Upper Cervical Spine Fusion

Surgical Indications and Considerations

Anatomical Considerations: The occiput-C1 articulations primarily allow for flexion and extension movements and the C1-C2 articulations primarily allow for rotation. Fifty percent of cervical spine rotation occurs at the C1-C2 joint complex.

Pathogenesis: Upper cervical instability can occur from intrinsic factors, such as rheumatoid arthritis, or extrinsic factors, such as trauma. Rheumatiod arthritis most commonly affects the cervical region as compared to the thoracic and lumbar regions. In the affected cervical spine, articular cartilage is destroyed and the inflamed soft tissue enlarges to involve the neighboring structures. Ligaments undergo "distention, attenuation," and rupture. Bone erosion occurs with osteoporosis, and cyst formation develops which can lead to changes in vertebral alignment in the upper and subaxial cervical spine. Rheumatoid arthritis can also lead to lesions such as atlantoaxial subluxation, atlantoaxial impaction, and subaxial subluxation. These lesions can cause compression of the spinal cord and can lead to generalized debility that can "culminate" into tetraparesis or death. Instability of the atlantoaxial joint can also occur congenitally, such as in the case of Down syndrome.

Extrinsic factors such as hyperextension injuries from motor vehicle accidents or falls can lead to instabilities of the upper cervical segments. Hangman's fractures or C2 traumatic spondylolisthesis involves a fracture to the pars interarticularis of the dorsal element. Other pathological conditions that can warrant a spinal fusion are atlanto-occipital subluxation/dislocation, atlas fractures, odontoid fractures, and occipital condyle injuries secondary to an avulsion of an ipsilateral alar ligament and supporting soft tissue structures as a result of excessive "shear, lateral bending, and rotary forces."

Epidemiology: As mentioned above, rheumatoid arthritis is a major contributing factor related to cervical lesions. Cervical spine subluxations are observed in 43 to 86% of patients, and occur more in males, despite a greater propensity for rheumatoid arthritis in women. According to a study, atlantoaxial subluxation and basilar "invagination" occur in 39% and 11% of patients with rheumatoid arthritis. Clinically, these patients present with severe neck pain, as well as myelopathy from craniocervical instability and spinal cord compression. If left untreated, the condition can cause neurological decline, patients can become bedridden, and the chances of surviving beyond seven years is unlikely.
Extrinsic biomechanical stress to the cervical spine is another factor which can contribute to cervical lesions. Upper cervical spine injuries resulting from trauma includes: 1)occipital condyle injuries resulting from an avulsion of the ipsilateral alar ligament from excessive shear, lateral bending, and rotatory forces, 2) atlanto-occipital subluxation/dislocation (survivals of this injury are rare) these injuries can cause a severe amount of instability and can be associated with cranial nerve and spinal cord involvement, 3) atlas fractures which can lead to C1-C2 instability due to "incompetency" of the transverse ligament and surrounding capsular structures, and 4) odontoid fractures, which account for 5-15% of cervical spine fractures.

Diagnosis:

- For upper cervical disc herniation clinical presentation may include numbness of the hands and arms, loss of fine motor control, dysesthesia or hypesthesia to pinprick stimulation, proprioception loss, ascending tingling and numbness in fingers, paresthesia over arms, neck pain, and loss of balance
- Mechanism of injury includes hyperextension or hyperflexion injuries involved with motor vehicle accidents or a fall from a height
- Clinical assessment include utilizing the alar ligament testing, Sharp-Purser testing, VBI insufficiency tests, and neurological status examination
- MRI and CT scans are helpful in demonstrating the presence, location, and severity of any fractures, subluxations, or cord compression
- Radiographs are also used to rule out bone pathology such as collapse of the vertebral bodies and osteophyte formation.

Nonoperative Versus Operative Management: Fusion of the upper cervical spine is usually recommended for patients who are unsuccessful with conservative interventions, such as ergonomic cuing, postural education, cervical stabilization/strengthening exercise and manual therapy for mobilization of soft tissue and joint mobility deficits in the upper and mid cervical spine segments.

