Posterior cervical fixation using a new polyaxial screw and rod system: technique and surgical results

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Object. Standard lateral mass plate and screw systems are of limited use in patients with abnormal cervical anatomy and do not easily allow for extension to either the occiput or the thoracic spine. The objective of this study was to demonstrate the safety, surgical efficacy, and advantages of a new cervical polyaxial screw and rod system for posterior occipitocervicothoracic arthrodesis.

Methods. The authors reviewed a multicenter series of patients who underwent surgery in which they used a new posterior cervical polyaxial screw and rod system. The system was implanted in 32 (20 women and 12 men) adult patients (mean age 56.9 years, range 23–84 years). Twenty-three of the patients were treated for spondylolisthesis; four for cervical fracture/dislocations; four for kyphosis; and one patient was treated for pseudarthrosis that developed after prior surgery.

The system was successfully implanted in all patients despite the presence of anatomical lateral mass abnormalities in the majority of cases. The mean number of levels fused was 3.9 (range one–eight levels). This dynamic system allowed for screw placement into the occiput, C-1 lateral masses, C-2 pars, C3–7 lateral masses, and low cervical as well as upper thoracic pedicles. Selective application of compressive or distractive forces was possible in adjacent segments. Surgery-related complications included one dural tear and one malpositioned screw. There were two cases of wound infection.

Conclusions. Unlike standard lateral mass plate and screw systems, the new cervical polyaxial screw and rod system easily accommodates severe degenerative cervical spondylosis and curvatures. This instrumentation system allows for polyaxial screw placement with subsequent multiplanar rod contouring and offset attachment. The authors have used this system successfully, and without significant complications, to achieve posterior cervical arthrodesis.

**KEY WORDS** • spinal fusion • cervical spine • lateral mass

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Abbreviation used in this paper: CT = computerized tomography.
posterior cervical arthrodesis in which the cervical poly-
axial screw and rod system was used. Twenty patients
were women and 12 were men, and their mean age was
56.9 years (range 23-84 years).

Patients underwent preoperative CT scanning to delin-
eate the osseous anatomy and the course of the vertebral
arteries. Preoperative diagnoses included cervical spondy-
lostenosis in 23, cervical fracture/dislocations in four (in-
cluding one case of occipitocervical fracture/dislocation
and one case of ankylosing spondylitis with a C-7 frac-
ture), kyphosis in four, and pseudarthrosis from failed
prior fusion in one patient (Table 1).

**Indications for Decompression and Fusion**

The indications for posterior cervical decompression
and fusion are numerous. In cases of cervical fracture/
dislocations in which there is evidence of vertebral in-
stability, the use of posterior instrumentation optimizes
arthrodesis. In cases of pseudarthrosis, posterior cervical
segmental instrumentation is useful to immobilize the seg-
ment and allow for fusion to occur.

In all of our 23 patients with spondylostenosis loss of
normal cervical lordosis was observed. These patients all
suffered cervical myelopathy or cervical radiculopathy in
combination with severe degenerative changes. In the
subset of these patients with cervical myelopathy requir-
ing posterior decompression, it has been our practice to
perform laminectomies combined with fusion if normal
cervical lordosis is not evident. In patients with severe
spondylotic radiculopathy in whom dynamic radiographs
suggest segmental instability, it has also been our practice
to perform posterior cervical decompression and stabil-
ization.1,2

**Posterior Instrumentation**

The system consists of 6- to 10-mm titanium occipital
screws and 14- to 18-mm titanium polyaxial cervicotho-
racic screws. The system’s titanium rods are malleable in
three dimensions, and there is an available rod with an
occipital plate on one end to allow for occipitocervical fu-
sions.

When needed, the occipital screws must be placed
through the apertures in the occipital plates. The polyaxi-
al cervicothoracic screws, however, are placed indepen-
dently of the rod system. The contoured rods are then
linked either directly to the polyaxial screw heads by us-
ing a locking cap screw or are linked using an offset con-
ector.

