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ORIGINAL ARTICLE

Periosteal turndown flap for posterior occipitocervical fusion: a technique review

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Abstract
Purpose Recently, several authors have proposed techniques for improving the fusion rate in pediatric posterior occipitocervical fusion including a variety of implants and the use of bone morphogenetic protein. A technique by Koop et al. using a periosteal flap for occipitocervical arthrodesis was described in 1984.
Methods A straight incision is made about the posterior neck to expose the occipitocervical region from the inion superiorly to the lowest cervical vertebrae to be fused inferiorly. The occiput is exposed superficial to the periosteum, which is then reflected and elevated from the occiput. The attachment is preserved at the caudal base of the flap and reflected over the intended area of fusion. When possible, fixation is then performed with cables, wires, screws, hooks, or plates.
Case example A 6-year-old male with an occiput to C2 distraction injury underwent posterior spinal fusion from occiput to C3 using sublaminar wires, periosteal turndown flap, and autologous iliac crest bone graft.
Conclusion In small children with traumatic upper cervical spine instability, the periosteal turndown technique may be used as a safe adjunct for occipitocervical fusions.

Keywords Cervical fusion · Periosteal turndown · Spine trauma · Pediatrics · Spine surgery

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Introduction

Though historically performed with the use of wiring and halo immobilization alone, occipitocervical fusion in the pediatric population is increasingly being performed with rigid internal fixation. However, situations in which there is an inability to achieve robust fixation due to structural defects or small anatomic structures in young children may present a challenge to the surgeon. Recently, several authors have proposed techniques for improving the fusion rate in pediatric posterior occipitocervical fusion including a variety of implants and the use of bone morphogenetic protein (BMP) [1–6].

A technique by Koop et al. using a periosteal flap in cases of occipitocervical arthrodesis was described in 1984 [7]. This technique may aid fusion by providing a source of osteogenic cells, especially in very young children, but little has been written about it for the past thirty years. We will review the technique for this procedure.

Methods

Surgical technique

The patient is intubated in the supine position and the halo ring is applied. Care is taken to avoid skull penetration with the pins, which are torqued to 2–4 inch-pounds of torque. After the application of halo pins, the patient is repositioned prone. Generally, the halo ring is secured to the head holder on the table. In cases of very small patients, it may be easier to apply the halo vest and bars and remove the posterior portion of the halo vest after the patient is prone. A roll is placed underneath the chest and hips for additional padding.

The halo ring is then adjusted to position the cervical spine in a neutral position. Care must be taken in this step as too much extension may make it difficult for the patient to visualize terrain in front of them, walk up stairs, and perform other activities requiring forward gaze. Conversely, too little extension may make swallowing and airway clearance more challenging [8–11]. A straight incision is made midline on the posterior neck to expose the occipitocervical region from the inion superiorly to the lowest intended cervical vertebrae to be fused inferiorly. Dissection is then carried down to expose the posterior elements at C1 down to the level of intended fusion. The occiput is exposed staying above the periosteum (Fig. 1a). The periosteal layer is then reflected at the occiput using a combination of forceps, a penfield, and a 15 blade to elevate the layer (Figs. 1b, 2). Bovie electrocautery can be used on the occiput to maintain hemostasis but care is taken not to cauterize the periosteal flap so that the osteogenic cells remain viable. The attachment is preserved at the caudal base of the flap, which can be divided into two adjacent flaps or reflected whole (Figs. 3, 4).

