Case Report

Cervical Pedicle Screw Placement in Challenging Deformity Surgery

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Case

62-year old female with ankylosing spondylitis (AS) in the cervical spine presented with loss of visual axis, difficulty swallowing solid food, frequent stumbling and episodes leading to significant falls. At the time of presentation, there was also increasing pain in the thoracic spine over a period of one year.

Imaging studies including full-spine standing radiographs (Fig.1), full-spine MRI (Fig.2), and reconstructed Angio-CT scans (Fig.3a-e) reveal:

- a global kyphosis in AS
- a cervical kyphosis from C2 to C7 with an old united fracture of C5 (Fig.3d)
- an active Anderson lesion at T9-T10 (Fig.3e)

The main deformity is derived from cervicothoracic hyperkyphosis, inducing the loss of visual axis.

Fig. 1

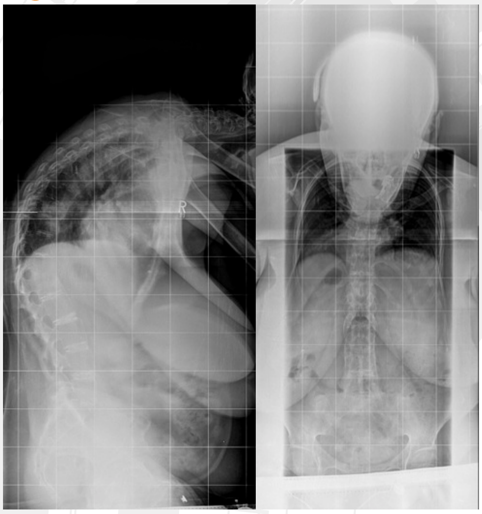


Fig. 2

Fig. 3a

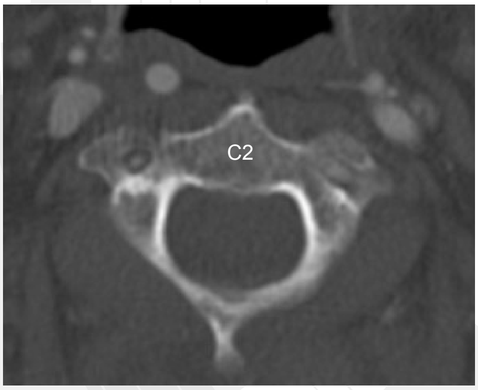


Fig. 3b

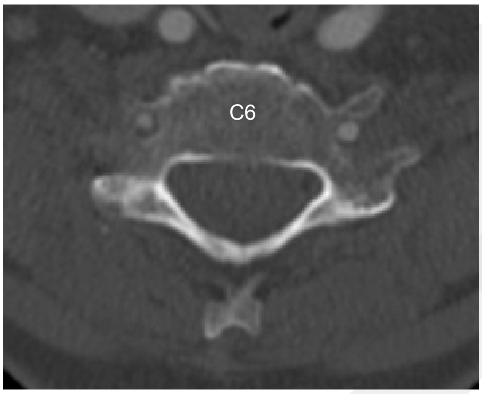


Fig. 3c

Fig. 3d

Fig. 3e

Operative goals

The operative goals are to halt the progression of the natural deformity course, correct cervicothoracic hyperkypophis to restore visual axis, resolve pain derived from the Anderson lesion T9-T10 and prevent late instability.

A corrective surgery indicates posterior instrumention and fusion of C2-T4, osteotomy at the cervicothoracic junction C7-T1, as well as fixation of the thoracic instability T8-T1.

Pre-Operative Assessment

Pre-operative radiographs reveal a major deformity at the cervicothoracic transition (Fig.1).

