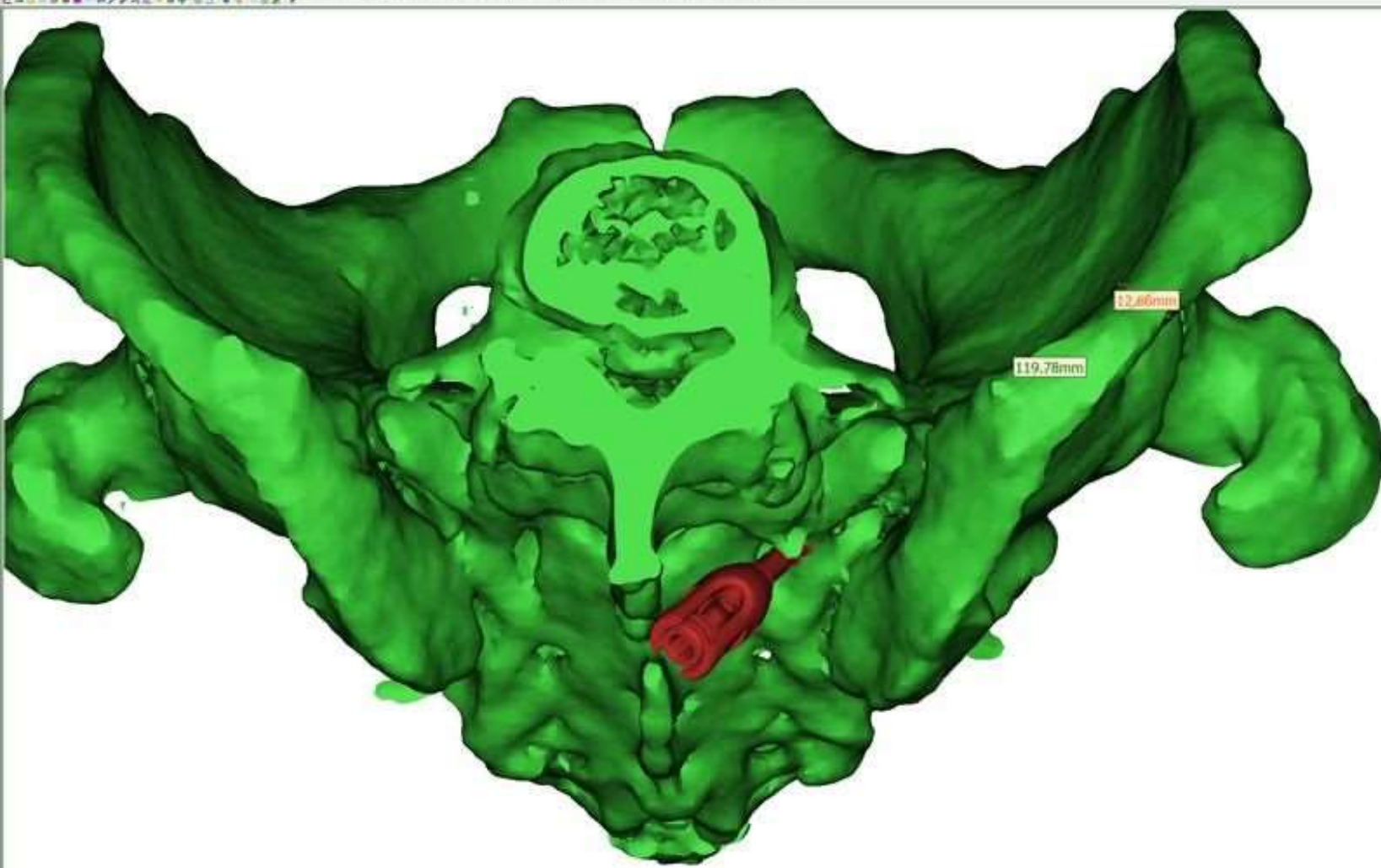
Masks				
Name	V...	L...	H...	A...
Gre				226 2210

Parts				
Name	V...	C...	T...	Q...
Gre				Med High
Res				Ops Unk

STLs				
Name	V...	C...	T...	Tr...







