Pediatric Occipitocervical Fusion

- Autologous rib graft augmentation for occipitocervical fusion in pediatric patients and a novel radiographic grading scale
- Pediatric Halo Use: Indications, Application, and Potential Complications
- Assessment of Flexion-Extension Motion After Occipitocervical and Atlantoaxial Fusion in Children
- Retro-odontoid mass resolution analysis and timing following posterior cervical spinal fixation: 16-year paediatric neurosurgery experience in a single UK institute
- Occipitocervical fusion and serious airway adverse events: A systematic review
- Halo Brace
- Characterizing pediatric cervical fusion in the modern era: indications, complications, and fusion rates
- Early Occipitocervical Fusion Surgery in a Rare Clinical Encounter of Non-traumatic Atlantooccipital Subluxation (AOS) in Down Syndrome (Trisomy 21)

Surgical indications

Although rarely encountered, pediatric patients with severe cervical spine deformity and instability may occasionally require occipitocervicothoracic instrumentation and fusion.

Occipitocervical fusion is the treatment of choice for occipitocervical instability that is symptomatic or threatens neurological function. In children, the most common distal fixation level with modern techniques is C2. Treated patients maintain a significant amount of neck motion due to the flexibility of the subaxial cervical spine. Distal fixation to the thoracic spine has been reported in adult case series. This procedure is to be avoided due to the morbidity of complete loss of head and neck motion. Unfortunately, in rare cases, the pathological condition or highly aberrant anatomy may require occipitocervical constructs to include the thoracic spine [1)].

Surgical management

The surgical management of craniovertebral junction (CVJ) instability in pediatric patients presents unique challenges. As compared with the adult patient, the anatomical variations of the CVJ in the pediatric patient are significant, complicate the approach, and limit the use of internal fixation. Diminutive osseous and ligamentous structures and syndromic craniovertebral abnormalities complicate the issue. Advances in imaging analysis and instrumentation have improved the armamentarium for managing the pediatric patient who requires craniocervical stabilization.

Menezes et al., published his experience of performing more than 850 pediatric CVJ fusions. This work includes the indications for atlantoaxial arthrodesis and occipitocervical fusion. Early atlantoaxial fusions were performed using interlaminar rib graft fusion, and more recently using either transarticular screw fixation in the older patient, or lateral mass screws at C-1 and rod fixation with either C-2 pars interarticular screw fixation or pedicle screw fixation. A C-2 translaminar screw fixation is also described. Occipitocervical fusions are performed with rib grafts in patients younger than 6 years of age. Subsequently, above that age, contoured loop fixation was performed, and in the past 8-10 years, screw and rod fixation was used. Abnormal spine growth was not observed in children who underwent craniocervical stabilization below the age of 5 years (clearly the bone grew with the patient). However, no deleterious effects were noted in the children treated with rigid instrumentation. The success rate for bone fusion alone was 98%. The author's success rate with rigid instrumentation is nearly 100%. A detailed review of the technique of fusion is presented, as well as the indications and means of avoidance of complications, their prevention, and management [2].

Techniques

Instrumentation of the cervical spine in children may be safer and more efficacious using screw constructs rather than wiring techniques [3].

Intraoperative CT is a helpful adjunct for confirming and readjusting the trajectory of the screws prior to leaving the operating room, which decreases overall treatment costs and reduces complications [4].

Standard 3.5 mm screws can be used for OC and upper cervical instabilities in children aged between 2 and 6 years. Some anchor points appeared safer compared with others. The occipital keel, C1 lateral mass, and C2 laminae offered adequate space for screw placement in almost all cases. C2 pedicles offered adequate space in 49 sides and barely adequate space in 25 pedicles. Transarticular screws could be safely placed in only 4 of 100 sides. Close radiographic assessment of the vertebral artery course and bony architecture are recommended before surgery in pediatric patients with OC and upper cervical instability [5]

Including bicortical occipital screw placement in occipitocervical constructs in children may result in a high fusion rate but at the cost of a notable complication rate [6].