The exposed intended area of fusion is then decorticated. Cancellous bone strips are harvested from the iliac crest and placed surrounding the decorticated occipitocervical posterior elements to bridge the occipitocervical region. Additional autograft or allograft may be used as necessary. The periosteal flaps are reflected caudally. The flaps are sutured in place to the spinous process of the most inferior cervical level to be fused (Figs. 1c, 5). The distal portion of the flap is folded underneath itself, placing the osteophyte rich occipital surface of the flap against the defect (Fig. 2). Cables may be added to provide additional security to the bone graft. When possible, fixation is then performed with wires, screws, hooks, or plates according to surgeon preference and anatomic considerations of the patient (Fig. 1d). At the conclusion of the procedure, the

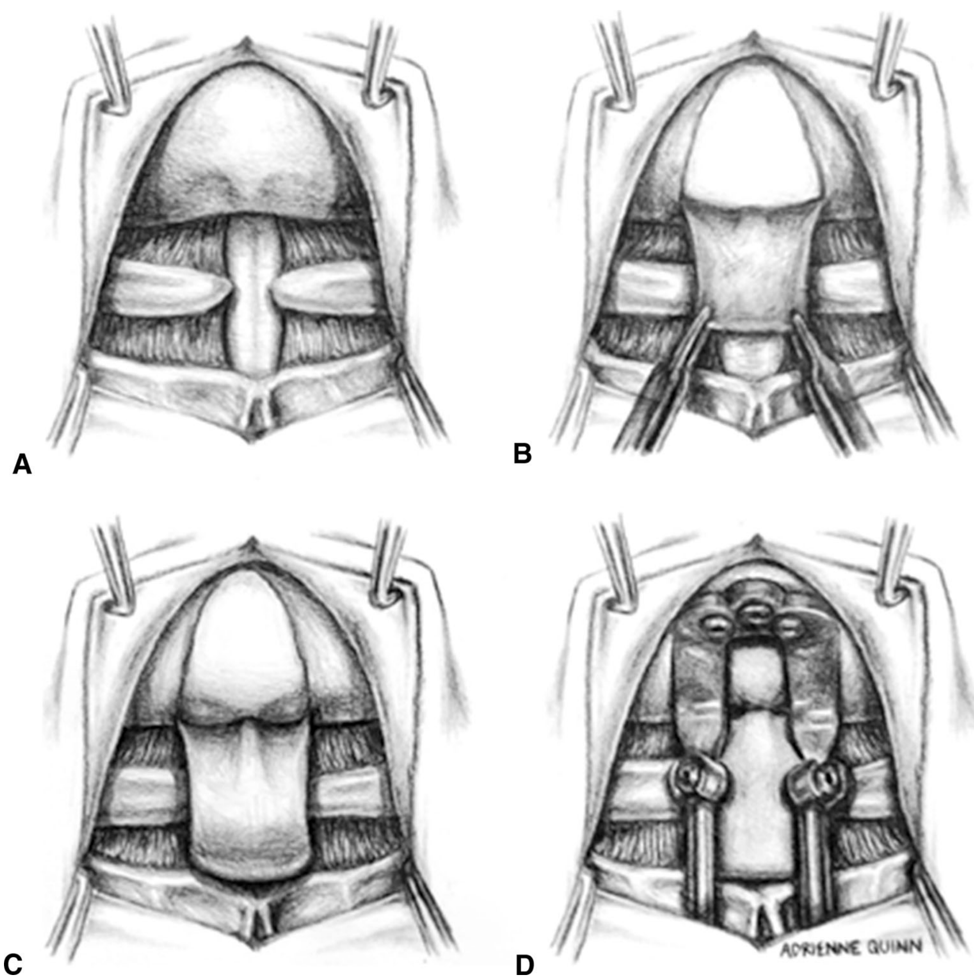

Fig. 1 Figure depicts progressive stages of exposure, elevation and suturing of periosteal flap. Occiput is exposed following vertical incision and dissection (**a**). Periosteal layer is reflected at the occiput using a combination of forceps, a penfield, and a 15 blade to elevate the layer (**b**). Periosteal flap is reflected caudally over the bone graft and sutured in place to the spinous process (**c**). Hardware fixation is performed over the periosteal flap (**d**)

Fig. 2 Figure 2 depicts the distal portion of the flap folded underneath itself, placing the osteophyte rich occipital surface of the flap against the defect, to enhance bone growth