Measures | Measurements | Annotations

No.	V...	L...	H...	A...
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Parts | Analysis Objects | Realize Objects | Soft tissue

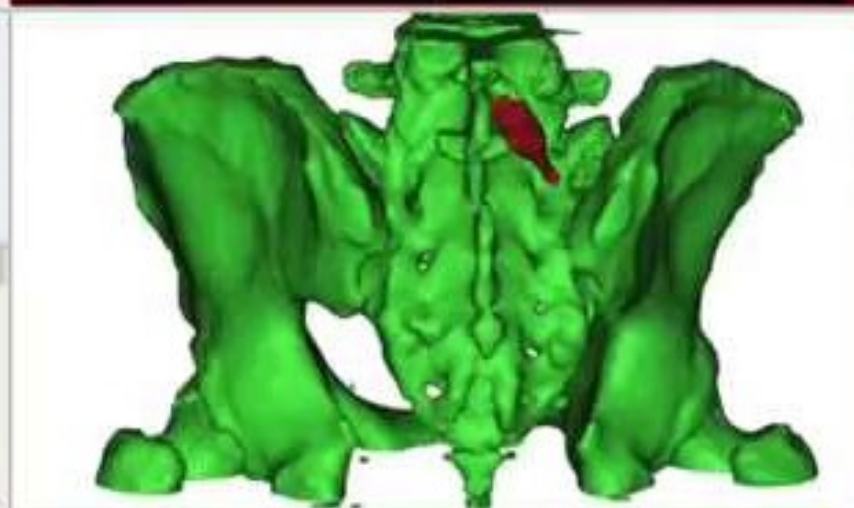
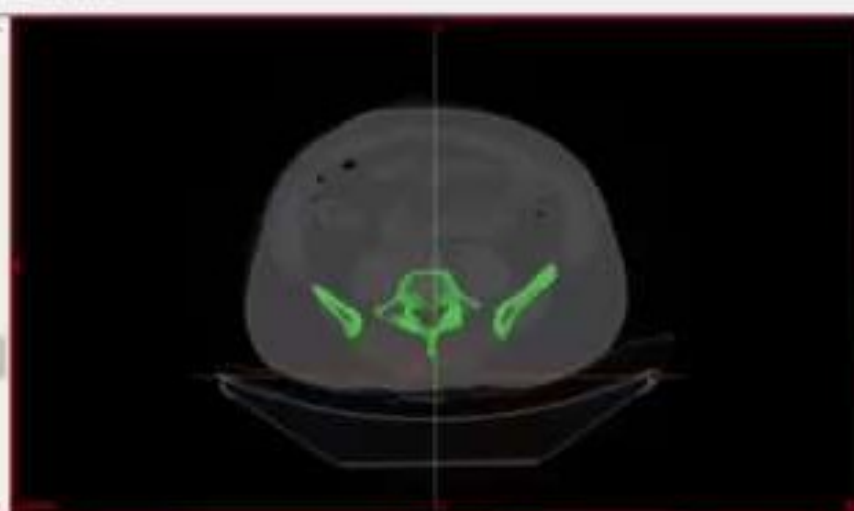
No.	V...	C...	T...	Q...	P...
#Gre				Med High	
#Real				Ops Unk	

STIs | Polyline | Simulation Objects | FEA Mesh

Name	V...	C...	T...	Tr...
------	------	------	------	-------

Contrast | Volume Rendering | Clipping | Snapping

A histogram showing the distribution of values for the selected object. The x-axis represents the value range from 0 to 255, and the y-axis represents the frequency. A diagonal line indicates the current contrast setting.



