Multilevel cervical arthroplasty with artificial disc replacement

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Object. In this study, the authors review the technique for inserting the Prestige ST in a contiguous multilevel cervical disc arthroplasty in patients with radiculopathy and myelopathy. They describe the preoperative planning, surgical technique, and their experience with 10 patients receiving a contiguous Prestige ST implant. They present contiguous multilevel cervical arthroplasty as an alternative to multilevel arthrodesis.

Methods. After institutional board review approval was obtained, the authors performed a retrospective review of all contiguous multilevel cervical disc arthroplasties with the Prestige ST artificial disc between August 2007 and November 2009 at a single institution by a single surgeon. Clinical criteria included patients who had undergone a multilevel cervical disc arthroplasty performed for radiculopathy and myelopathy without the presence of a previous cervical fusion. Between August 2007 and November 2009, 119 patients underwent cervical arthroplasty. Of the 119 patients, 31 received a Hybrid construct (total disc resection [TDR]-anterior cervical decompression and fusion [ACDF] or TDR-ACDF-TDR) and 24 received a multilevel cervical arthroplasty. The multilevel cervical arthroplasty group consisted of 14 noncontiguous and 10 contiguous implants. This paper examines patients who received contiguous Prestige ST implants.

Results. Ten men with an average age of 45 years (range 25–61 years) were treated. Five patients presented with myelopathy, 3 presented with radiculopathy, and 2 presented with myeloradiculopathy. Twenty-two 6 × 16-mm Prestige ST TDRs were implanted. Six patients received 2-level Prestige ST implants. Five patients received TDRs at C5–6 and C6–7, and 1 patient received TDRs at C3–4 and C4–5. One patient received a TDR at C3–4, C5–6, and C6–7 where C4–5 was a congenital block vertebra. Three patients (2 with 3-level disease and 1 with 4-level disease) received contiguous Prestige ST implants as well as a Prevail ACDF as part of their constructs. The mean clinical and radiographic follow-up was 12 months. There has been no case of screw backout, implant dislodgment, progressive kyphosis, formation of heterotopic bone, evidence of pseudarthrosis at the Prevail levels, or development of symptomatic adjacent level disease.

Conclusions. Multilevel cervical arthroplasty with the Prestige ST is a safe and effective alternative to fusion for the management of cervical radiculopathy and myelopathy. (DOI: 10.3171/2010.1.FOCUS1031)

Key Words • cervical arthroplasty • multilevel cervical arthroplasty • Prestige ST • radiculopathy • myelopathy

Anterior cervical decompression and fusion has been the procedure of choice for refractory cervical radiculopathy and myelopathy for more than 50 years. Historically, the primary goal of surgery has been preservation and restoration of neurological function. As an adjuvant, segmental arthrodesis has been incorporated as a means to provide stability and prevent further segmental degeneration. Over the past several decades, instrumentation, interbody devices, and biologics have greatly improved segmental fixation rates. However, segmental fixation may not be the ideal adjuvant to neural decompression within the cervical spine.

In single level subaxial fixation, the cervical spine is able to compensate and maintain overall motion. However, as more levels are incorporated into the construct, cervical motion is adversely affected. Levels adjacent to a cervical fusion may experience increased stressors that contribute to degeneration. In 1999, Hilibrand et al. reported on a consecutive series of 374 patients with a total of 409 ACDFs in whom symptomatic adjacent disease was reported to occur at a rate of 2.9% per year. Although the natural progression of degenerative disc disease must be a contributing factor, the work by Goffin et al. demonstrated that adjacent-segment disease is more likely related to the arthrodesis.

Brian Cummins was one of the first pioneers in cervical arthroplasty to report on the efficacy of the TDR in the cervical spine. In a small case series, Cummins et al. demonstrated that cervical arthroplasty was safe, effective, and preserved segmental motion. Recently, the 5-year outcomes for the Prestige ST (Medtronic Sofamor Danek) were presented showing improved outcomes for patients receiving a TDR versus an ACDF. In addition,
Cummins introduced the exciting concept of multilevel arthroplasty as an alternative to multilevel fusion. In cadaveric spines, both hybrid (TDR and ACDF) and multilevel cervical disc arthroplasty constructs have been shown to maintain segmental motion and preserve adjacent-level range of motion.\textsuperscript{1,3,18} Several case series have demonstrated that multilevel cervical arthroplasty for the treatment of radiculopathy and myelopathy can be an alternative with good outcomes.\textsuperscript{5,15} In a prospective study, Pimenta et al.\textsuperscript{14} demonstrated that multilevel cervical arthroplasty had improved outcomes over single-level arthroplasty. Several clear advantages to performing multilevel cervical arthroplasty are preserved motion, decreased adjacent-level biomechanical stressors, and potentially better outcomes.