Angio-CT scan depicts vertebral artery entry at C6 bilateral (Fig. 3c), enabling safe neurovascular osteotomy at C7-T1. MRI does not show myelopathy signals at the level of osteotomy (Fig.2).
Operative challenges are increased by the large deformity and significant correction forces that will be transferred to the distal and proximal sites of the osteotomy with a need for a solid screw-bone interface.
A large habitus, significant kyphotic deformity, the usual loss of posterior anatomical landmarks in AS, an inclined prone positioning of the patient, which makes surgery difficult for the instrumenting surgeon, pose challenges to safe and efficient pedicle screw instrumentation. Intra-operative radiographic visualization of landmarks will be difficult to obtain due to the ankylosing spondylitis, the deformity and patient size. Even with a maximum anti-trendelenburg positioning, the patient's head and eye position has to be assumed in vertical direction and below the heart level by virtue of the large cervicothoracic hyperkyphosis. This increases the risk for venuous congestion in the cervical and particularly the cerebral and ocular regions. Due to these potential risks, any effort to accelerate intra-operative work-flow and surgical efficiency is recommended in such cases.

Pedicle Preparation Instrumentation: PediGuard® probe

The PediGuard® probe is enabled with DSG™ (Dynamic Surgical Guidance) technology.

A bipolar sensor is embedded at the tip of each PediGuard® device. A low frequency and low voltage current is emitted through a bipolar electrode in the probe. Measuring the local conductivity of tissue 5 times per second, the device can accurately inform the surgeon of the type of tissue at its tip by changes in the pitch and cadence of an audio signal and a flashing LED light. Thus, the surgeon can be alerted of an imminent cortical breach and redirect appropriately during pedicle preparation.

PediGuard® 2.5 XS

The PediGuard® 2.5 XS probe was used during this case. The sharpness and stiffness of the tip of the device allow for penetration into sclerotic bone and small pedicles, especially in the cervical area.

The PediGuard® probe is used straight forward in manual techniques as the surgeon is used to with his standard pedicle awl.

Clinical Summary

Surgery was performed in the prone position with maximum anti-trendelenburg alignment (Fig.4).
To shorten surgery, three surgeons worked in parallel:

- two surgeons at the cervical spine
- one surgeon at the thoracic spine.

Radiographs were obtained after the following steps even though the quality was poor in both the cervical and the thoracic spine. Imaging was used for:

1) level marking (Fig.5a)
2) after preperation with the PediGuard® 2.5 XS probe (Fig.5b)
3) after insertion of screws (Fig.5c) and identify osteotomy limits (Fig.5d)
4) following completion of surgery (Fig.5e).

