Case Report

C1-C2 sublaminar taping for displaced odontoid synchondrosis fracture in an infant: A case report and novel surgical technique

ABSTRACT

Pediatric cervical spine injuries are rare, and the diagnosis and management can be challenging. Surgical intervention has been recommended in unstable odontoid synchondrosis injuries or those that have failed nonoperative measures. However, the literature remains sparse on the operative management of severe injuries due to the low incidence. An 18-month-old female sustained an unstable odontoid synchondrosis fracture from a motor vehicle accident. Due to ongoing instability after initial immobilization in a halo, the decision was made to proceed with surgical management. With the patient positioned prone and neural monitoring throughout, a posterior approach was utilized. Subperiosteal exposure of the C1 posterior arch was performed bilaterally. A spinal fixation band was passed under the right C1 posterior arch, around the C2 spinous process, under the left C1 posterior arch, and finally back under the C2 spinous process. The C1-C2 distraction was reduced using intraoperative imaging, and the sublaminar tape construct was secured and reinforced. The halo was then reattached. Postoperative recovery was complicated by a halo pin-site infection which was treated with oral antibiotics. The halo was removed after 3 months, following a computerized tomography that demonstrated union. X-rays at 6 months revealed anatomical alignment with the union. Surgery is recommended in pediatric odontoid synchondrosis fractures refractory to nonoperative management. Sublaminar taping of C1-C2 with a spinal fixation band has been demonstrated to be an effective surgical technique in the management of an unstable odontoid synchondrosis fracture.

Keywords: Odontoid fracture, odontoid synchondrosis fracture, pediatric spine, spine trauma

INTRODUCTION

The management of pediatric odontoid synchondrosis fractures remains a challenge for the treating surgeon. Although uncommon, these injuries are associated with significant morbidity and there remains no consensus on the optimal management.^[1,2] The C-2 vertebra is vulnerable to injury in the pediatric population due to an increased head-to-body ratio resulting in a comparatively cephalad fulcrum of flexion/extension, ligamentous laxity, incomplete ossification of the synchondrosis has not completed ossification, injury to the synchondrosis most commonly presents in patients under the age of 7, with a traumatic hyperflexion

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Ryan J. Campbell^{1,2}, Motofumi Yasutomi¹, Sarah Nicholls^{1,2}, Elizabeth Mazepa¹, Stephen Ruff¹, Randolph Gray^{1,2}

¹Department of Orthopaedics and Trauma Surgery, Royal North Shore Hospital, ²Department of Orthopaedic Surgery, The Children's Hospital at Westmead, Sydney, NSW, Australia

Address for correspondence: Dr. Ryan J. Campbell, Department of Orthopaedics and Trauma Surgery, Royal North Shore Hospital, Sydney, NSW, Australia. Department of Orthopaedic Surgery, The Children's Hospital at Westmead, Sydney, NSW, Australia. E-mail: rj.campbell16@gmail.com

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injury mechanism.^[1,2] Fortunately, the majority of patients with odontoid synchondrosis fractures will not experience neurological deficits, although the lack of these objective signs may delay diagnosis.^[1]

There remains no consensus on the optimal management of odontoid synchondrosis fractures. The management strategies currently described in the literature for stable injuries include closed reduction with halo traction and external stabilization with a halo vest, collar, or orthosis.^[1,3,4] In failing conservative management or in the presence of an unstable injury with displacement over 100%, angulation over 30°, or neurological deficits, surgical intervention has been recommended.^[1,5,6] Given the rarity of this injury, the literature remains sparse on the operative management of such cases. Previous case reports have described surgical techniques in the forms of posterior instrumented fusion,^[5,7,8] temporary instrumentation without arthrodesis,^[9] C1 laminectomy with fusion,^[10] suture fixation,^[11] and sublaminar wiring.^[12,13] This report aimed to propose a novel surgical technique in the stabilization of an odontoid synchondrosis fracture using C1-C2 sublaminar taping in an 18-month-old patient. This case report was produced in accordance with the SCARE criteria.[14]