**TABLE 1**

Demographic data obtained in 32 patients

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>spondylostenosis</td>
<td>23</td>
</tr>
<tr>
<td>cervical fracture/dislocations</td>
<td>4</td>
</tr>
<tr>
<td>occipitocervical fracture/dislocation</td>
<td>1</td>
</tr>
<tr>
<td>ankylosing spondylitis</td>
<td>1</td>
</tr>
<tr>
<td>cervical kyphosis</td>
<td>4</td>
</tr>
<tr>
<td>pseudarthrosis</td>
<td>1</td>
</tr>
</tbody>
</table>

**Surgical Technique**

A standard midline posterior cervical exposure was per-
formed to reveal the lateral aspects of the cervical facets.
The exposure was extended for one to two levels below the
inferior end of the planned arthrodesis to allow for
optimal screw placement. In patients with marked de-
generative changes, the osteophytes on the posterior facets
were removed to provide better visualization, to help
define the anatomy of the facets, and to provide a suitable
surface to allow for rotation of the polyaxial screw heads.
We preserved, where possible, however, the posterior cor-
tex of the articular mass to provide for better screw pur-
chase. In the case of occipitocervical fusions, we exposed
the suboccipital area up to the inion, and in that of cervi-
cothoracic fusions, we also exposed the thoracic trans-
verse processes.

In cases in which posterior decompression was neces-
sary, we drilled and tapped pilot holes for the screws prior
to performing laminectomies to preserve the normal
anatomical landmarks for the screw trajectories. In addi-
tion, the lamina served to protect the neural elements dur-
ing the preparation of screw holes. At C-7 and T-1, when
decompression of the spinal canal was not necessary, at
least minimal laminotomies were performed to expose the
medial walls of the C-7 and T-1 pedicles prior to pedicle
screw placement.

After the exposure was completed, we focused on cer-
vical polyaxial screw placement. Initially, we used a high-
speed drill to perforate the posterior cortices of the lateral
masses. Our screw trajectories for C-3 to C-7 were based
on prior guidelines (RW Haid, et al., unpublished data).
Enter points were 1 mm medial to the center of the lateral
mass, and trajectories were 20° cephalad and 20 to 30° lat-
eral (Fig. 1). We “normalized” the entry point and screw
trajectory at each lateral mass to allow for changes in the
orientation of the lateral masses secondary to accentuated
cervical lordosis or kyphosis and to allow for each patient-
t’s unique pathoanatomy. Because we did not routinely
use fluoroscopy or image guidance (except when placing
screws into C-1 and C-2), attention to the patient’s unique
cervical anatomy was of paramount importance.

![Fig. 1. Illustration showing that, after drilling and tapping, the polyaxial screw is inserted without the constraint of a lateral mass plate.](image-url)
For screw placement into the lateral mass of C-1, we performed the technique described by Harms and Melcher\(^8\) and refined by Fiore, et al.\(^3\) The screw entry point was at the junction of the C-1 posterior arch and the center of the C-1 posteroinferior lateral mass. The screw trajectory was parallel to the plane of the C-1 lamina and was aimed straight anterior from the entry point.

For screw placement into the C-2 pars, we paid close attention to the preoperative CT studies to assess the course of the vertebral artery. In addition, we used a blunt probe to palpate the medial pars to help guide our screw trajectory. We used a screw entry point 3 to 4 mm superior and lateral to the medial aspect of the C2–3 facet joint. The screw trajectory was 10 to 15° medial and 35° cephalad. We typically used 4-mm wide and 16-mm long screws for the C-2 pars (Fig. 2). For C1–2 transarticular screw placement, the entry point and trajectory are the same as those for C-2 pars screws; the screw length, however, is longer.\(^6,7\)

Screw placement at C-7 is dependent on the osseous anatomy. We scrutinized the preoperative CT scan to determine if the patient’s C-7 lateral mass had typical cervical anatomy or had transitional thoracic anatomy with a well-formed pedicle. When the C-7 anatomy was transitional, we preferred to place a C-7 pedicle screw.

For pedicle screw placement at C-7 or in the upper thoracic spine, we exposed and palpated the medial walls of the pedicles and utilized an entry point 1 mm below the center of the facet joint, and followed a trajectory 25 to 30° medial while maintaining a perpendicular angle in the sagittal plane.

