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Cervical, thoracic, lumbar spine and scoliosis surgery – with Artis zeego

Ebara Sohei, MD,
Shonan Fujisawa Tokushukai Hospital, Spine and Scoliosis Center, Japan

Overview of spinal workflows in Hybrid Operating Rooms

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Shonan Fujisawa Tokushukai Hospital, Spine and Scoliosis Center

SHONAN FUJISAWA TOKUSHUKAI HOSPITAL was re-opened after reconstruction in October 2012 as a key clinical institute in this region.

Tokushukai group is one of the largest, and it manages 66 hospitals and more than 280 clinical institutes that provide healthcare service in Japan. In accordance with the fundamental principles of "All living beings are created equal" (President, Torao Tokuda), the Tokushukai Group Hospitals ensure the health and livelihood of patients.

A hybrid operating room dedicated for the spine and scoliosis center was set up and equipped with the Artis zeego robotic imaging system, the TruSystem 7500 operating table, and the CURVE navigation system (BrainLab). This hybrid operating room provides surgeons with the latest technology for greater surgical precision.

It is the first installation dedicated solely for spinal surgery worldwide and it plays a pioneering role in orthopedic surgery in Japan.



Dr. Sohei Ebara, the director of the spine and scoliosis center and vice president of the hospital has been a leader in new technologies over the last years. He is a pioneer in developing safer and more advanced procedures using less invasive techniques, monitoring equipment and computer assisted surgery. Minimally invasive spine surgery techniques using endoscopes is applied whenever possible.

He has a long experience with the use of mobile C-arms. However, to achieve better images and higher precision he chose to use a fixed C-arm for his hybrid operating room. 3D imaging and a better workflow provide more safety for more sophisticated procedures like adolescent scoliosis surgery for example.

Since the opening more than 360 cases, with over 80 scoliosis cases, have been performed by Dr. Ebara and his team.





Cervical spine

The cervical spine involves the vertebral bodies inferior to the skull. The most important issue is the proximity to the central nervous system and the vertebral arteries. In case of injury, e.g. fractures or dislocation, the damage can be massive, such as respiratory failure or complete paralysis.

Surgery in this area is extremely challenging for the spine surgeon. It demands the highest precision within very little space. This is a situation in which 3D imaging and exact navigation can be very beneficial both for the surgeon as well as for the patient.

Patient positioning

The patient is positioned in a stable prone position with the head safely in a PMI Doro radiolucent headclamp attached to the table. The position is supported with high cushions underneath the pelvis and the chest to leave the abdomen free for unobstructed breathing. The legs are also placed in soft cushions to avoid pressure injuries. The arms with the intravenous lines are placed alongside the patient as is the tracheal tube so that the anesthesiologist has free access to the equipment.

A test run for 3D imaging is performed before the start of surgery to confirm the position of the patient and to make sure there are no collisions with any surgery equipment. The Artis zeego and the table including the head clamp are fully integrated and coordinated to avoid collisions.



Surgical preparation

After the patient is in the final position, he/she is covered in sterile drapes and surgery begins. The patient, the Artis zeego and the entire table are covered with sterile drapes to provide maximum sterility even underneath the table. After surgical preparation of the anatomy, the DRB (dynamic reference base) is placed on the cervical spine for registration with the navigation system.

The DRB needs to be visible to the infrared camera of the navigation system as well as the reflective markers on the Artis zeego. A 5 second *syngo* DynaCT protocol is performed for a 3D volume. This specific protocol is configured for this setup with the navigation system.

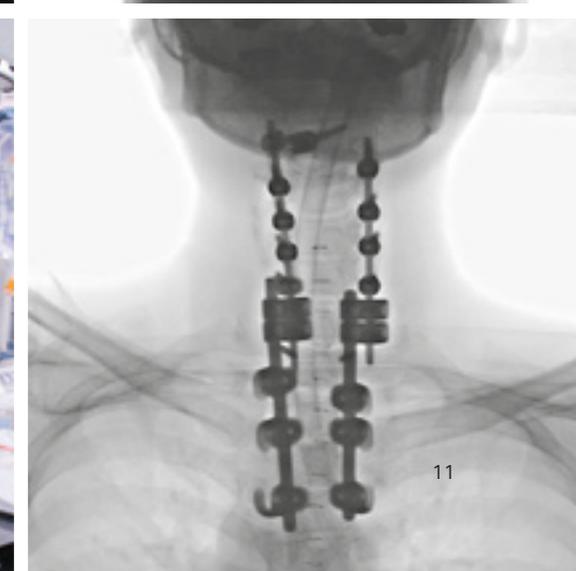
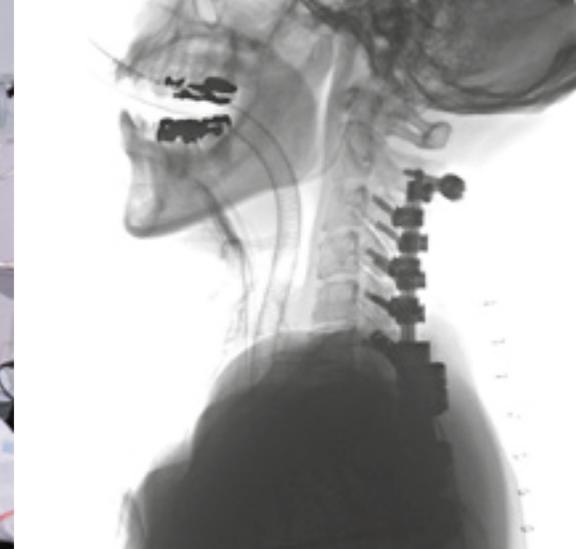
The 3D data set and patient data, such as name and age, etc., are automatically transferred to the navigation system so that the surgeon can move the Artis zeego into a park position and can start with the navigated placement of the screws.



Verification of screw position

The procedure is performed and the screws are placed with confidence. The combination of the intraoperative CT-like imaging and the navigation system provides the surgeon precise guidance and visualization of the anatomy.

With the intraoperative *syngo* DynaCT, the placement of the screws is verified right in the OR. Implants that may not be ideally positioned can be corrected immediately. Patients can count on optimal postoperative results. There is no nervously waiting for the postoperative CT scan or deciding how to deal with an imperfectly placed screw. The intraoperative quality control leads to better outcomes and fewer secondary surgeries.