CASE REPORT

An 18-month-old female was involved in a motor vehicle accident. She was restrained in a toddler's chair in the front passenger seat of a van that rear-ended a stationary car at 60 km/h. The airbags were deployed which likely struck the patient in the head. The girl had a loss of consciousness for <1 min on scene and was urgently transferred to a tertiary trauma center in a stable condition. In the emergency department, it was noted that the patient was not moving the right upper limb. X-ray and computerized tomography (CT) imaging of the patient's cervical spine revealed an odontoid synchondrosis fracture with flexion displacement [Figure 1]. The fracture extended into the left lateral mass and there was a widening of the posterior elements of C1-C2.

She was subsequently intubated and paralyzed and transferred to our tertiary pediatric hospital for ongoing trauma management. On arrival, urgent magnetic resonance imaging was arranged. This demonstrated cerebrospinal fluid effacement and indentation of the spinal cord without signal change at the C1-C2 level [Figure 1]. A fluid collection in the prevertebral space was noted, likely representing a dural tear ventrally at the level of the fracture. Ligamentous injuries to the anterior longitudinal ligament, tectorial membrane,



Figure 1: Preoperative X-ray (a) and magnetic resonance imaging (b) demonstrating odontoid synchondrosis fracture with flexion displacement and prevertebral fluid collection

posterior atlanto-occipital membrane, posterior atlantoaxial membrane, and ligamentum flavum were also demonstrated. The patient's other injuries included complete avulsion of nerve roots from C4-T2 on the right side, a right midshaft clavicle fracture, a nondisplaced left mandible fracture, a complex full-thickness lip laceration, dentoalveolar fracture with avulsion of deciduous teeth, and contusion to the right upper lobe of the lung.

Surgical technique

The patient was initially taken to the operating theater for the application of a halo. Two pounds of traction was applied, and appropriate reduction was confirmed on a lateral shoot-through. Postoperatively, she was maintained in neutral positioning of the cervical spine. Three days later, she was returned to the theater for application of a halo jacket and re-tensioning of the pins. Unfortunately, subsequent imaging in the coming days revealed ongoing instability with loss of reduction.

After considering preoperative planning, definitive management was performed with C1-C2 sublaminar taping the following week. The patient was positioned prone and there was neural monitoring throughout the case. The posterior halo struts were loosened before a sterile prep and drape. A midline incision and dissection were performed. During dissection, the nuchal ligament was noted to be torn. A cerebrospinal fluid leak through a traumatic dural tear in the C1-C2 interlaminar space was also noted and addressed with a fibrous sealant. Subperiosteal exposure of the C1 posterior arch was performed bilaterally. The C1 arch was curetted, and a path was created dorsal to the posterior atlantoaxial ligaments. A posterior spinal fixation band malleable leader (3.0 mm NILE Alternative Fixation Spinal System)[15] was bent and under direct vision passed under the right C1 posterior arch in a caudal to cephalad direction [Figure 2a]. The tape was then passed around the C2 spinous process, deep to the supraspinous ligament [Figure 2b]. The tape was passed under the left C1 posterior arch in an identical manner to that performed on the right [Figure 2b] and brought back around under the C2 spinous process. The C1 C2 distraction was reduced with intraoperative fluoroscopy and the sublaminar taping construct tensioned and clamped. Sutures were passed through the band to secure the reduction [Figure 2c] and reinforced with ligating clips [Figure 2d]. Irrigation was performed, drains inserted, and layered closure performed in a standard manner. The halo was then reattached. Formal postoperative X-rays were obtained [Figure 3a].

The patient's postoperative recovery was complicated by a halo pin-site infection which was treated with oral antibiotics. Three months postoperatively, the halo was removed and replaced with a semi-rigid collar for a further month, following a CT which demonstrated a union of the synchondrosis fracture and enlocated lateral C1-C2 joints. X-rays at 6 months revealed stable anatomical alignment with union [Figure 3b]. With the exception of the right upper limb (C4-T2 nerve root avulsions), the patient was neurologically intact.