Fig. 4

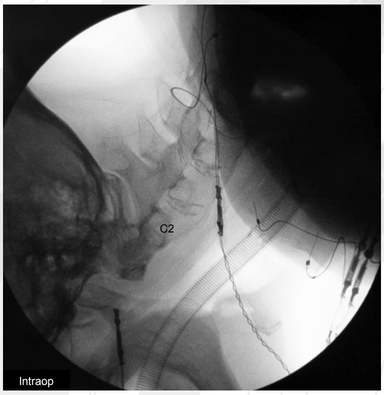


Fig. 5a

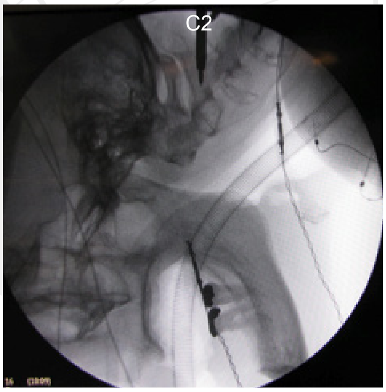


Fig. 5b

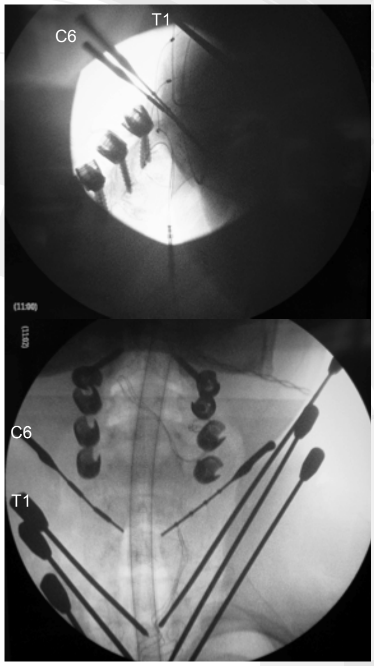


Fig. 5c

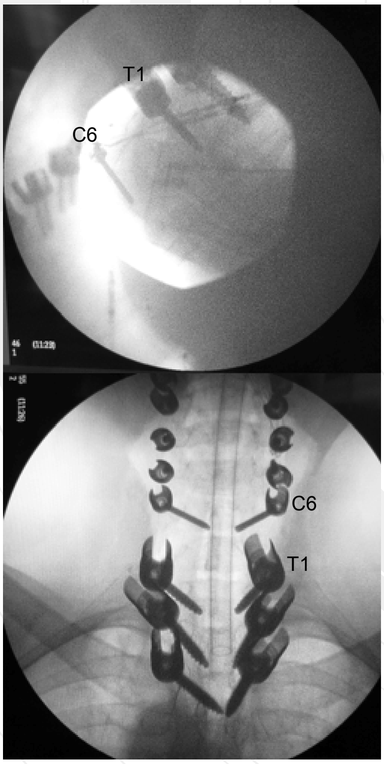


Fig. 5d

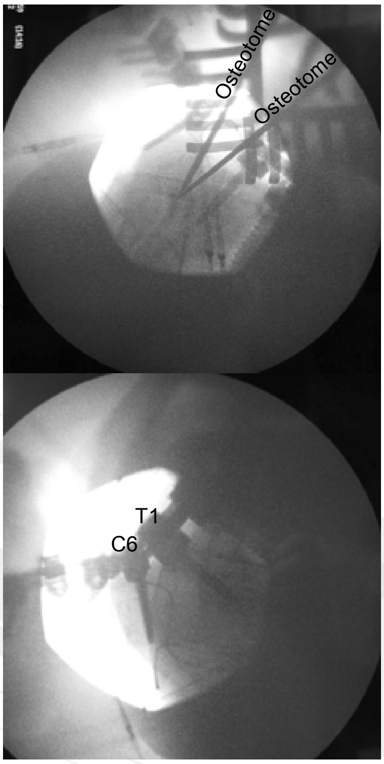
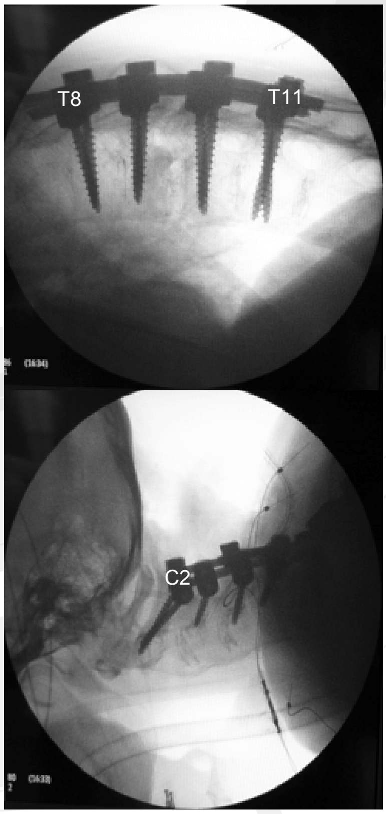


Fig. 5e



The use of the PediGuard® 2.5 XS probe was shown to be efficient as no other time and space-consuming navigation was used for pedicle screw fixation, while radiographs using an image intensifier were only used for definition of anatomical level and control of probes / screws. With the PediGuard®2.5 XS probe, larger diameter and longer pedicle screws were placed with bicortial placement in the lower cervical and thoracic spine (Fig.6a-g).