Lumbar spine

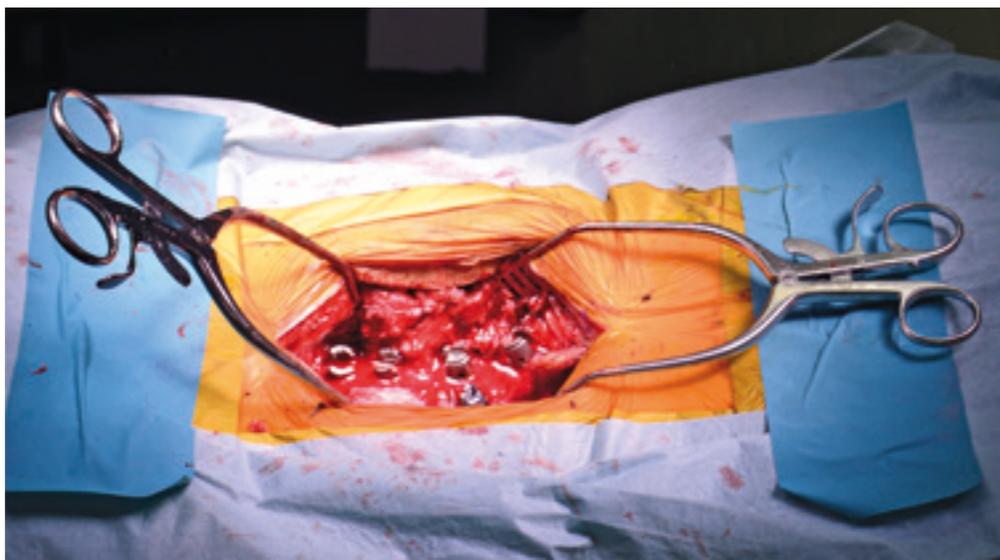
The lumbar spine is the lower end of the spine, consisting of the 5 vertebral bodies between the pelvis and the thorax. This part of the spine helps to support the weight of the body and permits movements of the lower extremities. It is mostly affected by degenerative diseases. Demographic or life style issues like being overweight and sedentary lifestyle add to this disease. Most of the worldwide population suffers from lower back pain at least once.

The trend toward minimally invasive surgery is very strong in lumbar spine surgery. Small incisions compared to open surgery allow the patient to recover more quickly. High quality imaging enables the surgeon to place the screws with confidence.

Surgical preparation

The patient is positioned and safely supported with cushions under the chest and pelvis for an optimal position and unobstructed breathing. The anesthesia equipment is fully accessible in this setup, with the patient's head placed in a foamed pillow. The pillow has cutouts for the eyes and the mouth to avoid pressure marks and the endotracheal tube is in a safe position. One arm is placed alongside the patient while the other one is positioned in an armrest for optimal access to the IV lines. The integrated OR table allows the sophisticated patient positioning required in an orthopedic OR environment and 2D and 3D imaging at the same time.

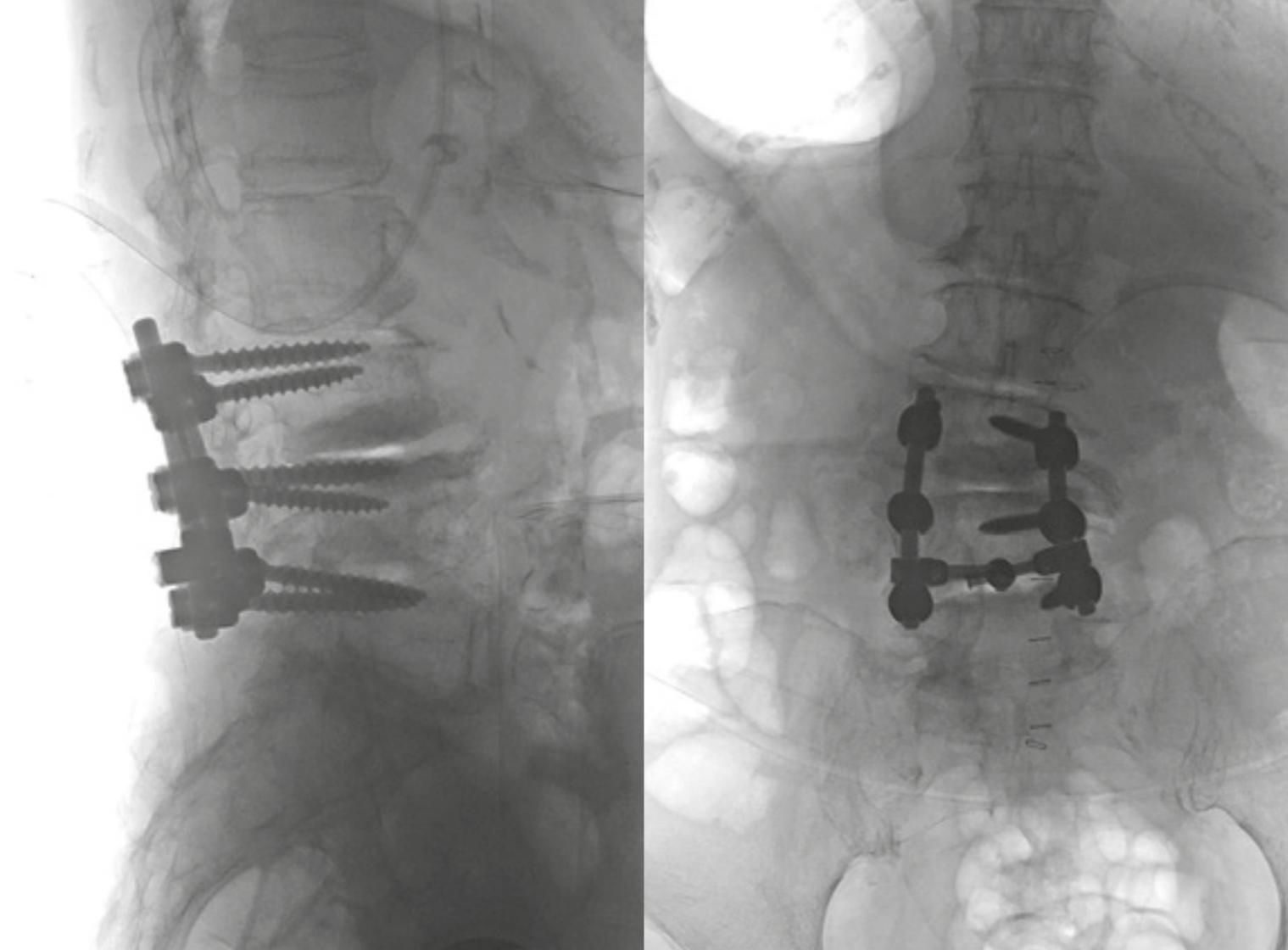
The pedicle screws, cages or other spinal implants have to be precisely positioned under the most sterile conditions. The Artis zeego imaging system fulfills the highest hygienic standards. Even in a working position with a running laminar air field, the robotic system meets Class 1A standards.