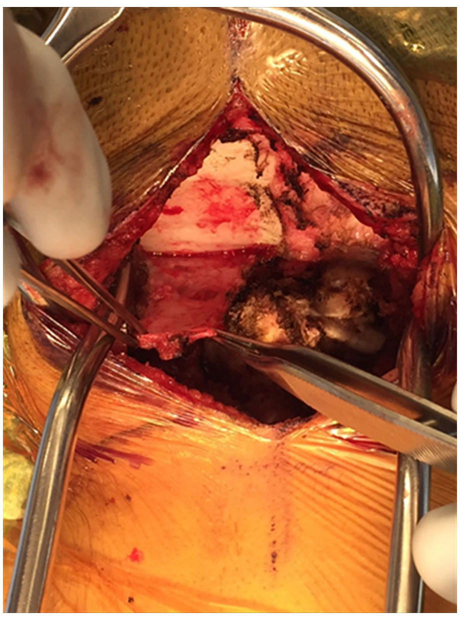

Fig. 3 The attachment is preserved at the caudal base of the flap, which can be divided into two adjacent flaps or reflected as a whole

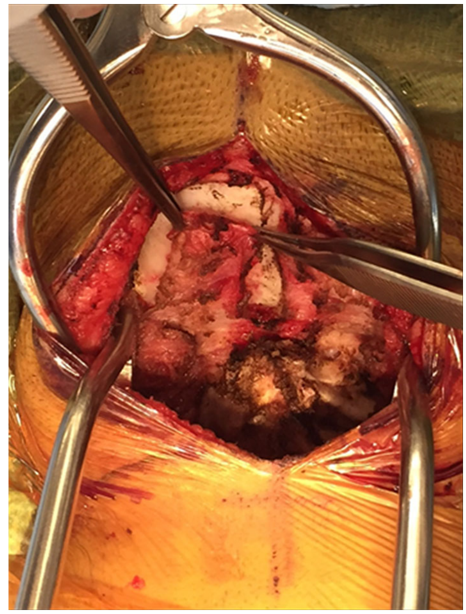

Fig. 4 Illustrating flap of periosteum after it has been reflected

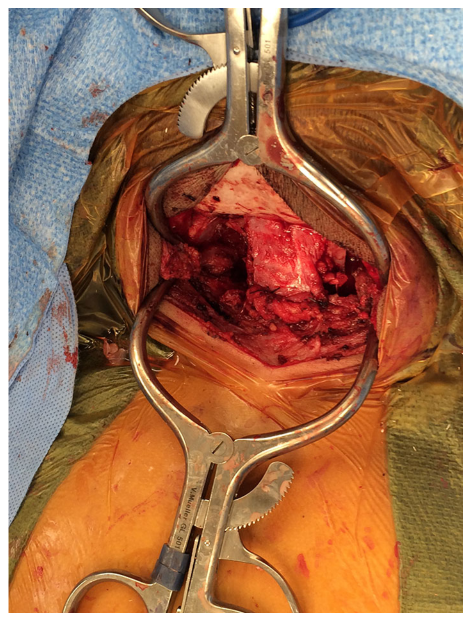

Fig. 5 The periosteal flaps are reflected caudally over the bone graft and sutured in place to the spinous process

halo vest is assembled, and fluoroscopy is used to confirm the position of the cervical spine and in cases of an instrumented fusion to evaluate the hardware.

Case example

A 6-year-old male presented with an occiput to C2 distraction injury following a pedestrian vs auto accident. He was seen initially at an outside facility where he was placed in a halo for cervical spine instability and transferred to our hospital. MRI demonstrated ligamentous injury from the occiput to C2. He underwent posterior spinal fusion from occiput to C3 using sublaminar wires. The periosteal turndown flap technique was used in conjunction with autologous iliac crest bone graft. Immobilization with a halo was continued until 100 days postoperatively when he had formed a solid arthrodesis (Fig. 6).

At most recent follow-up of 5 months, there were no neurologic deficits and he had a solid fusion mass. No additional procedures were required to achieve fusion and no other complications were encountered.