Parts Measurements Annotations  
No. V. L. R. A.  
File # 228.2193

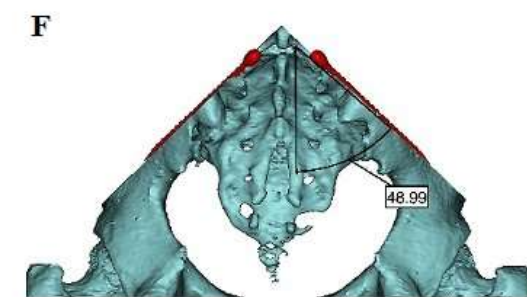
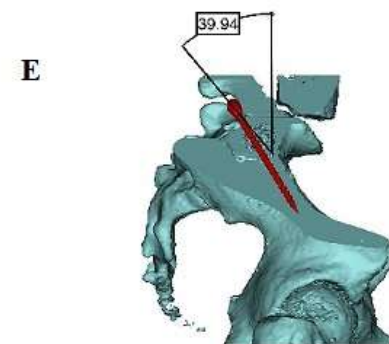
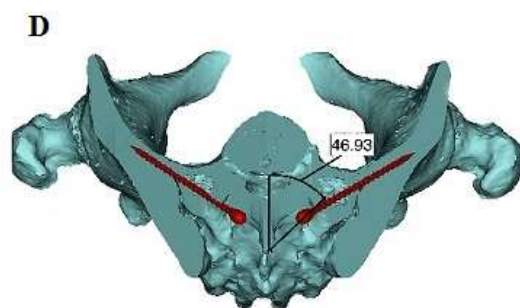
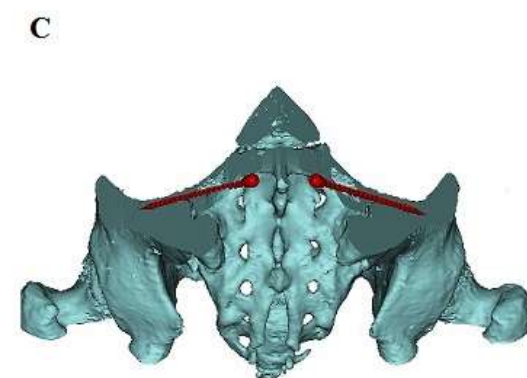
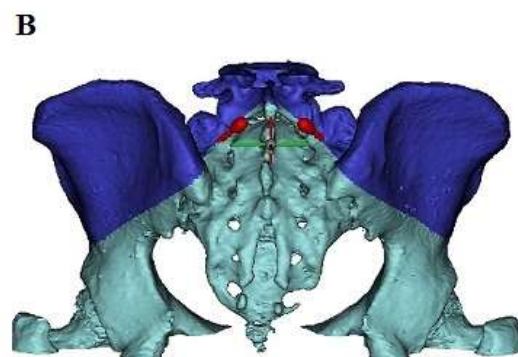
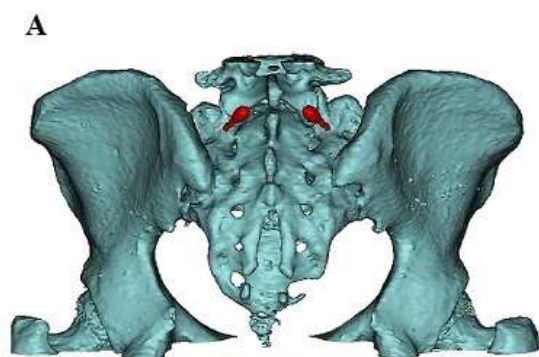
Parts Analysis Objects Active Objects Soft tissue  
No. V. C. T. Tr. Q. P.  
Name - - - - -  
File # - - - - -

STL Properties Simulation Objects FEA Mesh  
Name V. C. T. Tr.