The severity of the cervical lesion shown on imaging studies (MRI, CT scan and X-rays) as well as the patient's clinical presentation will determine if surgery for spinal fusion is indicated. Radiographic findings such as 1) osteophyte formation into the spinal canal, 2) spinal cord compression, and 3) odontoid and/or atlas bony involvement are all indications for surgical stabilization. Surgical intervention does not guarantee that the existing problem will be cured. There is always the possibility of post surgical complications. Early postoperative complications (up to 1 month postoperatively) include infection, neurologic injury (delayed paresis), graft extrusion (anteriorly and posteriorly), instrumentation loosening and failure. Late postoperative complication can involve the adjacent vertebra segments because the fusion will change the biomechanics of the cervical spine by placing increased stress on the non-fused joints, thus increasing the risk of creating an instability in the segments adjacent to the surgically fused segments. Higher complication rates associated with preoperative and intraoperative risk factors include:

- Obesity
- Smoking
- Diabetes
- Osteoporosis
- Pulmonary conditions
- Malnutrition
- Cerebral palsy
- Myelodysplasia
- Longer surgical procedures
- Increased operating room traffic
- Failure to use antibiotics

Surgical Procedures:

Anterior Cervical Spinal Fusion: The procedure provides wide, bilateral exposure, it decreases the incident of contamination of the oral and pharyngeal cavities, and it gives the surgeon access to segments below C4. The patient is positioned supine with the head slightly extended and rotated 30 degrees away from the surgical side. The surgeon makes an incision 2 cm below and parallel to the mandible. A vertical incision of the platysma is made and is transected horizontally. The submandibular gland is elevated, and the facial artery and vein are dissected free. The digastric, hypoglossal, pharyngeal constrictor, longus colli, longus capitus muscles along with the hypoglossal and superior laryngeal nerves and the ventral vertebral and carotid arteries are carefully dissected and retracted to expose the anterior tubercle of C1, C2 and C3 so they can be palpated. An allograft or autograft can be used depending on the patient requirement. The grafts can be bone used from the humerus or the ilium. A plate is selected and is measured to insure the distance from the top of the graft to the body of C3 caudally. Four bicarbonate screws are used to secure the plate onto C1 and C3. Radiographic images are used to help guide the pins and screw placements.

Posterior Cervical Spinal Fusion: The patient is positioned in prone. If the neck is stable, the patient's head is flexed forward to no further than a "finger-width" from the sternum. If not stable, the procedure will be completed with the patient in the neutral position in traction or halo immobilization. A posterior midline incision is made from the external occipital protuberance caudally to allow sufficient exposure as far as C3 level. The dissection is kept midline and "subperiosteally" to expose the spinous processes and laminae of C2 and C3 as far lateral as the facet joints. Uncovering of the posterior arch of the atlas is performed with care. The occiput is exposed if it is included in the fusion, and hemostasis is achieved by electrocautery. For C1-C2 fixation using the Magerl's transartcular screw placement technique, long screws are placed from the posterior aspect of C2 facet laminar junction to the C1 lateral mass by drilling. Titanium lag screw of the desired length is used with its lagged part only in the C1 portion to provide "compression fixation." Radiographic images are used to help guide screw placements. Damage to the vertebral artery can result. If damage to vertebral artery occurs with the placement of the first screw, placement of the second screw is avoided. Lateral mass fixation at C2-C3 level can also be achieved posteriorly. With this procedure, a titanium plate is positioned over the facet joints and screws of 14 to 18 mm in length are inserted through the lateral mass of C3 and into the pedicle of C2. This procedure is useful with facet dislocation type injuries and instability at the level of the laminectomy.