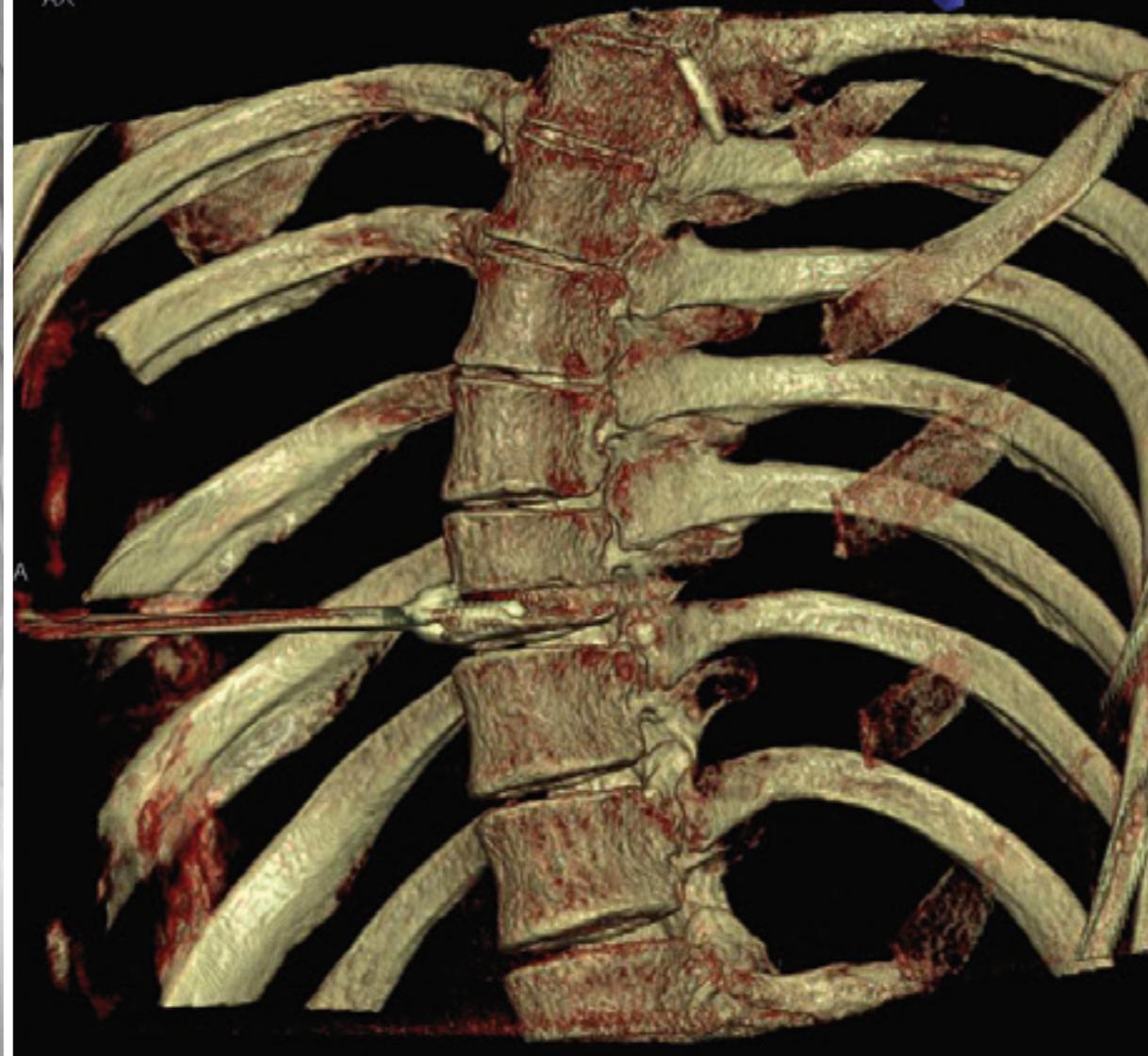
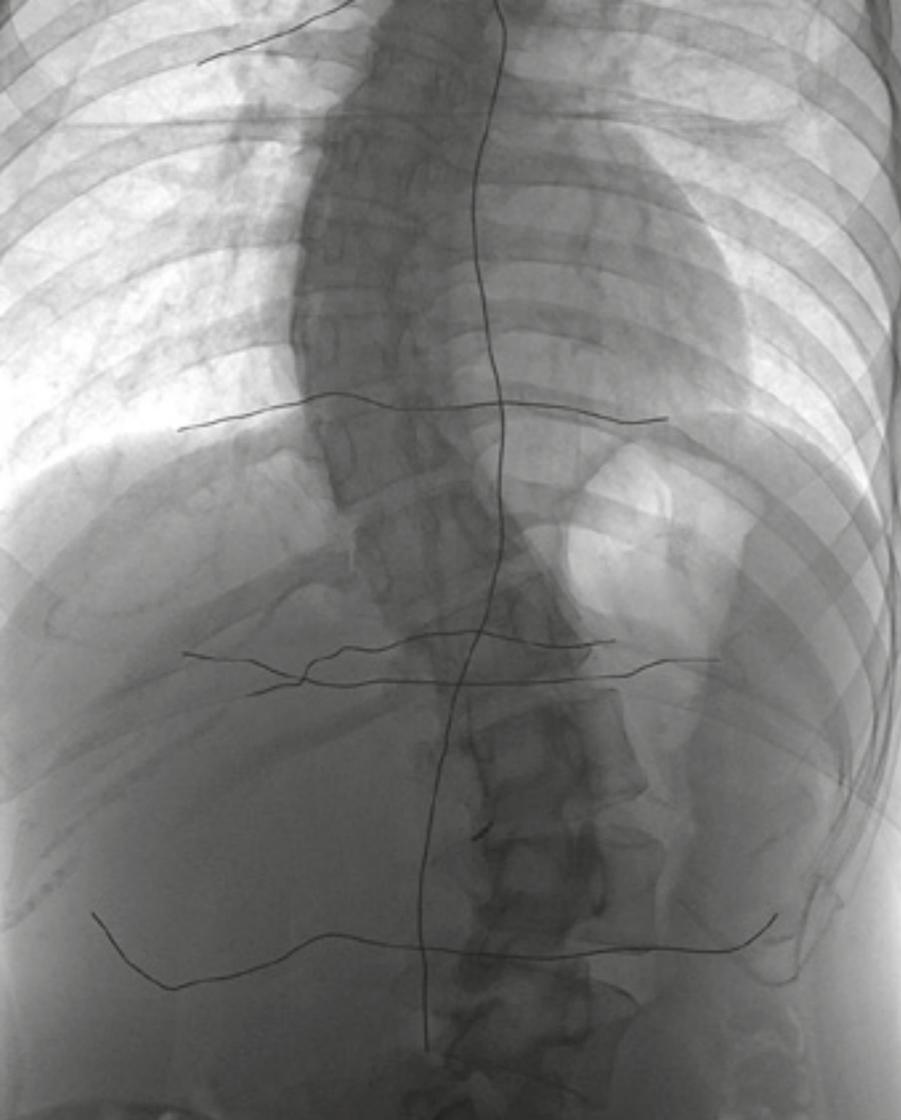


Intraoperative imaging guidance

The Artis zeego system provides a large field of view with a 30 x 40 cm detector size. With the possibility of a rotation of the detector from landscape to portrait, a larger segment of the spine can be visualized in one image shot. The power generator enables high quality images to be acquired even in obese patients where the anatomy is challenging, like at the thoracolumbar junction.