Fixation at the craniovertebral junction (CVJ) is necessary in a variety of pediatric clinical scenarios. Traditionally an occipital bone to cervical fusion is preformed, which requires a large amount of hardware to be placed on the occiput of a child. If a patient has previously undergone a posterior fossa decompression or requires a decompression at the time of the fusion procedure, it can be difficult to anchor a plate to the occipital bone. The authors propose a technique that can be used when faced with this difficult challenge by using the occipital condyle as a point of fixation for the construct. Adult cadaveric and a limited number of case studies have been published using occipital condyle (C-0) fixation. This work was adapted for the pediatric population. Between 2009 and 2012, 4 children underwent occipital condyle to axial or subaxial spine fixation. One patient had previously undergone posterior fossa surgery for tumor resection, and 1 required decompression at the time of operation. Two patients underwent preoperative deformity reduction using traction. One child had a Chiari malformation Type I. Each procedure was performed using polyaxial screw-rod constructs with intraoperative neuronavigation supplemented by a custom navigational drill guide. Smooth-shanked 3.5-mm polyaxial screws, ranging in length from 26 to 32 mm, were placed into the occipital condyles. All patients successfully underwent occipital condyle to cervical spine fixation. In 3 patients the construct extended from C-0 to C-2, and in 1 from C-0 to T-2. Patients with preoperative halo stabilization were placed in a cervical collar postoperatively. There were no new postoperative neurological deficits or vascular injuries. Each patient underwent postoperative CT, demonstrating excellent screw placement and evidence of solid fusion. Occipital condyle fixation is an effective option in pediatric patients requiring occipitocervical fusion for treatment of deformity and/or instability at the CVJ. The use of intraoperative neuronavigation allows for safe placement of screws into C-0, especially when faced with a challenging patient in whom fixation to the occipital bone is not possible or is less than ideal. [7].

Postoperative Immobilization

The scientific literature does not have a consensus about the role and method of postoperative immobilization after occipitocervical fusion in the pediatric population. The primary goal of this study is to review the medical literature and evaluate different immobilization methods and their impact on fusion, following the surgical management of craniocervical instability in children. It started with an extensive research of randomized controlled trials, series of cases and case reports, describing occipitocervical junction pathologies, clinical, epidemiological characteristics, and treatment. The search was performed using the Pubmed database evaluating all the literature involving postoperative immobilization after occipitocervical fusion in pediatric patients. The results showed that most cases of occipitocervical stabilization were due to congenital spinal instability followed by trauma in most series. The most common type of surgery performed was occipitocervical fusion using screw and rod constructs. The different methods of postoperative immobilization did not affect outcomes. Then, we can conclude that screw-and-rod constructions in occipitocervical fusion augment the rates of fusion, independently from which immobilization was used, even when none was used at all [8].

Outcome

Surgical arthrodesis for pediatric occipitocervical instability has a high rate of success in a wide variety of challenging circumstances; however, identifying potential risk factors can help to target variables that should be the focus of improvement.

Pediatric patients in the cohort of Mazur et al., with postoperative wound infections requiring surgical debridement had higher surgical failure rates after occipitocervical fusion. Those with skeletal dysplasia and congenital spinal anomaly were more likely to require reoperation for hardware failure. Better understanding of the mode of surgical failure may enable surgeons to develop strategies to decrease the need for reoperation in pediatric patients with OC instability [9].

Surgical fixation in the pediatric cervical spine is hampered by fragile posterior structures. A postoperative immobilization by halo vest for 4 months is customary. Selective anterior corpectomy and plate fixation is not recommended in pediatric patients with skeletal dysplasias [10].

Retrospective cohort studies

Case series

Martinez-Del-Campo et al, assessed cervical spine radiographs and CT images of 18 patients who underwent occipitocervical arthrodesis. Measurements were made using postoperative and follow-up images available for 16 patients to determine cervical alignment (cervical spine alignment [CSA], C1-7 sagittal vertical axis [SVA], and C2-7 SVA) and curvature (cervical spine curvature [CSC] and C2-7 lordosis angle). Seventeen patients had postoperative and follow-up images available with which to measure vertebral body height (VBH), vertebral body width (VBW), and vertical growth percentage (VG%-that is, percentage change from postoperative to follow-up). Results for cervical spine growth were compared with normal parameters of 456 patients previously reported on in 2 studies.

Ten patients were girls and 8 were boys; their mean age was 6.7 ± 3.2 years. Constructs spanned occiput (Oc)-C2 (n = 2), Oc-C3 (n = 7), and Oc-C4 (n = 9). The mean duration of follow-up was 44.4 months (range 24-101 months). Comparison of postoperative to follow-up measures showed that the mean CSA increased by 1.8 ± 2.9 mm ($p < 0.01$); the mean C2-7 SVA and C1-7 SVA increased by 2.3 mm and 2.7 mm, respectively ($p = 0.3$); the mean CSC changed by -8.7° ($p < 0.01$) and the mean C2-7 lordosis angle changed by 2.6° ($p = 0.5$); and the cumulative mean VG% of the instrumented levels (C2-4) provided 51.5% of the total cervical growth (C2-7). The annual vertical growth rate was 4.4 mm/year. The VBW growth from C2-4 ranged from 13.9% to 16.6% ($p < 0.001$). The VBW of C-2 in instrumented patients appeared to be of a smaller diameter than that of normal patients, especially among those aged 5 to < 10 years and 10-15 years, with an increased diameter at the immediately inferior vertebral bodies compensating for the decreased width. No cervical deformation, malalignment, or detrimental clinical status was evident in any patient.

The craniovertebral junction and the upper cervical spine continue to present normal growth, curvature, and alignment parameters in children with OCF constructs spanning a distance as long as Oc-C4 [11].

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