Fig. 6a

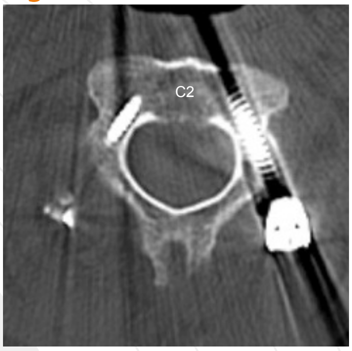


Fig. 6b

Fig. 6c

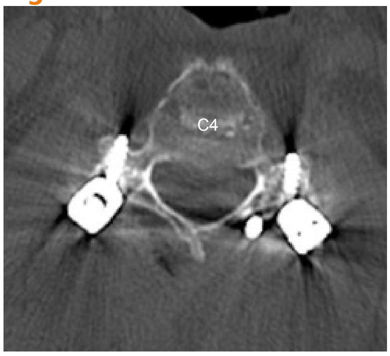


Fig. 6d

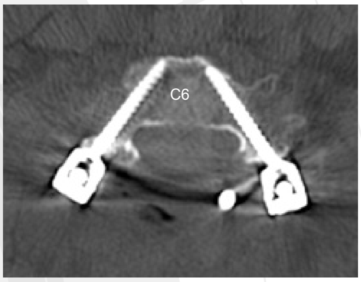


Fig. 6e

Fig. 6f

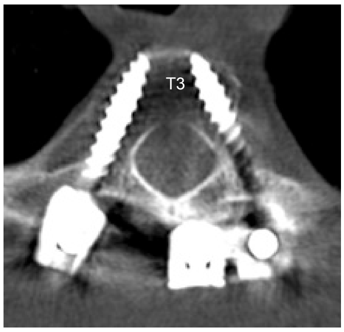
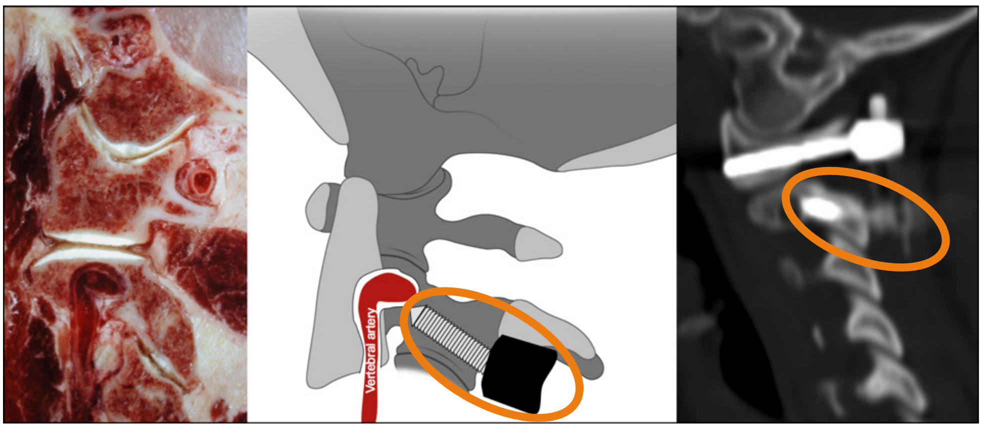


Fig. 6g

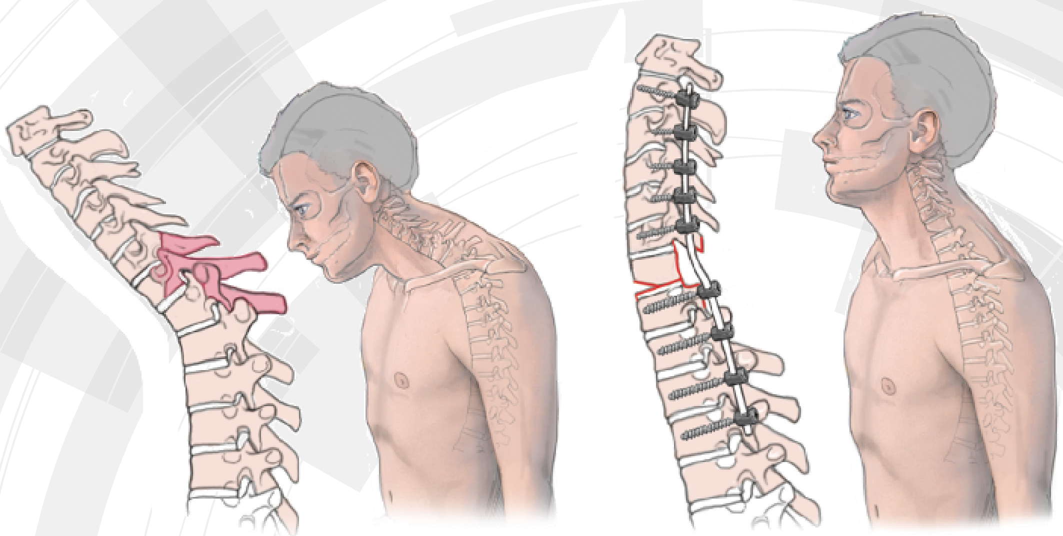
Bicortical fixation is beneficial in patients with demineralized bone that require corrective forces.
The PediGuard® 2.5 XS probe assisted with enabling screw tip placement to the ideal target, which was at the anterior cortex in the current case ('Targeted-Screw-Placement' using the PediGuard® 2.5 XS, Fig.7).