An image of up to 24x45 cm can be acquired. This field of view has never been possible before.





Scoliosis

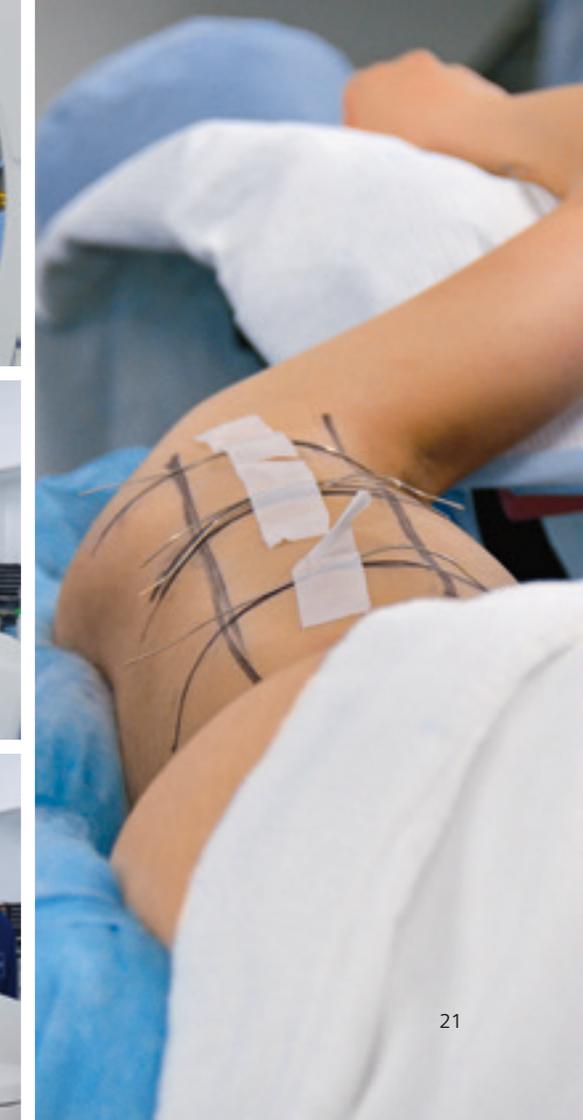
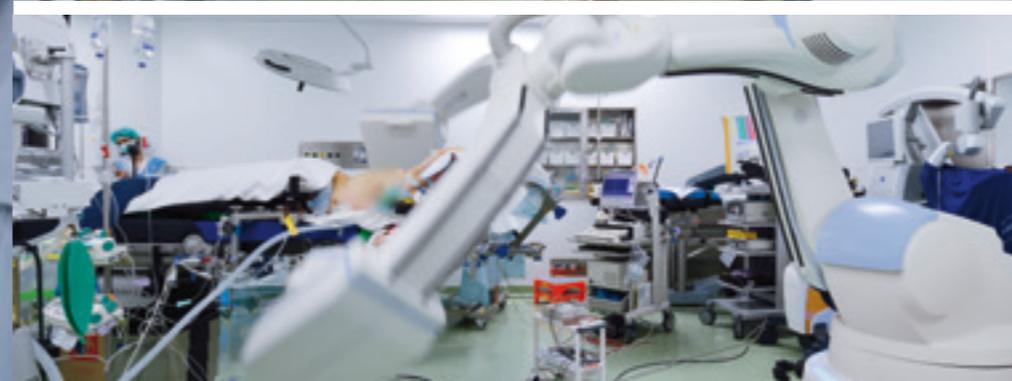
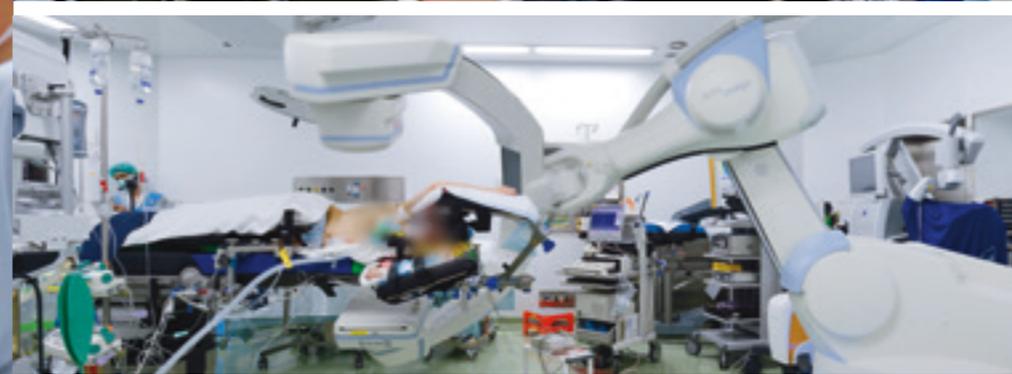
Scoliosis is a curved 3-dimensional deformity of the entire spine, often affecting the cervical, thoracic, and lumbar spine. The origin is either congenital, idiopathic or results as a secondary condition from a neuromuscular disease. The disease affects young patients as well as older patients who experience later onset of the disease. In young patients, scoliosis can cause severe deformity if untreated, and lead to pulmonary malfunction. There are various non-surgical treatment options. However, surgery is recommended in very specific cases or if conservative methods are insufficient.

Lateral approach – patient positioning

The anesthesiologist needs to verify the position of the tube using an endoscope. If surgery requires a lateral approach through the thorax, a double luminal tube is necessary. In this case the patient is positioned on the left side and surgery is performed through the right thorax. For better access to the spine, the right lung needs to be collapsed. Meanwhile, the other lung is ventilated to maintain a sufficient oxygen supply to the patient.

The patient is positioned carefully in a lateral position and metal wires are placed on the skin for better orientation. A syngo DynaCT run is performed preoperatively. It serves as an exact surgical planning tool.

A preoperative CT loses its value with a change in the patient's position. The anatomy with the patient positioned laterally is not the same as with the patient in the supine position in a preoperative CT.