Contrast Volume Rendering Clipping Shading



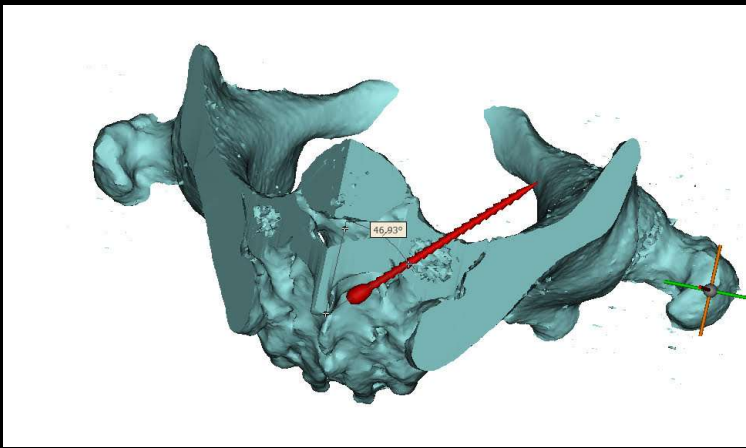
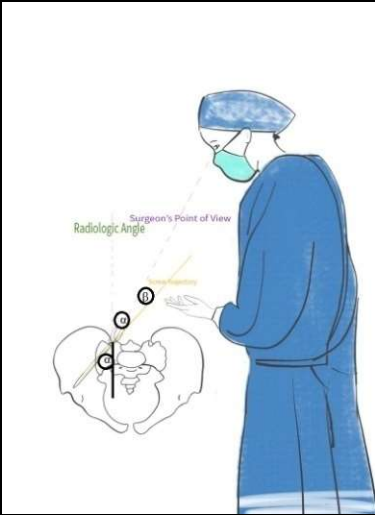
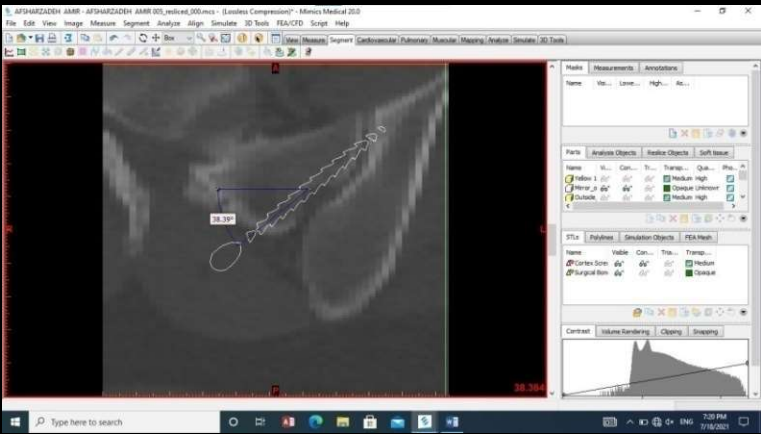
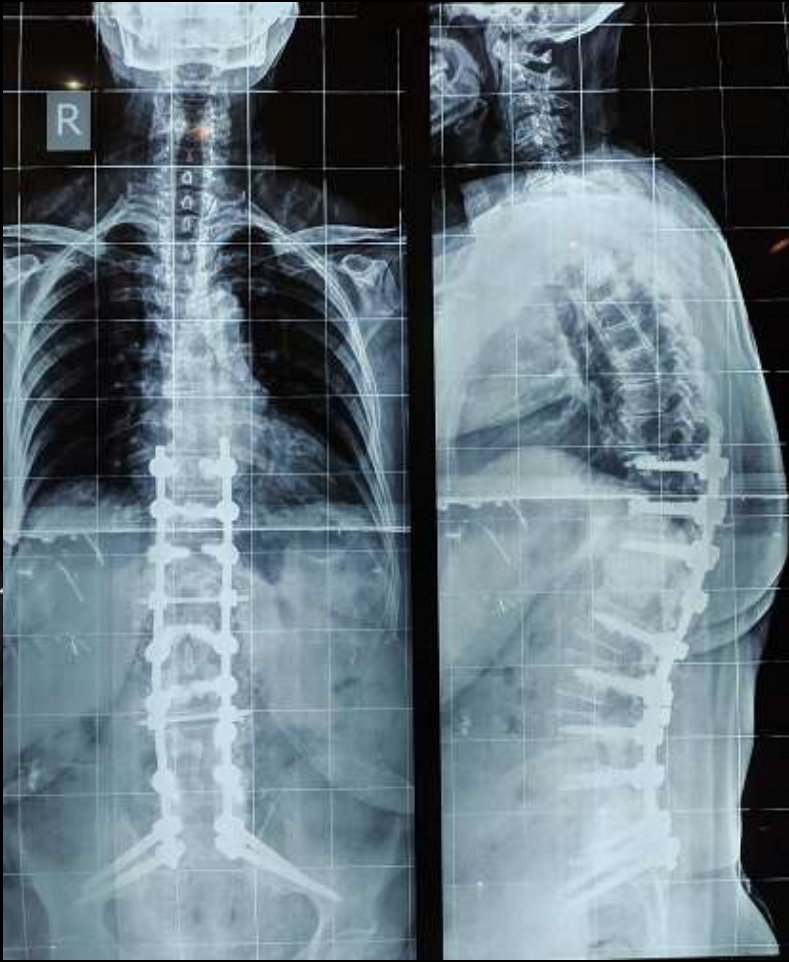
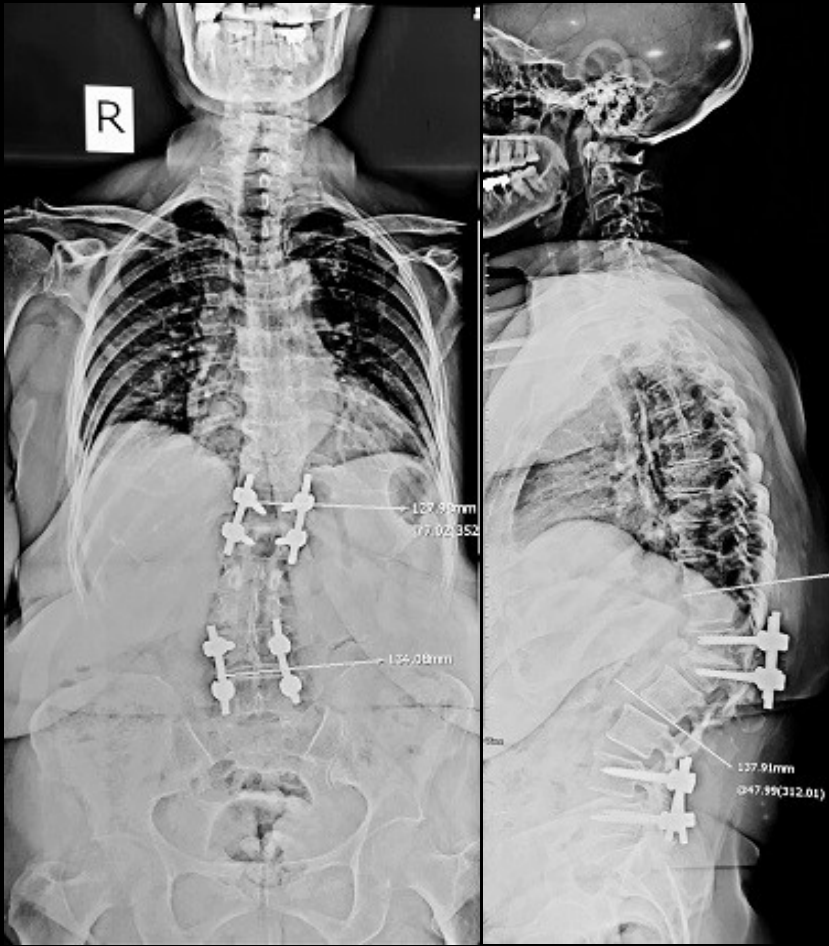
```
17:06] Translate operation applied to the object(s)
Modified object(s): Rescaled_Rescaled_bone screw Assem1
17:17] Translate operation applied to the object(s)
Modified object(s): Rescaled_Rescaled_bone screw Assem1
17:45] Translate operation applied to the object(s)
Modified object(s): Rescaled_Rescaled_bone screw Assem1
17:51] Autosaving
17:52] Save project
File name: C:\Users\ghazal\AppData\Local\Temp\AMN MOHSEN 005_autosave_6752.ecs
17:53] Rotate operation applied to the object(s)
Modified object(s): Rescaled_Rescaled_bone screw Assem1
```