Fig. 7



With the PediGuard® 2.5 XS probe, screw placement was the shortest technical part of this challenging deformity surgery while the cervical osteotomy at C7-T1 and instrumented correction were the longest. Osteotomy was done in a modfied Y-shape fashion (Fig.8a-b) to increase kyphosis while maintaing bone approximation at the anterior column and osteotomy gap as well as reducing the need for posterior shortening if compared to standard PSO or SPO. The osteotomy resembles a modification of a PSO and SPO converted into a Closing-Opening Wedge Osteotomy (Fig. 8b). Osseus resection included the C7 lamina, the pedicles, a posterior C7 wedge with distal wedge tip at mid-sagittal level of C7-T1 and posterior base, as well as C6 and T1 laminas (Fig.8b). Instrumented correction was done using malleable rods and approximation of osteotomy surface at the posterior one-half of the C7-T1 disc space.

Fig. 8a **Fig. 8b**



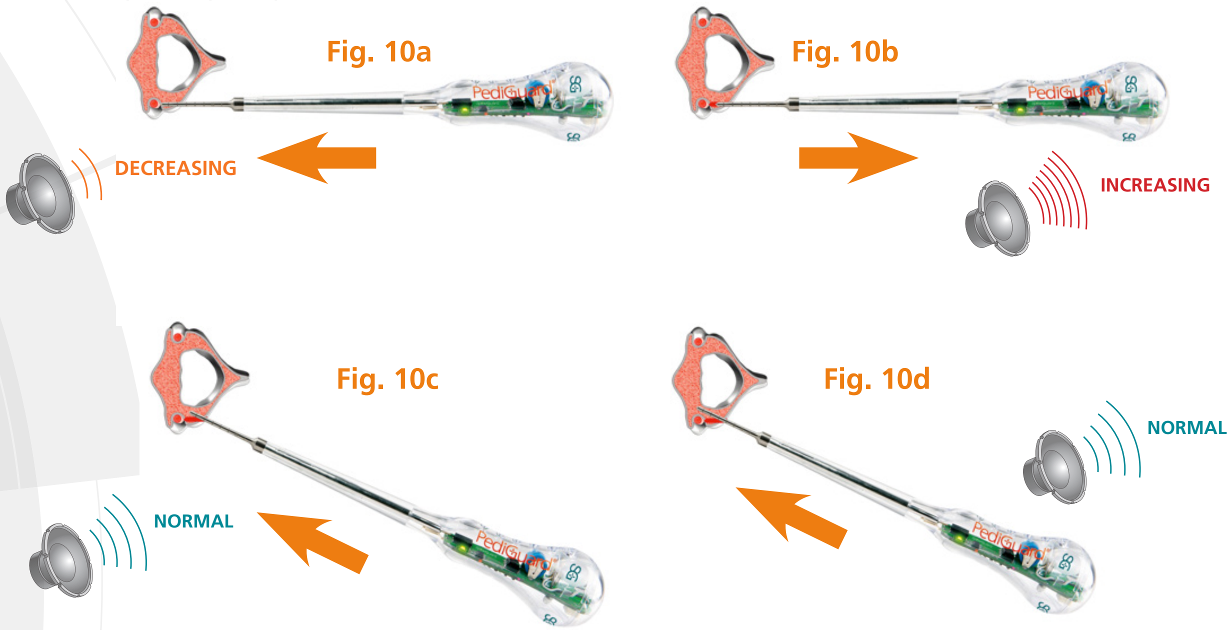
The total surgical time was 7 hours. Blood loss was 1050ml. Intra-operative neuromonitoring and neurological course post-operatively was uneventful and the patient regained full horizontal visual axis with the absence of thoracic pain and swallowing difficulties. A post-operative wound dehiscence necessitated a revision and was successful. Post-operative radiographs (Fig.9) and reconstructed CT-scans (Fig.6a-g) show accurate screw placement in all levels, a durable cervicothoracic reconstruction using 3-rods at the osteotomy site, and an excellent deformity correction.