Lateral approach – surgical preparation

After the exact planning of the procedure, surgery starts. The thorax is opened through small incisions and an endoscope is used to guide the surgical instruments. The right lung is desufflated by the anesthesiologist, and the surgeon prepares the anatomy.

Intraoperative imaging plays a decisive role. Using the minimally invasive approach, the surgeon loses tactile sense and natural 3D vision. He or she has to fully rely on the images provided by the endoscope and the Artis zeego.

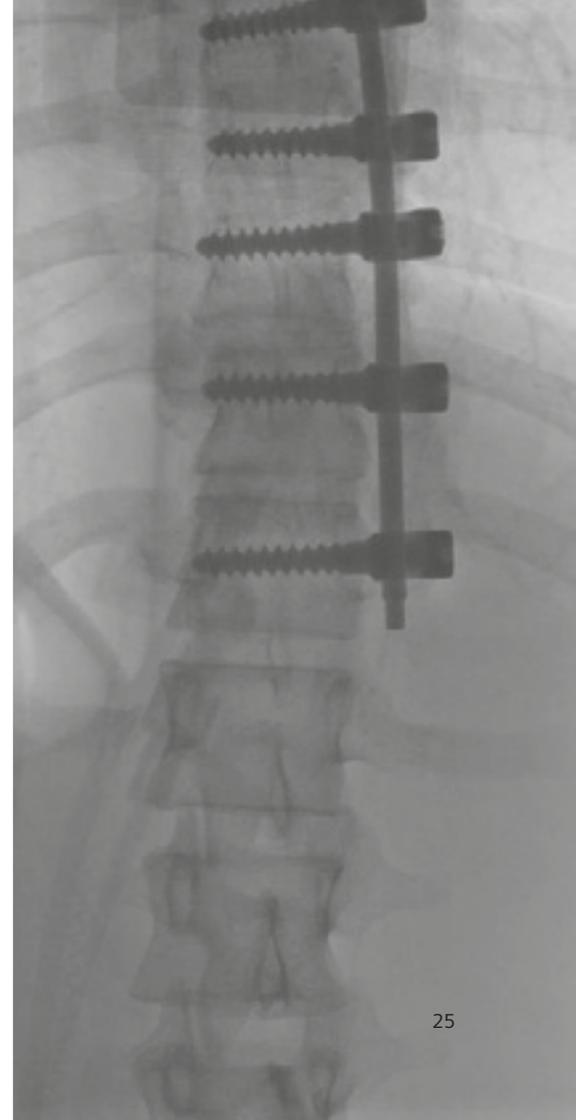
As soon as the anatomy is prepared, the dynamic reference base (DRB) of the navigation system is placed in the region of interest. Another syngo DynaCT run, now under sterile conditions, is performed and the 3D data is automatically transferred to the navigation system.



Lateral approach – placement of the screws

The first screws are placed with the help of the navigation system, the referenced instruments and the endoscope. The DRB and the instruments need to be visible to the camera of the navigation system to achieve the highest precision. Cross-sectional imaging helps the surgeon decide whether the screws are placed correctly. The process of screw placement is checked regularly using fluoroscopy. In this case, the Artis zeego can easily move in and out of the surgical field without disturbing the workflow and sterility. If the screw position is correct, the surgeon continues. The closer the screw placement is to the DRB, the greater the degree of precision.

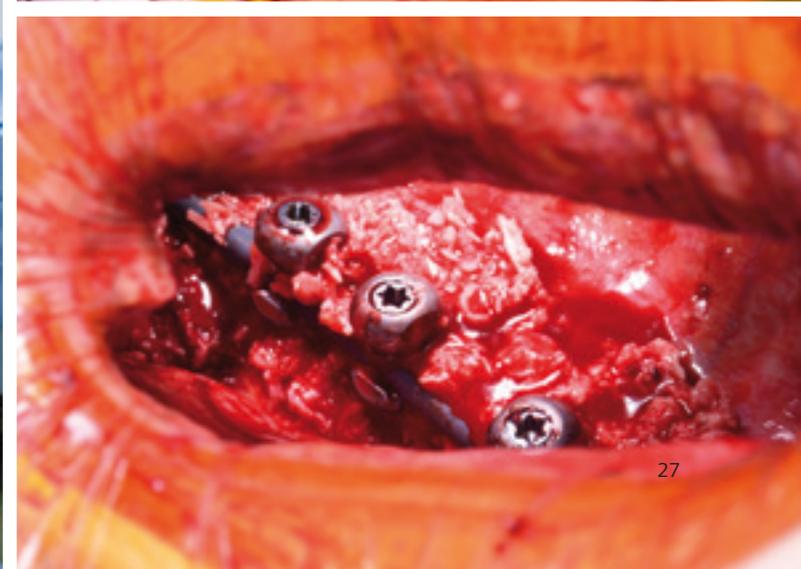
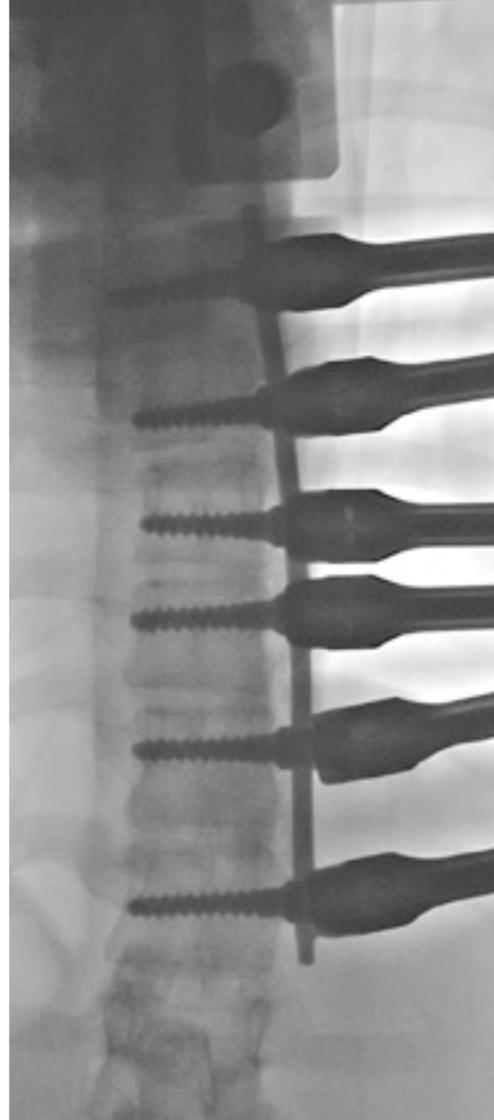
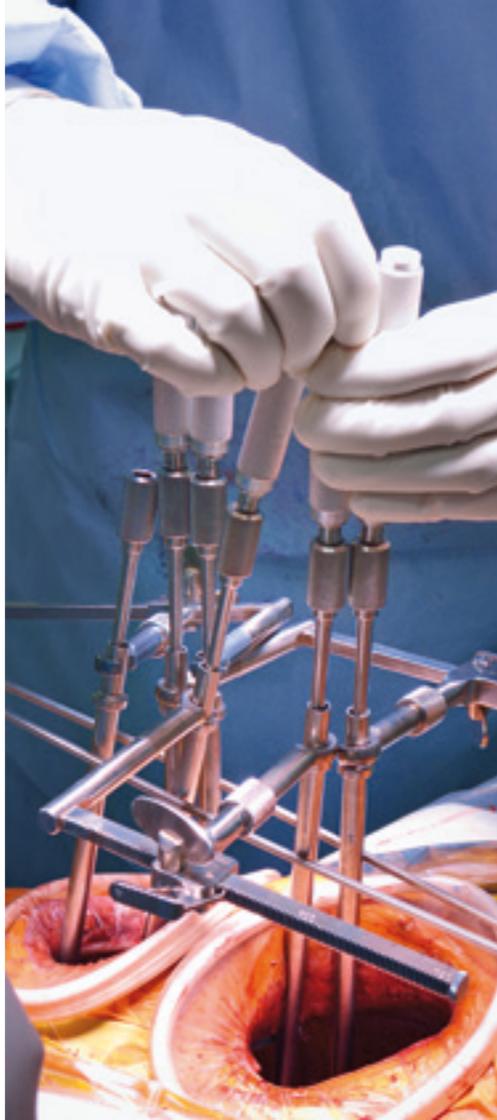
For these long stretches of the spine, the placement of screws is even a bigger challenge. The large field of view and high image quality of the Artis zeego support this process.



