

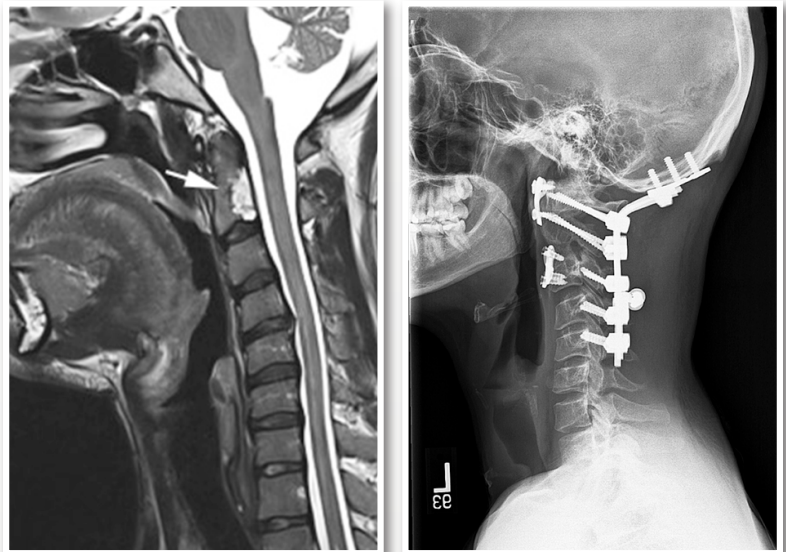
En Bloc Spondylectomy and TransOral Robotic Surgery for Cervical Chordoma

► Neurosurgeons and otorhinolaryngologists at Penn Medicine are incorporating trans-oral robotic surgery (TORS) into the protocols for en bloc spondylectomy for upper cervical primary spinal tumors, including skull-base (C1-C2) chordomas.

Skull-base chordomas are rare primary spinal tumors that originate at the vestigial notochord, remnants of which are greatest at the cervical and sacral spine. Dense and fibrous in character, chordomas are benign, a distinction that belies their propensity for locally aggressive, tenacious, and invasive progression over time with the consequent risk of brainstem compression. Recurrence in the absence of complete eradication is characteristic of chordomas.

Surgery is the mainstay of treatment for chordomas, which are generally resistant to medication and first-line radiotherapy. Historically, en bloc spondylectomy for cervical chordomas—removal of the tumor as a single unit with clear margins—has had the best outcomes from the perspective of recurrence and survival. However, given the exceptional technical difficulty of these intricate surgeries, the literature contains fewer than a dozen case reports for en bloc cervical chordoma resection. Adjuvant proton beam radiation therapy, when combined with intra-lesional surgery (which removes as much of a chordoma as possible without damaging the spinal cord or its neurovascular structures) can be beneficial when en bloc surgery is infeasible.

At Penn Medicine, en bloc chordoma spondylectomy for cervical chordomas involves the collaboration of neurosurgeons, radiation-oncologists and otorhinolaryngologists (see Faculty section) performing multi-stage surgeries incorporating posterior and anterior techniques (e.g., posterior osteotomy with anterior column reconstruction and pharyngeal closure). Since November 2017, these procedures have also included trans-oral robotic surgery (TORS). TORS is a technique developed by Drs. O'Malley and Weinstein of Penn Otorhinolaryngology-Head and Neck Surgery to prevent the morbidity identified with traditional open skull-base and reconstructive surgeries for head and neck cancers. The neurosurgery team worked with Dr. O'Malley's team to bring TORS into the neurosurgical field as a tool to maximize outcomes in these complex spinal and skull base procedures.



► **Figure 1:** (Left) Chordoma (arrow) situated at the posterior cortical rim of C2; there was no invasion of the dura or vertebral arteries.

► **Figure 2:** (Right) The same patient following en bloc spondylectomy and TORS for chordoma at C2; pedicle screws and rods

CASE STUDY

Mr. W, a 26-year-old corporate real estate developer, visited a neurosurgeon in New York City after follow-up scans for a motor vehicle accident revealed a skull-based chordoma at C1-C2 (Figure 1). Concluding that the tumor was inoperable, the neurosurgeon referred Mr. W to the Roberts Proton Therapy Center for treatment.

At Penn Medicine, primary tumors of the spine are reviewed by the Neuro-Oncology Tumor Board, which comprises specialists from the Departments of Neurosurgery, Otorhinolaryngology, Radiation-Oncology and Orthopaedic Oncology. The Board's comprehensive review of Mr. W's imaging determined that the lesion was encapsulated in vertebral bone and that dural and vascular invasion had not yet occurred. Mr. W's chordoma was then recategorized and he was referred to neurosurgeon Neil Malhotra, MD, for en bloc resection of the tumor.

A three-phase procedure over two days was planned, beginning with a posterior osteotomy of the vertebral bone around the lesion, followed by TORS exposure so that Dr. Malhotra could complete the transoral removal of the bone-tumor with minimal healthy tissue manipulation (the first TORS procedure for chordoma on record) and, finally, anterior and posterior stabilization of the spine and surgical site.

Prior to surgery, Mr. W was sedated and placed in the prone position with head stabilization. Then, using image-guided navigation, an ultrasonic osteotome was used posteriorly to create parallel cuts at C2 through -side cuts at the margin between the tumor and bone. Hardware for stabilization, screws, were then placed for the rods that would support the head following surgery. Mr. W was then extubated and spent the night in the ICU with his family.

(Continued on back)

CASE STUDY *(Continued from cover)*

The following day, a TORS procedure was performed to expose the anterior vertebral body of C2 and the osteotomies performed on the prior day of surgery. With exposure completed, with minimal tissue manipulation, attention was turned to the base of the Dens and the C2-3 disk. Cuts across the Dens and C2-3 disc connected to the previously completed parallel osteotomies and the bone and tumor were removed through the mouth en bloc. A 4 cm section of non-vascularized hip bone was then grafted in place with plates to replace the resected spinal bone. At this point, a second TORS procedure was performed to close the point of access. Finally, Mr. W received the posterior rods to support his head (Figure 2).

Mr. W was discharged to home on postoperative day six, and has since returned to work. To date, there is no evidence of tumor recurrence or complications as a consequence of his surgery.

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FACULTY TEAM

The Penn Center for Cranial Base Surgery uses an approach combining the expertise of Penn specialists who collaborate to determine an individualized treatment plan designed expressly for each patient. Physicians from neurosurgery, otorhinolaryngology-head and neck surgery, medical oncology, endocrinology, neuroradiology, radiation oncology, and plastic and reconstructive surgery meet at a biweekly skull base Tumor Board to discuss every case and formulate a treatment plan. Throughout the course of a patient's comprehensive care, additional support is provided by experienced physical and occupational therapists, speech and swallowing therapists, rehabilitation medicine physicians, social workers, endocrinologists, neuro-ophthalmologists and dieticians.

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