Revision Sx:

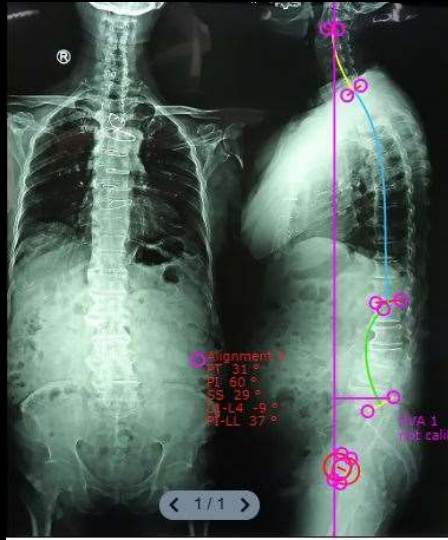
Adult Deg  
Kyphoscoliosis  
After FBSS



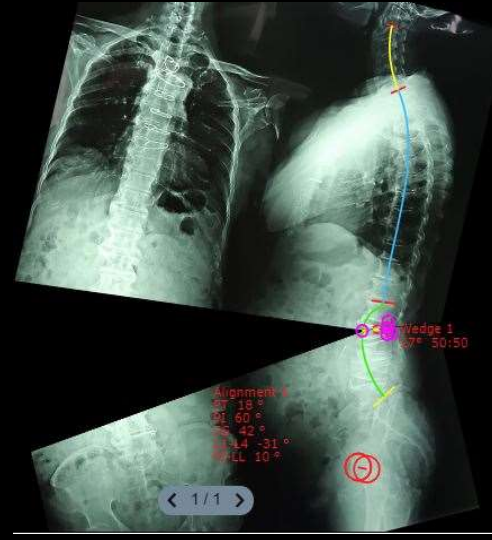
# Revision Sx: Flat Back & FBSS



Preop



Preop SP  
Measurements

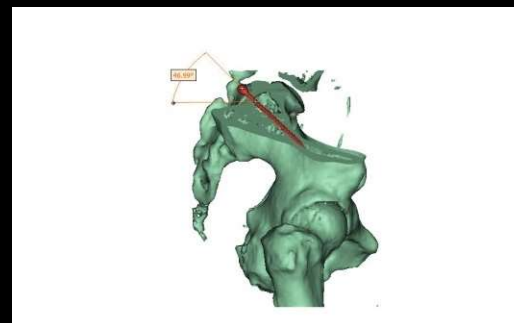
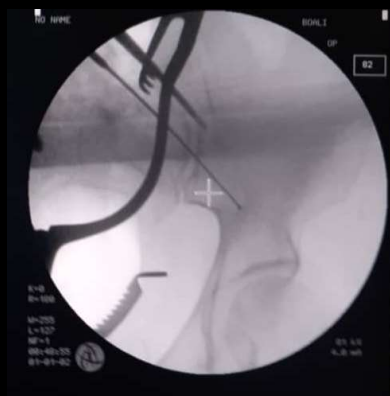