Lateral approach – intraoperative image guidance

The fixation of the spinal implants is controlled with fluoroscopy. Even with the large frames and all the surgical instruments, fluoroscopy can be easily performed with the C-arm of the robotic system.

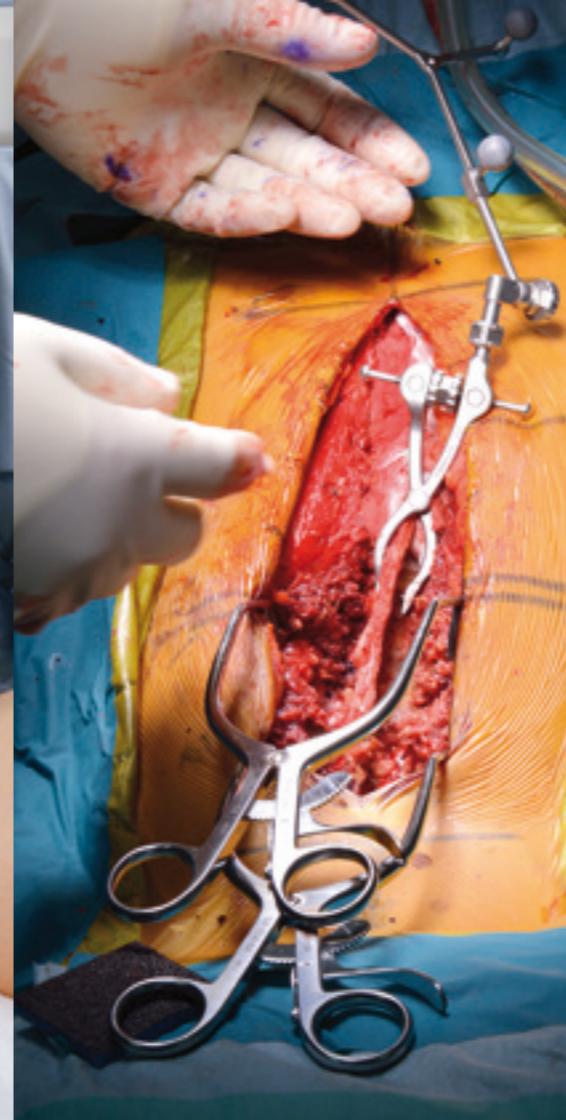
The next step is to stabilize the screws. This part of the workflow is also checked using fluoroscopy. When everything is fixated to full satisfaction and all screws optimally positioned, surgery is finished. As soon as the thorax is closed, the lung is insufflated to allow normal function. For postoperative quality control, another *syngo DynaCT* run is performed in the hybrid OR before the patient is released to the ward.



Dorsal approach – patient positioning and surgical preparation

For the posterior approach the patient is positioned in prone position. Cushions underneath the pelvis and the chest provide the required safety and also the needed position of the spine. Again, the head and the arms are also safely positioned. For better orientation wires are placed on the skin and the spine is centered with the help of a laser cross beam.

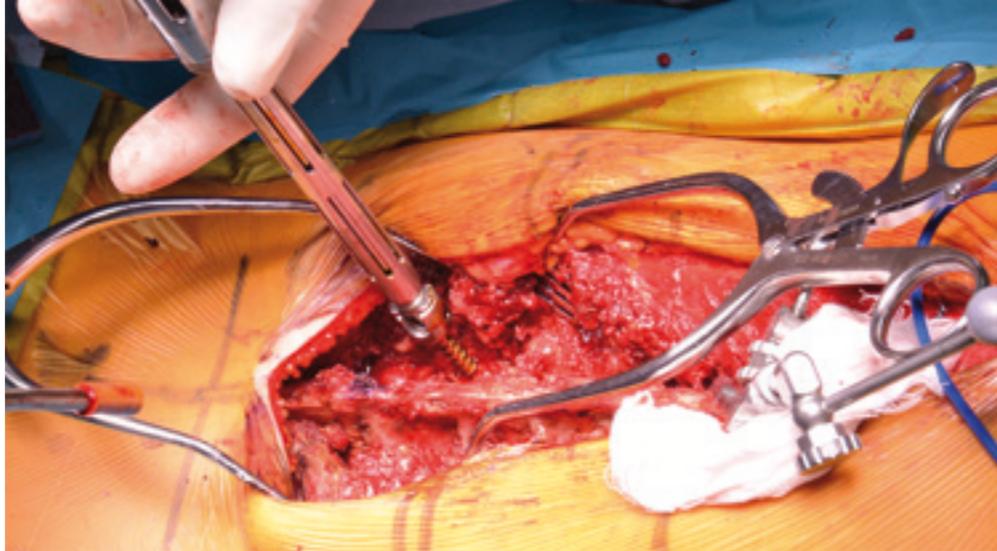
Surgery is started and the anatomy is prepared. The DRB is placed on the spine. The reflective markers of the DRB and the reflective markers attached to the Artis zeego are detected by the infrared camera of the navigation system. The 5sec Body protocol for the *syngo* DynaCT is configured for the communication of the Artis zeego and the navigation system. The 3D volume and the patient data is automatically transferred in a short time period.