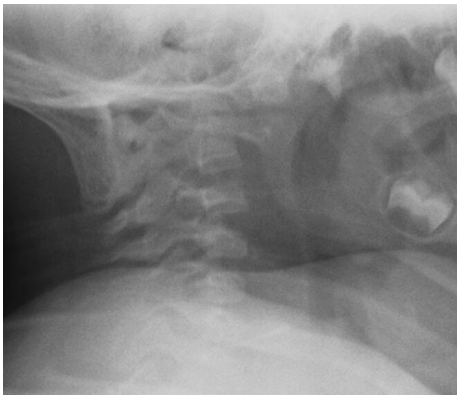

Fig. 6 Radiograph depicting fusion mass 106 days post operatively

Discussion

Several techniques exist for occipitocervical fusion in the pediatric population. While many surgeons have a preferred technique, the periosteal turndown technique can be used to augment any of them. Koop et al. first described the technique for the periosteal turndown flap in 1984 in a retrospective review of 13 patients who had undergone posterior cervical fusion [5]. In their study, all but two patients had arthrodesis performed without instrumentation. One of the patients described in this series developed a nonunion; this patient was the sole subject in which bone allograft had been used as opposed to autograft.

Previous studies on occipitocervical arthrodesis have examined outcomes with use of internal fixation and bone graft alone. Hwang et al. reported on outcomes of instrumented cervical spine fusion in the pediatric population with a pooling of patients from the literature and their own patients [4]. In a cohort of 285 patients who had undergone occipitocervical fusion, fusion rate was 99% with screw implantation and 95% with the use of wiring (with or without rod implantation). However, postoperative complications occurred in 14% of cases in the screw group and 50% of cases in the wiring group with several related to the instrumentation. In the screw construct group, these included screw pullout, instrumentation malposition, vascular injury, nonunion, intraoperative cerebral spinal fluid leak, and transverse sinus injury. Those with wire construct included the previously mentioned complications as well as resorption of graft, unintended fusion mass extension, and instrumentation failure.

There are several potential challenges to achieving robust fixation for occipitocervical fusion in pediatric patients. These include the small size of their vertebrae, presence of structural defects such as absent posterior vertebral elements, and poor bone quality [4]. In these cases, alternative techniques may be useful. Anderson et al. performed a retrospective review of 95 pediatric patients younger than 18 years who underwent atlantoaxial or occipitocervical fixation [5]. Of 25 patients who required alternative internal fixation due to difficult anatomy prohibiting placement of standard bilateral transarticular screws, 19 were patients undergoing occipitocervical fixation.

In general, we prefer rigid fixation if the child's size and anatomy allow for safe placement without excessive implant prominence. However, in very young children, or in the presence of any aberrant anatomy, that is not always possible. The periosteal turndown technique can be used in the presence or absence of instrumentation. This relatively simple and safe technique has the potential to provide more osteogenic cells and warrants consideration and additional study. We hope that the description of this technique will form the basis to stimulate further investigation on this topic.

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Compliance with ethical standards

Conflict of interest DLS (reports personal fees from ZimmerBiomet, Grand Rounds, Medtronic, Orthobullets, Zipline Medical Inc., Green Sun Medical, Biomet Spine, Johnson & Johnson, and Wolters Kluwer Health-Lippincott Williams & Wilkins; nonfinancial support from Growing Spine Foundation, Growing Spine Study Group, Scoliosis Research Society, Orthobullets; other from Zipline Medical Inc.; research grants from Pediatric Orthopaedic Society of North America, Scoliosis Research Society (Paid to Columbia University), Ellipse (Co-PI, Paid to Growing Spine Foundation), outside the submitted work).

LMA (reports personal fees from Biomet, Medtronic, and Orthobullets; other from Eli Lilly; nonfinancial support from Pediatric Orthopaedic Society of North America and Scoliosis Research Society, Journal of Pediatric Orthopedics, outside the submitted work).

Ethical approval This study has been carried out with approval from the Committee on Clinical Investigations at Children's Hospital Los Angeles.

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