In this study, we review the technique for inserting the Prestige ST in a contiguous multilevel cervical disc arthroplasty in patients with radiculopathy and myelopathy. We describe the preoperative planning, surgical technique, and our experience with 10 patients receiving a contiguous Prestige ST implant. We present contiguous multilevel cervical arthroplasty as an alternative to multilevel arthrodesis.

**Methods**

After institutional review board approval was obtained, a retrospective review of all contiguous multilevel cervical disc arthroplasties with the Prestige ST artificial disc between August 2007 and November 2009 at a single institution by a single surgeon (senior author M.R.) was completed. Clinical criteria included patients that had undergone a multilevel cervical disc arthroplasty performed for radiculopathy and myelopathy without the presence of a previous cervical fusion. Between August 2007 and November 2009, 119 patients underwent cervical arthroplasty. Of the 119 patients, 31 received a Hybrid construct (TDR-ACDF or TDR-ACDF-TDR) and 24 received a multilevel cervical arthroplasty. The multilevel cervical arthroplasty group consisted of 14 noncontiguous and 10 contiguous implants. This paper examines patients who received contiguous Prestige ST implants.

**Clinical and Radiographic Evaluation**

The clinical evaluation of any patient begins with a thorough history and physical examination. At our institution there are several disqualifiers for cervical arthroplasty; primary axial neck pain in the absence of radiculopathy or myelopathy, osteopenia or osteoporosis, autoimmune disorders, malignancy involving the spine, acute cervical trauma, subluxation of the cervical segment greater than 3.5 mm on flexion-extension radiographs, ossified posterior longitudinal ligament, severe facet arthrosis demonstrating lack of motion, and congenital stenosis. Patients with radiculopathy or myelopathy caused by disc herniation or osteophytes are candidates for surgery.

All patients undergo preoperative radiography in flexion-extension, CT scanning, and MR imaging of the cervical spine. In addition, patients also undergo standing anteroposterior and lateral scoliosis radiographs for evaluation of overall balance and deformity. Alone, the presence of cervical kyphosis is not a disqualifier for cervical arthroplasty. The Prestige ST can be inserted between C-3 and T-1 in patients with 1-, 2-, 3-, or 4-level disease. Although not all levels may accommodate a Prestige ST, hybrid constructs utilizing stand-alone interbody spacers such as the Prevail (Medtronic Sofamor Danek) can be inserted. Given the limitations imposed by the overall anatomical shape of the C-2 VB, we have not inserted a Prestige ST at C2–3.

Computed tomography scanning can be used to approximate implant depth; however, the final Prestige ST depth tends to always be less than the preoperative measurement due to bone removal during the carpentry portion of the surgery. The VB height can be determined from the sagittal CT scan to help evaluate for potential placement of adjacent-level implants. The limitation is the inferior lip of the superior VB that will be removed, and the remaining anterior body height may no longer facilitate the placement of an adjacent-level Prestige ST. The superior and inferior Prestige ST flanges are 7.5 and 7.1 mm long. Therefore, more than 16 mm of exposed anterior VB is necessary for insertion of an adjacent level Prestige ST.

**Prestige ST Implant**

The Prestige ST implant is a stainless steel ball-in-trough cervical arthroplastic device. The ball-in-trough motion is relatively unconstrained and comparable to that of the cervical spine. The endplates have anterior flanges that make an angle similar to that of the VBs. The flange profiles are 3.0 and 2.5 mm with and without the set screw, respectively. The superior and inferior flange lengths are 7.5 and 7.1 mm, respectively. The flanges are secured with 4.0 × 13–mm screws or 4.5 × 13–mm salvage screws. The endplates come in 12-, 14-, 16-, and 18-mm depths that will allow an interbody height of 6, 7, 8, or 9 mm. The endplates are grit-blasted to promote osteointegration. The Prestige ST was first introduced in 2002 and was FDA approved in 2007.