Figure 2: Diagrammatic representation of C1-C2 sublaminar taping operative technique. (a) Posterior spinal fixation band passer bent and passed under the right C1 posterior arch. (b) The fixation band was passed around the C2 spinous process and under the left C1 posterior arch. (c) The band was passed back under the C2 spinous process and the C1-C2 distraction reduced. The band was tensioned, clamped, held with sutures, and reinforced with ligation clips (d)

DISCUSSION

Pediatric odontoid synchondrosis fractures remain challenging due to the rarity of these injuries and the absence of a consensus on optimal management strategies. Many fracture patterns will be amenable to nonoperative management with the use of closed reduction with traction followed by external immobilization with a halo, collar, or orthotic braces. Huber *et al.* also performed a successful closed reduction through open-mouth digital reduction.^[16] In a combined series of 45 patients, Fassett *et al.* conducted a review of nonoperatively managed odontoid synchondrosis fractures with a fusion rate of 93%.^[11] This included patients managed with halo immobilization, Minerva orthoses, and collars. Furthermore, Razii *et al.* demonstrated complete remodeling with halo and collar immobilization at long-term follow-up following a displaced fracture with 35° of angulation.^[3]

In the current case, an attempt was made at a closed reduction with the application of a halo device with traction followed by immobilization in a halo jacket. The goal of this treatment was to relieve the compression of the spinal cord, restore alignment, and provide temporary stabilization to allow fracture healing while preserving the motion segment in the long term. The application of traction in injuries with distraction must be done with caution and under fluoroscopy, as a further distraction may bring about C1-C2 dysjunction as described by Salunke *et al.*^[4] Compliance and comfort with these devices in the pediatric population can prove challenging for the patient and family, and diligent monitoring is required for pin-site infections, loosening, and pressure areas associated with the jacket.

Monitoring of our patient's neurology was confounded due to age, remaining intubated for multiple operations for other injuries, and right C4-T2 nerve root avulsions. There was also



Figure 3: (a) Anatomical reduction of synchondrosis fracture immediately postoperatively and in halo jacket and (b) 3 months postoperatively with complete union

a significant radiological progression of fracture angulation and C1-C2 distraction in the 1st week, and thus, nonoperative management was abandoned. The current described operative techniques each come with several key considerations. The decision must be tailored to the patient's age, fracture pattern, degree of displacement and angulation, neurological status, concomitant injuries, and surgeon experience. To date, these have included posterior instrumented fusion,^[5,7,8] temporary instrumentation without arthrodesis,^[9] C1 laminectomy with fusion,^[10] suture fixation,^[11] and sublaminar wiring.^[12,13] In the case of an 18-month-old, sublaminar wiring may fail due to cut out through the incompletely ossified posterior arch. Theoretically, this could occur on tightening or during the postoperative period and would likely require hardware removal. Posterior instrumentation with or without arthrodesis has shown promising union and fusion rates to date, although the long-term consequences, particularly regarding loss of motion and long-term degenerative change, remain unknown.^[5,7-10] Thus, in the current case, posterior C1-C2 stabilization in the form of sublaminar taping with the use of a spinal fixation band was the preferred option. This provided adequate stability and allowed fracture healing in anatomical alignment. The current imaging studies show no concern for rotatory instability with the lateral C1-C2 joints demonstrating stability in dynamic studies. The long-term outcome of pain, range of motion, and function remains to be seen in our patient.

CONCLUSIONS

C1-C2 posterior stabilization with sublaminar taping using a spinal fixation band is a safe and effective surgical treatment option for unstable odontoid synchondrosis fractures in infants. This provides an alternative to wiring, fixation, and fusion techniques when surgery is indicated.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the legal guardian has given his consent for images and other clinical information to be reported in the journal. The guardian understands that names and initials will not be published, and due efforts will be made to conceal the identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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