Surgimap  
Simulated PSO



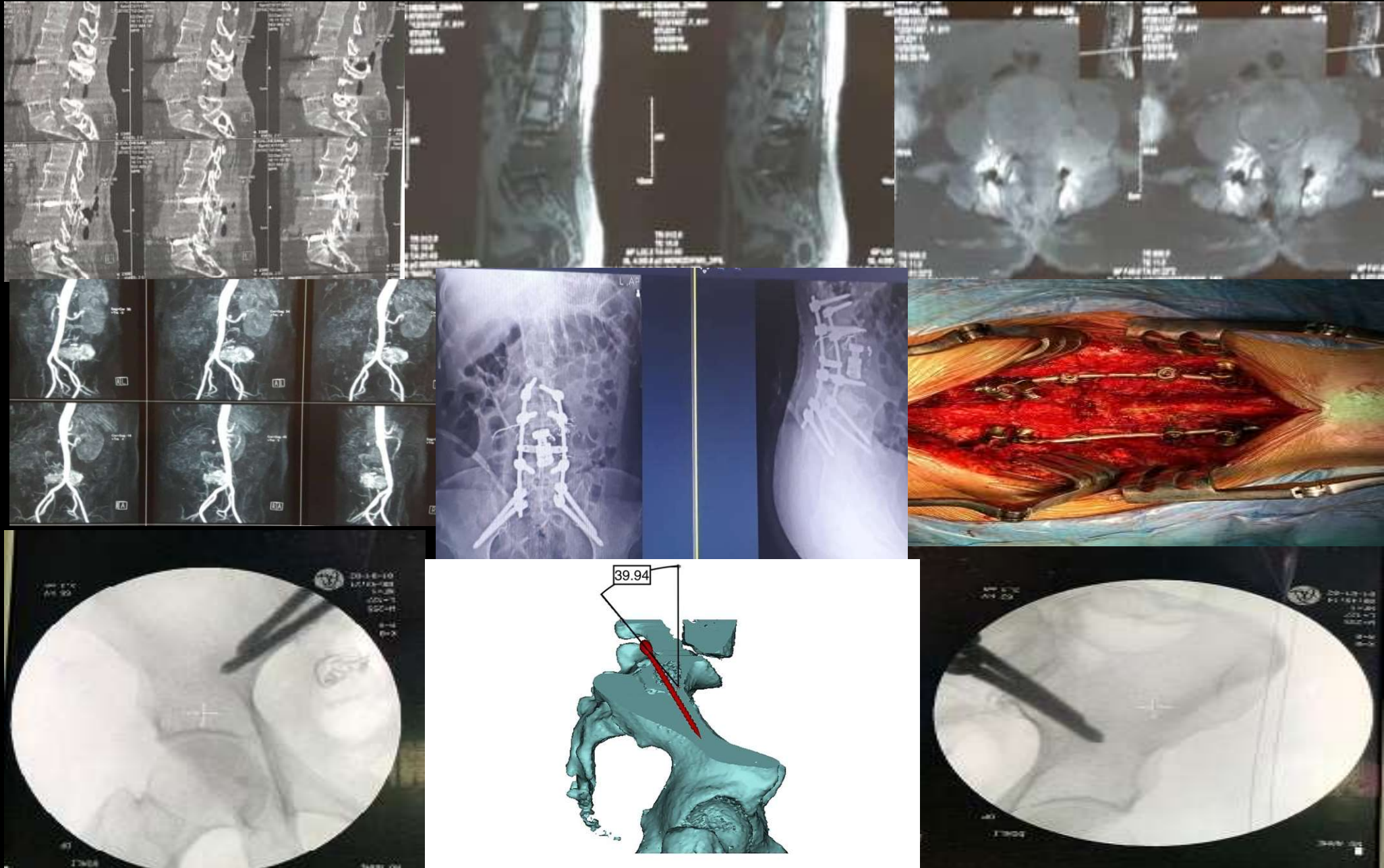
Postop





Revision Sx:  
High Grade Spondylolisthesis-  
4<sup>th</sup> Revision Sx

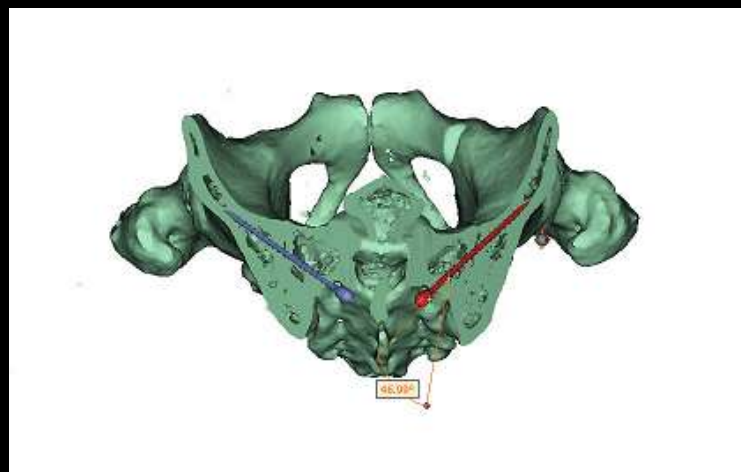
# Highly Vascular L4 Met Revision Sx (Pre-op Embolization+ ASF + PSF)





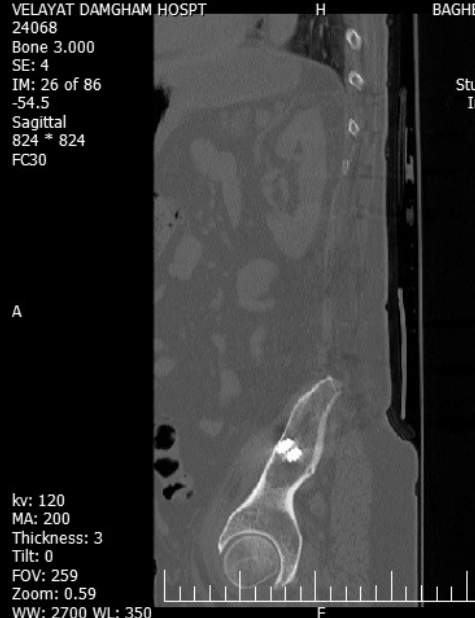


# Revision Sx: L5/S1 Pseudarthrosis After Scoliosis Surgery



VELAYAT DAMGHAM HOSPT  
24068  
Bone 3.000  
SE: 4  
IM: 26 of 86  
-54.5  
Sagittal  
824 \* 824  
FC30

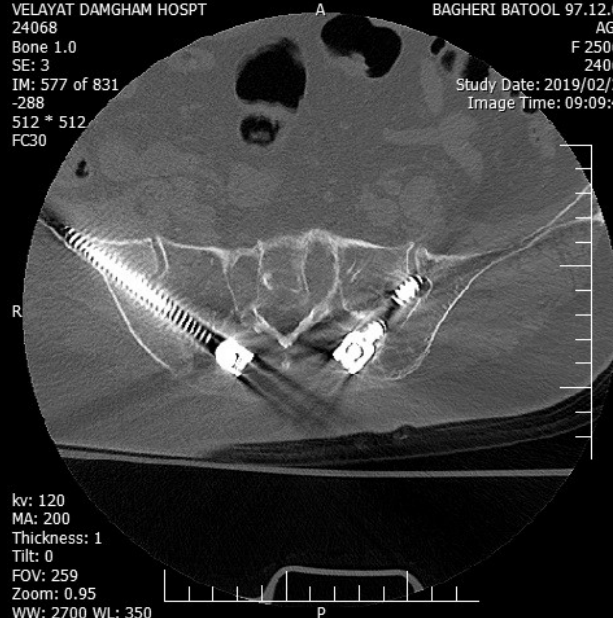
BAGHERI BATOOL 97.12.01  
AGE:  
F 25063  
24068  
Study Date: 2019/02/20  
Image Time: 09:14:59



kv: 120  
MA: 200  
Thickness: 3  
Tilt: 0  
FOV: 259  
Zoom: 0.59  
WW: 2700 WL: 350