**Surgical Technique**

Patients are positioned supine on the operating table. Patients who can tolerate slight neck extension have a shoulder roll placed to help with exposure, and pressure points are padded. For all cases we use neuromonitoring for somatosensory evoked potentials and motor evoked potentials. Preoperative antibiotics and steroids are given. Fluoroscopy and surface landmarks are used to delineate surgical levels and to determine the appropriate incision location. For most patients we use a transverse incision extending from the midline toward the sternocleidomastoid muscle. The anterior cervical spine is approached through a standard fascial dissection. After the longus colli is dissected laterally and the retractors are placed, the endotracheal cuff is deflated and reinflated to diminish recurrent laryngeal nerve compression from retraction.\textsuperscript{1} The midline of the VBs are marked, and the overhanging lip of the superior VB is carefully drilled away to open up the disc space. The intervertebral disc and cartilaginous endplates are thoroughly removed.
After the discectomy is completed, the endplates are fashioned with a high-speed drill and made parallel. The cartilaginous endplate is removed to expose the subchondral bone. Meticulous care is taken not to violate the subchondral bone, as this may weaken the fixation of the implant. Preparing the endplates prior to decompression opens the corridor and is efficient. The posterior anulus and posterior longitudinal ligament must be removed if a TDR is considered. The posterior endplates are trumpeteted, and wide foraminotomies are performed. The wide foraminal decompressions are essential since motion is retained and any foraminal encroachment may aggravate a radiculopathy. The anterior VB can only be slightly curved. Otherwise, the anterior VB flanges will not be flush with the VB and will remain proud. The Prestige ST trials allow you to size and determine if appropriate endplate as well as anterior VB carpentry has been achieved. Prior to trial insertion, any VB distraction pins should be removed. The trials should fit snug but not under too much tension. If the implant is inserted under stiff ligaments, motion may be limited. Once the implant is inserted and secured, the head is flexed and extended under fluoroscopy to evaluate motion. It is essential that the implant be no more than 1–2 mm from midline due to the theoretical risk of uneven facet loading and potential postoperative pain as well as potential for advanced facet arthrosis.

In multilevel disease, the most cephalad level is decompressed first to ensure that the arthroplasty is at the top of the construct. The ability to insert a subsequent Prestige ST at the level below is dependent on the amount of superior anterior VB available. Once the adjacent level is ready for the implant, the profile trial, which has superior and inferior flanges the same height as the implant, is used to determine if a second Prestige ST can be inserted. If so, the implant is carefully inserted into the disc space so as not to ride up on the above implant. The top screws need to be secured almost completely but not so much as to limit securing the bottom screws. While the inferior screws are being inserted, the surgeon has to be mindful of the top flange. There is a tendency for the superior flange to ride up on the inferior flange of the superior implant while the inferior screws are inserted. Once all 4 screws are inserted, the inserter is removed and the screws are slowly tightened down, alternating in a diagonal manner. The locking screws are then inserted and tightened. The implant should be flush with that of the above level. If the implant cannot be secured, a stand-alone interbody device should be considered. The Prestige ST is a possible option. The device is made of polyetheretherketone, ample amount of packing space for arthrodesis, and has a superior and inferior midline screw that will not interfere with the adjacent Prestige ST. The implant can be packed with allograft cellular bone matrix containing native mesenchymal stem cells (Osteocel, Nuvasive), autogenous bone graft, demineralized bone matrix, or combination of the above.