Preoperative Rehabilitation: Since pathology due to rheumatoid arthritis involving the cervical spine is linked with severe peripheral joint involvement, an attempt at slowing the "progression" early by medical intervention is promoted. Monitoring the spine continuously with radiographic as well as neurological examination is an important aspect of non-operative management. Non-operative treatments include: cervical collars (may help decrease local discomfort), soft tissue mobilization, strengthening/stabilization exercises, transcutaneous electrical nerve stimulation, and anti-inflammatory medications.

POSTOPERATIVE REHABILITATION

Phase I: Hospital setting: 1-7 days post operation.

Goals: Control pain and swelling
Protect fusion

Intervention:
- Immobilization with rigid collar brace for 4-8 weeks
- Anti-inflammatory and pain medication

Phase II: After discharge: Post-op 4-8 weeks

Goals: Control pain
Protect fusion
Increase endurance
Movement into painfree range

Intervention:
- Rigid collar brace if indicated by physician
- Anti-inflammatory and pain medication
- Gentle AROM exercises into painfree ranges
- Strengthening exercises to tolerance – especially focus on endurance training of cervical neck flexors
- Patient education of proper postural mechanics with functional activities

Part III: Outpatient physical therapy reconditioning program-3 phases

Phase I: Cognitive stage: 4-8 weeks

Goals: Protect the fusion
Control pain and inflammation
Maintain upright posture and neutral spine with functional activities
Increase soft tissue mobility of the cervical and scapular muscles

Intervention:
- Ice, hot packs, electrical stimulation, and soft tissue mobilization
- Postural re-education to maintain upright posture and neutral spine
- Passive and active stretches to the neck and shoulder complex
- Static cervical and dynamic scapular stabilization program

Phase II: Motor Learning: 8 weeks to 4 months

Goals: Progress cervical and scapular dynamic stabilization
Progress with endurance and upper extremity program

Intervention:

- Scapular and extremity strengthening while maintaining neutral spine
- Upper extremity endurance program (e.g., UBE, elliptical rider)
- Functional training simulating functional activities

Phase III: Autonomous stage: (on-going)

Goals: Return to unrestricted activity

Intervention:

- Work hardening and conditioning

Note: Most surgeons allow their patients to return to normal unrestricted activity and do not recommend physical therapy after postoperative intervention.

Selected References

Benzel E. Upper cervical and occipitocervical arthrodesis. *Spine Surgery: Techniques, complications avoidance, and management*. Philadelphia, Elsevier, 2005.

Brown C., Eismont F. Complications in spinal fusion. *Orthopedic Clinics of North America*. 1998;29: 679-697.

Chen T. The clinical presentation of uppermost cervical disc protrusion. *Spine*. 2000; 25:439-442.

Craig E. Rheumatoid arthritis of the spine. Cervical spine trauma: upper and lower cervical spine injury. *Clinical Orthopaedics.* New York, Lippincott Williams & Wilkins, 1999.

Harm J., Melcher R. Posterior C1-C2 fusion with polyaxial screw and rod fixation. *Spine.* 2001; 26:2467-2471.

Leamer, T. Lumber spine fusion. University of Pacific, Power point presentation. 2004

Matsunaga S., et al. Prognosis with upper cervical lesions caused by rheumatoid arthritis. *Spine.* 2003; 28:1581-1587.

Omura K., et al. Evaluation of posterior long fusion versus conservative treatment for progressive rheumatoid cervical spine. Spine. 2002;27;1336-1345.

Sandhu F., et al. Occipitalcervical fusion for rheumatoid arthritis using the inside-outside stabilization technique. *Spine.* 2003; 28:414-419.

Tan M., et al. Morphometric evaluation of screw fixation in atlas *via* posterior arch and lateral mass. *Spine.* 2003; 28:883-895.

Vaccaro A., et al. Cervical trauma: rationale for selecting the appropriate fusion technique. *Orthopedic Clinics of North America*. 1998;29:745-754.

Vender J., et al. Fusion and instrumentation at C1-3 via high anterior cervical approach. *J Neurosurg.* 2000;92:24-29.