Dorsal approach – placement of the screws

The screws are placed one after another. The surgical instruments, also equipped with reflective markers, are registered with the navigation system through the infrared camera. The navigation system calculates the distance between the reflective markers on the DRB as well as on the surgical instruments. This increases the precision for placement of the screws.

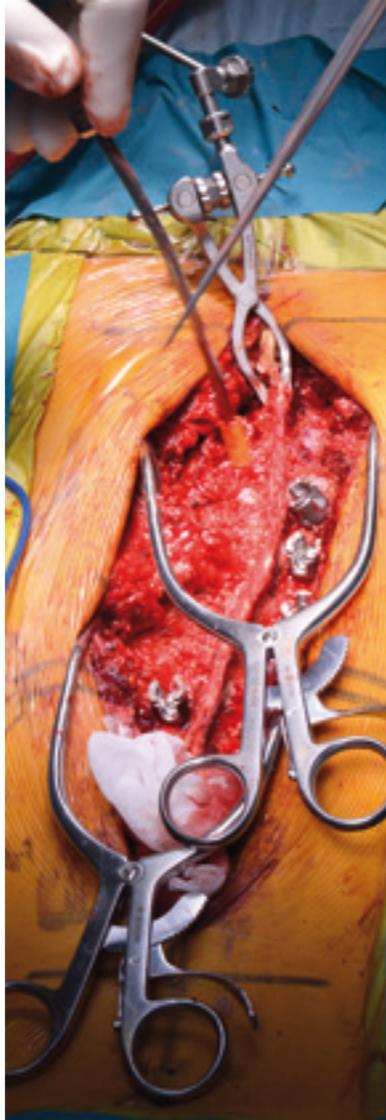
The surgeon follows the placement of the screws on a separate screen of the navigation system using the intraoperative 3D volume. The *syngo* spine composing software of the robotic C-arm system can be used at the same time. This allows stitching multiple images of segments of the spine into one image. The surgeon is able to evaluate the severity of the deformity, plan thoroughly and assess the success of the procedure.



Dorsal approach – intraoperative image guidance

Once the screws are in place, a metal bar is placed in the openings to stabilize the spine and fixate it properly. One disadvantage with this technique is the lack of spinal flexibility for the patient after surgery. However further degeneration and other organ impairment can be prevented, which outweighs the disadvantage.

Surgical progress is checked regularly. The Automap function allows positions and angulations of the Artis zeego to be easily stored and reached whenever needed with only a few clicks. This speeds up the procedure and facilitates surgical workflow.

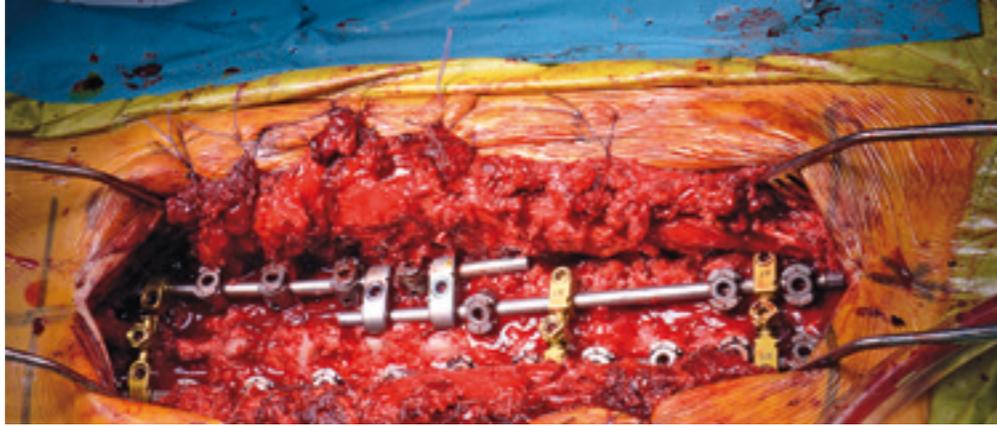


Dorsal approach – intraoperative image guidance

At the end of the procedure, the surgeon verifies the position of the screws.

With the help of the Large volume syngo DynaCT and the image composing option, the surgeon can visualize the entire spine in a few steps. Any screw that requires repositioning can be adjusted right in the OR.

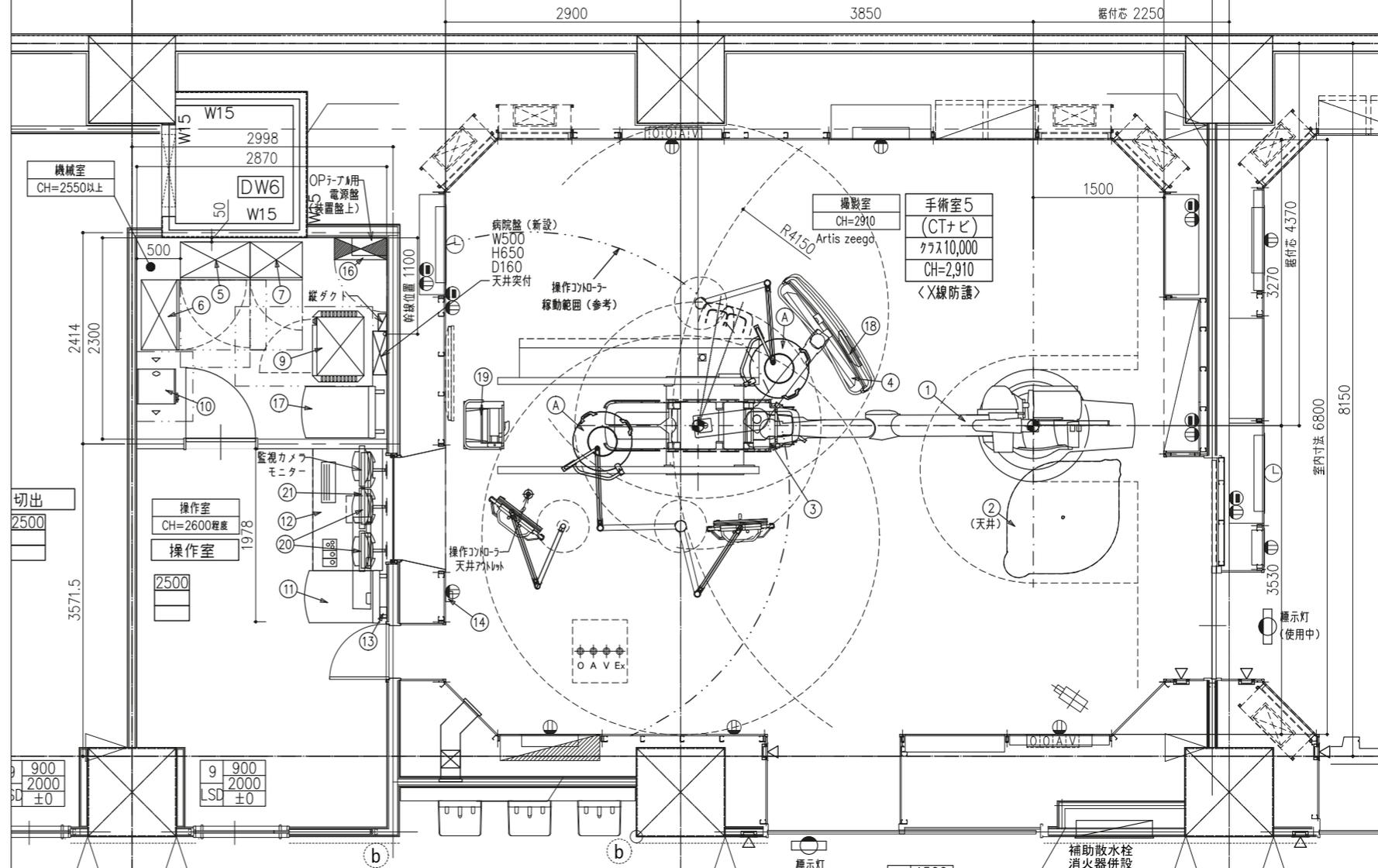
Consequently, the surgeon is able to finish surgery confidently with all screws properly positioned and then release the patient to the ward.