**Table 1: Characteristics of patients undergoing multilevel cervical arthroplasty with the Prestige ST**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Lesion</th>
<th>Presentation</th>
<th>Procedure</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47, M</td>
<td>C4–5,6,6–7, &amp; 6–7 HNP</td>
<td>myelopathy</td>
<td>C4–5 TDR, C5–6 TDR, &amp; C6–7 ACDF</td>
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</tr>
<tr>
<td>2</td>
<td>48, M</td>
<td>C5–6 &amp; C6–7 HNP</td>
<td>radiculopathy</td>
<td>C5–6 &amp; C6–7 TDR</td>
<td>none</td>
</tr>
<tr>
<td>3</td>
<td>43, M</td>
<td>C4–5, 5–6, &amp; 6–7 HNP</td>
<td>myelopathy</td>
<td>C4–5 TDR, C5–6 TDR, &amp; C6–7 ACDF</td>
<td>none</td>
</tr>
<tr>
<td>4</td>
<td>25, M</td>
<td>C5–6 &amp; 6–7 HNP</td>
<td>radiculopathy</td>
<td>C5–6 &amp; 6–7 TDR</td>
<td>none</td>
</tr>
<tr>
<td>5</td>
<td>45, M</td>
<td>C5–6 &amp; 6–7 HNP</td>
<td>radiculopathy</td>
<td>C5–6 &amp; 6–7 TDR</td>
<td>none</td>
</tr>
<tr>
<td>6</td>
<td>49, M</td>
<td>C5–6 &amp; 6–7 HNP</td>
<td>myelopathy</td>
<td>C5–6 &amp; 6–7 TDR</td>
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</tr>
<tr>
<td>7</td>
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<td>C5–6 &amp; 6–7 TDR</td>
<td>none</td>
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<tr>
<td>8</td>
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<td>myelopathy</td>
<td>C3–4 TDR, C4–5 TDR, C5–6 ACDF, &amp; C6–7 TDR</td>
<td>none</td>
</tr>
<tr>
<td>9</td>
<td>54, M</td>
<td>C3–4, 4–5, 6–7 HNP</td>
<td>myeloradiculopathy</td>
<td>C3–4, 5–6, &amp; 6–7 TDR</td>
<td>none</td>
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<tr>
<td>10</td>
<td>39, M</td>
<td>C3–4 &amp; 4–5 HNP</td>
<td>myelopathy</td>
<td>C3–4 &amp; 4–5 TDR</td>
<td>none</td>
</tr>
</tbody>
</table>

* HNP = herniated nucleus pulposus.

Results

The following data were collected and are presented in Table 1: age, sex, etiology, clinical presentation (radiculopathy, myelopathy), surgical procedure, and complications. Ten men with an average age of 45 years (range 25–61 years) were treated. Five patients presented with myelopathy, and the 3 patients presented with radiculopathy, and 2 patients presented with myeloradiculopathy. Twenty-two 6 × 16–mm Prestige ST TDRs were implanted. Six patients received 2-level Prestige ST implants. Five patients received TDRs at C5–6 and C6–7 (Fig. 1), and 1 patient received TDRs at C3–4 and C4–5. One patient received a TDR at C3–4, C5–6, and C6–7 where C4–5 was a congenital block vertebra (Fig. 2). Three patients (2 with 3-level disease and 1 with 4-level disease) received contiguous Prestige ST implants as well as a Prevail ACDF as part of their constructs.

All patients underwent operative placement of the Prestige ST and Prevail ACDF without technical difficulty. No neurological or vascular injury occurred. The mean clinical and radiographic follow-up was 12 months (range 3–27 months). There has been no case of screw backout, implant dislodgment, progressive kyphosis, formation of heterotopic bone, evidence of pseudarthrosis at the Prevail levels, or development of symptomatic adjacent-level disease.
Illustrative Case

History and Examination. This 61-year-old otherwise healthy man presented to the clinic with neck pain, progressive loss of fine motor control, clumsiness, and bilateral upper-extremity paresthesia. The patient was evaluated and treated by physical therapy with no improvement prior to the clinic visit. The patient stated that his gait had become increasingly unsteady over 1 week’s time. The patient did not recall any inciting event.

On examination, the patient was hyperreflexive and had a bilateral upper-extremity paresthesia that was not limited to any one dermatome, a bilateral Hoffman sign, and an unsteady gait. Plain radiographs showed advanced degenerative disc disease at C5–6 and C6–7. Analysis of the MR imaging study showed cervical stenosis at C3–4, C4–5, C5–6, and C6–7 with cord signal change at the respective levels (Fig. 3).