Fig. 9

Pedicle Preparation Technique

In the C2 vertebra (Fig.6 a-b and g), the PediGuard® 2.5 XS probe was used the same way as a standard pedicle probe. With a mid-sagittal and mid-coronal entry point on the posterior C2 articular process, the PediGuard® 2.5 XS probe was slowly advanced with slight pressure. It was advanced more medial than lateral as the lateral cortical wall is usually thinner than the medial wall. This is particularly true in patients with AS. To obtain the longest possible screw given by the individual anatomy and to yield for 'targeted-screw-placement', the PediGuard® 2.5 XS probe was advanced until signals indicated anticipation of a breach, e.g. anterior cortex at C2 or into the C1-C2 joint. The insertion depth was measured and subsequently a pedicle screw was inserted.

How to avoid screw misplacement: The PediGuard® 2.5 XS signals indicate and can anticipate a bony breach during screw tract preparation. That information can be used for real-time navigation with the PediGuard® 2.5 XS (Fig.10a-d). The PediGuard® 2.5 XS can be retracted a bit (Fig.10b) then redirected (Fig.10c) to further advanced it in the correct position (Fig.10d).



In difficult cases such as in dysplastic, sclerotic and small pedicles, the PediGuard® 2.5 XS probe can help to achieve a sufficient insertion depth, as determined by the surgeon. The screw of an appropriate length can be inserted in the same direction of the PediGuard® 2.5 XS probe (See 'target-screw-placement', Fig.7).

'Target-screw-placement' also is possible for lateral mass screws in the subaxial spine with lost anatomy and with need for long screw fixation. With sagittal plane deformity corrections, the use of a straight rod in the coronal plane eases the deformity correction and increases construct stability in comparison to multidimensional bent rods. Therefore, lateral mass screws are placed in a modified 'in-line technique' with bicortical fixation to enable a straight rod fixation with the pedicle screw anchors at C2, C6 and T1-T4 as well as straight rod bridging the osteomy side.

At the osteotomy sites, C6 and T1, accurate screw placement and strong fixation are crucial as the vertebra that is close to the osteotomy closure will carry significant loads during the deformity correction.
Accordingly, making a bicortical fixation thanks to the PediGuard® 2.5 XS probe was intended and achieved at C6 and upper thoracic levels as well (Fig. 6d-g).
The pedicles had soft cancellous bone in the upper thoracic spine and C6 presented small areas of cortical bone at the pedicle entry point that challenged the pedicle tracts preparation. With continuous pressure and clock-wise hand-drilling movements, the PediGuard® 2.5 XS probe was advanced in the anterior and medial trajectory.

Conclusion

The use of the PediGuard® probe in challenging deformities proved to be efficient for surgical time and screw placement accuracy. In large, cervical, deformity surgery, there is a risk of significant intrinsic complications. However, using the PediGuard® probe as a tool to improve surgical efficiency and screw placement accuracy helps to alleviate concerns regarding screw misplacement.

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