In the thoracic spine, pedicle screws can also be placed laterally into the costotransverse joint to achieve greater cortical purchase (Fig. 3).\(^17\)

The final step was to contour and attach the rods. A rod template was used to estimate the required rod-related length and contour (Fig. 4 left). The titanium rods were then measured, cut, contoured, and directly attached to the polyaxial screw heads by using locking cap screws (Fig. 4 right). In cases in which the patient’s pathoanatomy required significantly different lateral or medial screw positions at successive levels, we used small offset connectors to facilitate rod attachment.

When occipitocervical fusions were planned, we used a specialized rod with an occipital plate attached at the cephalad end. Based on the rod trial, the rod and occipital plate were contoured and we positioned the occipital plate over the midline occipital keel to provide for the most bone purchase for the occipital screws. The occipital screws are not polyaxial and must be placed through the apertures in the occipital plates.

After the instrumentation was placed, but before final tightening of the construct, we compressed, distracted, or laterally rotated each successive segment as needed. We then packed autograft and occasionally bone extenders over the tops of the fusion sites.

**RESULTS**

Thirty-two patients underwent posterior cervical arthrodesis. Of these, 14 patients were treated by the Emory University group, 10 patients by the University of Iowa group, and eight patients by the Indianapolis group. The mean number of levels fused was 3.9 (range one–eight levels) (Table 2).

The dynamic properties of the polyaxial screw and rod system allowed for successful screw placement into the occiput (four patients; Fig. 5), C-1 lateral masses (one patient; Fig. 5), C-2 pars (four patients), C3–7 lateral masses (31 patients), and low cervical and upper thoracic pedicles (15 patients). In one patient occiput–T1 fusion was performed using a single construct. In one patient a supplemental C1–2 transarticular screw fixation was sup-
implemented by placement of the posterior polyaxial system (Fig. 5). Six patients underwent supplemental anterior fixation (Fig. 6).

There were two surgery-related complications. In one patient, who had undergone prior cervical surgery, a dural tear occurred during decompression and was repaired primarily. Another patient, who was treated for a pseudarthrosis, suffered C-7 dysesthesias secondary to a malpositioned C-7 screw (Fig. 7). This patient was returned to surgery for screw revision, and his symptoms resolved thereafter.

DISCUSSION

Lateral mass plating has been shown to be an effective method of achieving posterior cervical arthrodesis and stabilization. Reported complication rates are low. Injury to the cervical spinal cord or vertebral artery have not been reported in recent large published series on lateral mass plating. The rate of radiculopathy from malpositioned screws has ranged from 0 to 6% of patients.

Lateral mass plates, however, are of limited use when fusion is performed from the occiput to the thoracic spine in patients with abnormal cervical anatomy because the system lacks malleability and predetermined screw hole trajectories. Although the Cervifix system overcomes some of these problems, it is suboptimal for cervicothoracic fusions because it requires connector devices at the cervicothoracic junction, which decreases the rigidity of the system. In addition, the Cervifix system requires threading of a contoured rod through closed loop eye bolts, which can be tedious and sometimes impossible.

The new Medtronic posterior polyaxial cervical screw and rod system overcomes these problems because of its unique design. It has the versatility to accommodate oc-
Posterior cervical fusion

Fig. 7. Axial CT scan demonstrating a malpositioned C-7 screw impinging on the neural foramen.

cipitocervical fusions with C-1 lateral mass screws, C-2 pars screws, or C1–2 transarticular screws. In addition, it allows for lateral mass fixation from C-3 to C-7 as well as pedicle fixation in the lower cervical and upper thoracic spine without the limitations inherent in placing screws through holes in lateral mass plates. Finally, the rods are easily attached either directly to the polyaxial screw heads or by using toploading offset connectors (Fig. 6 right).

We have successfully used this system in 32 patients to achieve posterior cervical arthrodesis, with minimal complications. Further studies will be required to establish long-term results and fusion rates.

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Disclosure

The following authors are consultants for Medtronic Sofamor Danek: Regis W. Haid, Jr., M.D., Vincent C. Traynelis, M.D., Rick C. Sasso, M.D., Brian R. Subach, M.D., and Gerald E. Rodts, M.D.

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