Operation. The patient agreed to undergo an anterior C3–4, 4–5, 5–6, and 6–7 decompression and arthroplasty rather than fusion. A single transverse incision was made at the level of C-5. The C3–4 discectomy was performed first. Once the implant was inserted and secured at the respective level, the subsequent level was decompressed and instrumented. The C3–4 and C4–5 levels could accommodate a Prestige ST 6 × 16-mm implant; however, the C-5 VB could not accommodate a second Prestige ST. A Prevail interbody device packed with the patient’s autogenous bone was inserted at the C5–6 level followed by a Prestige ST at the C6–7 level. No intraoperative complications were appreciated. The patient was extubated and was transferred to the postanesthesia care unit.

Postoperative Course. Postoperative imaging revealed excellent placement of instrumentation (Fig. 4). The patient was discharged on postoperative Day 1. On follow-up, the patient stated that paresthesia, clumsiness, and unsteady gait had all greatly improved.
Multilevel cervical arthroplasty

Discussion

Cervical disc arthroplasty is an exciting new technique in the management of cervical radiculopathy and myelopathy. Cervical TDRs offer many distinct advantages over the traditional ACDF to include preserved segmental motion, decreased adjacent level strain, and improved outcomes. Although initially intended for single-level disease, cervical TDRs are being used in contiguous and Hybrid constructs with excellent outcomes.

Currently, only the Prestige ST and ProDisc C (Synthes Spine) have been approved by the FDA for cervical spine arthroplasty. The Prestige ST offers several advantages to include anterior fixation for initial stability, unconstrained motion similar to that of the cervical spine, and a simple insertion technique. Success is determined by proper patient selection and the surgeon’s ability to obtain an appropriate decompression and fashion the endplates. As with the ACDF, if the endplates are oblique in the horizontal plane, a coronal deformity could be introduced into the cervical spine. In addition, the implant needs to be centered within several millimeters of the midline for proper loading of the facets during motion. If the implant is not centered, the unequal loading may promote posterior joint arthrosis. To date, the senior author has not had to revise any Prestige ST implants.

Inserting contiguous Prestige ST implants can be challenging. The anterior VB at a minimum must have at least 16 mm of exposed surface to accommodate a Prestige ST above and below. Interestingly, all of the contiguous Prestige ST implants inserted by the senior author have been performed in men. This is primarily due to the VB height being greater in men than in women. Of the 30 Hybrid TDR constructs performed by the senior author (unpublished data), 15 were performed in females. In all but one, attempts to insert an adjacent level Prestige ST were made using the above-described technique. In 14 of these patients, the fusion option was used at the adjacent level.

Cervical myelopathy has both a static and dynamic component. Traditionally, anterior cervical decompression has been followed by fusion. Fusion is thought to reduce neural manipulation, arrest bone spur formation, and reduce posterior cord compression from buckled ligamentum flavum by increasing neuroforaminal height. However, multilevel fusions are associated with high pseudarthrosis rates, iliac crest donor site morbidity, persistent postoperative dysphagia, and the development of adjacent-level degeneration and disease. Arthroplasty may be the solution to these comorbidities. Sekhon was the first to report that cervical arthroplasty in the setting of cervical myelopathy was a safe and excellent alternative to fusion. Since Sekhon’s study, several other authors have shown that cervical arthroplasty in the setting of cervical myelopathy can have a good outcome. Our results confirm that in the short term, multilevel cervical arthroplasty is a safe and effective adjuvant implant strategy to decompression in the setting of cervical myelopathy or radiculopathy.

Currently, cervical arthroplasty remains an alternative to fusion. Long-term data are still necessary to determine whether single or multiple level cervical arthroplasty is superior to the veteran ACDF.

Conclusions

Multilevel cervical arthroplasty with the Prestige ST is a safe and effective alternative to fusion for the management of cervical radiculopathy and myelopathy.

Disclosure

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the United States Army, Unites States Navy, or the Department of the Defense. The authors are employees of the Unites States government. This work was prepared as part of their official duties and as such, there is no copyright to be transferred.

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: MK Rosner. Acquisition of data: MJ Cardoso, MK Rosner. Analysis and interpretation of data: MJ Cardoso, MK Rosner. Drafting the article: MJ Cardoso. Critically revising the article: MJ Cardoso, MK Rosner. Reviewed final version of the manuscript and approved it for submission: MK Rosner. Statistical analysis: MJ Cardoso. Study supervision: MK Rosner.

References


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