VELAYAT DAMGHAM HOSPT  
24068  
Bone 1.0  
SE: 3  
IM: 577 of 831  
-288  
512 \* 512  
FC30

BAGHERI BATOOL 97.12.01  
AGE:  
F 25063  
24068  
Study Date: 2019/02/20  
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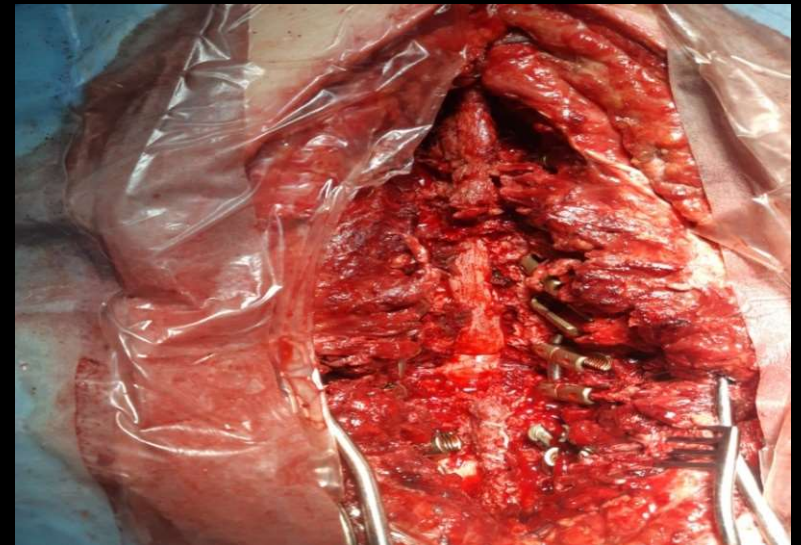
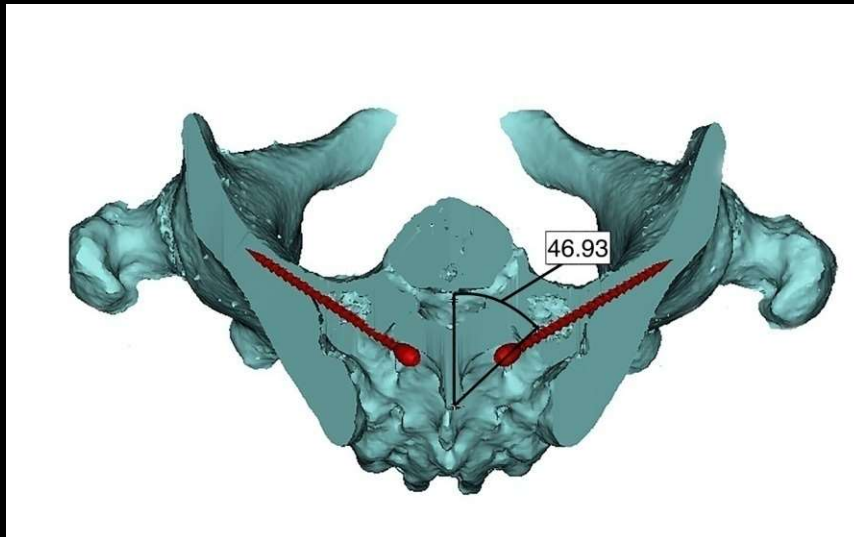
VELAYAT DAMGHAM HOSPT  
24068  
Bone 0.505  
SE: 6  
IM: 20 of 51  
-20.4  
Coronal.20  
824 \* 824  
FC30

BAGHERI BATOOL 97.12.01  
AGE:  
F 25063  
24068  
Study Date: 2019/02/20  
Image Time: 11:00:36



kv: 120  
MA: 200  
Thickness: 0.5  
Tilt: 0  
FOV: 259  
Zoom: 0.59  
WW: 2500 WL: 300

# Adult Deg Kypho- Scoliosis





# Take Home Message

Due to the tremendous speed of innovations in spine imaging with the application in pre-op planning, every spine surgeon need to keep up and be adapted, as the future of spine surgery would be DIGITALIZED!

Some pre-op **low cost digital resources** would be good alternatives to high cost intra-op technologies, e.g. O-arm and navigation, in **low resource settings**.