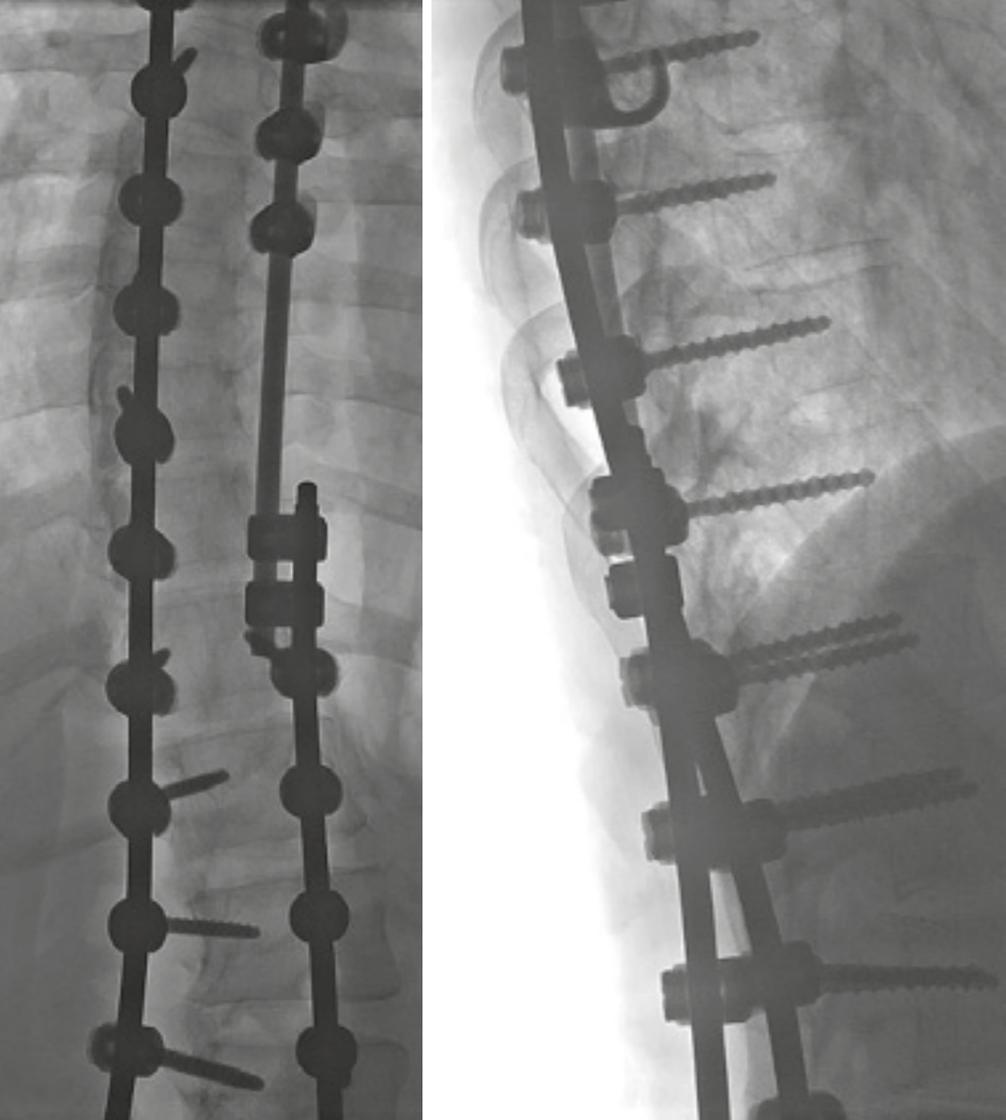


Configuration of the Hybrid Operating Room

Shonan Fujisawa Tokushukai Hospital,
Spine and Scoliosis Center, Japan

- Artis zeego VC21
- syngo iGuide and syngo iGuide Toolbox
- syngo DynaCT
- syngo spine composing
- Large volume dynaCT
- syngo InSpace 3D
- syngo Large volume DynaCT
- syngo iPilot
- Large display with DCS extended
- Trumpf operating tabletop (one piece or segmented) TruSystem 7500
- Brainlab Curve (R) navigation system
- Laser crosshair beam
- syngo X Workplace VB21





The Benefits at a glance

- Sound decision making
- Large field of view
- Great flexibility
- Good accessibility to work on the patient
- Laser guidance for precision
- Integration of navigation systems
- High contrast 3D imaging in the OR
- Soft tissue imaging
Image fusion capability
(preoperative MRI, etc.)



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Global Business Unit

Siemens AG
Medical Solutions
Angiography & Interventional
X-Ray Systems
Siemensstr. 1
DE-91301 Forchheim
Germany
Phone: +49 9191 18-0
www.siemens.com/healthcare

Global Siemens Headquarters

Siemens AG
Wittelsbacherplatz 2
80333 Muenchen
Germany

Global Siemens Healthcare Headquarters

Siemens AG
Healthcare Sector
Henkestr. 127
91052 Erlangen, Germany
Telephone: +49 9131 84-0
www.siemens.com/healthcare

Legal Manufacturer

Siemens AG
Wittelsbacherplatz 2
DE-80333 Muenchen
Germany

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