A Modified Technique for Occipitocervical Fusion Using Compressed Iliac Crest Allograft Results in a High Rate of Fusion in the Pediatric Population

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■ BACKGROUND: **In children, high rates of occipitocervical (OC) fusion have been demonstrated with the use of rigid instrumentation in combination with harvested autograft, with or without bone morphogenetic protein (BMP). Historically, the use of allograft materials demonstrated inferior OC fusion outcomes compared with autograft. However, autograft harvest harbors an increased risk of patient morbidity, and the use of BMP is costly and controversial in children. Thus, there remains a need for safer, less costly, yet efficacious techniques for OC fusion in the pediatric population.**

■ METHODS: **We retrospectively reviewed the charts of patients younger than 21 years of age who underwent OC fusion with structural allograft placement at our institution from 2010 to 2015. Data collected included age, sex, follow-up duration, fusion outcomes, and postoperative complications.**

■ RESULTS: **A total of 19 patients (8 female and 11 male) underwent OC fusion with our surgical technique. Mean age was 8.5 ± 4.3 years. Radiographic follow up data were available for 18 of 19 patients. One patient was lost to clinical follow up but had radiographic confirmation of fusion. Thus, 18 of 18 (100%) of patients with radiographic follow-up achieved successful arthrodesis as determined by computed tomography. Median duration to documented fusion was 4.5 months. Clinical follow-up was available for 17 of 19 patients and was on average 18.8 ± 13.5 months. One patient required reoperation for graft fracture 8 months after radiographic confirmation of successful fusion. There were no vertebral artery injuries or other postoperative complications.**

■ CONCLUSIONS: **We demonstrate a modified technique for OC fusion in children with unique structural allograft shaping and affixation, leading to excellent fusion outcomes at follow up. This technique obviates the need for autograft harvest or BMP, and may decrease postoperative morbidity.**

INTRODUCTION

Posterior occipitocervical (OC) fusion is used for various types of pathology in the pediatric population, including cases of trauma, congenital anomalies, iatrogenic instability, and others. In these scenarios, failure to stabilize the OC junction can result in deformity, pain, and neurologic compromise. Therefore, fusion at the OC junction is critical in these situations, and for decades, high rates of arthrodesis have been achieved with a variety of surgical methods.[1]

Before the advent of contemporary rigid internal fixation techniques, surgeons often relied on precisely sculpted bone autografts held in place with wires, sutures, or bands.[2,3] In these less-rigid constructs, the harvested bone served not only as the substrate for eventual fusion but also as an integral component of its structural stability. Even with the most creative and precise surgical carpentry, patients undergoing these sorts of fusions

Key words
- Allograft
- Atlantooccipital dislocation
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- Craniocervical instability
- Occipitocervical fusion
- OC fusion
- Pediatric
- Pseudarthrosis

Abbreviations and Acronyms
AO: Atlantooccipital
BMP: Bone morphogenetic protein
CT: Computed tomography
OC: Occipitocervical

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often required halo immobilization or another form of external orthosis.

The development of more rigid internal fixation techniques, primarily relying on rod and screw fixation, has led to a multitude of ways to better fixate the occiput to the cervical spine.[4-10] These modern techniques have been associated with high fusion rates while often eliminating the need for external immobilization.[1,11]

With the advent of these improved techniques, less emphasis has been placed on the type of bone graft material used and its position within the construct. Decades ago, the use of allograft bone bank material was found to be inferior to autologous bone grafting for cervical fusion in the pediatric population.[12,13] In the recent literature, many groups have used autologous bone graft for high cervical and OC fusion, demonstrating excellent fusion outcomes.[1,5,14-17] Sites for autograft harvest include the iliac crest, the ribs, and others. Obtaining autologous bone from these sites generally is well tolerated, but donor site morbidity may occur in the form of infection, seroma formation, pneumothorax, or donor-site pain.[16,18] In addition, autograft harvest may add to surgical time and its associated costs.

Recent efforts across age groups to explore alternatives to autograft materials have included the use of allograft bone in addition to bone morphogenetic protein (BMP), with excellent results.[1,19-21] Although no study has directly compared the use of allograft versus autograft in OC fusion for children, recent evidence has suggested good fusion outcomes in the pediatric population with the use of allograft and BMP (90%).[1,11,22,23] Without BMP use, rates of OC fusion in children using rigid segmental instrumentation techniques and allograft alone have been reported to be approximately 75%.[1,24]

Here we describe a modified technique for OC fusion in children using allograft alone in combination with rigid internal fixation. A contoured iliac crest allograft was shaped and placed with maximal bony contact and held under compression, which led to high rates of arthrodesis without the need for autologous bone or BMP. We believe this modified technique of OC fusion has the benefit of eliminating donor-site morbidity without sacrificing bony healing and maximizing graft-to-bone contact and compression.

MATERIALS AND METHODS

Patient Selection/Data Collection

All patients younger than the age of 21 years undergoing OC fusion with structural allograft at our institution between 2010 and 2015 were identified. Information was collected retrospectively and included age, sex, graft type, method of graft compression, fusion outcomes, duration to confirmation of fusion, duration of clinical and radiographic follow-up, bracing duration (if used), and postoperative complications. This date range was chosen because it was the start of our experience using cadaveric allograft and the modified technique for our OC fusion procedures. Before this period, we used harvested rib autograft for these procedures. Postoperative bracing was used in select patients at the discretion of the primary surgeon when patients were found to have highly abnormal craniocervical anatomy or if they were thought to be at a greater risk for pseudarthrosis. Assessment of fusion was based on computed tomography (CT) imaging and performed both by the primary surgeon (L.R.), as well as an independent, board-certified pediatric neuroradiologist. Fusion was defined as bone graft incorporation with the occiput and the posterior elements of C2 using multiplanar imaging. The study was conducted under the approval of the institutional review board.

Surgical Technique

The patient is positioned in the operating room with a head clamp with pre- and post-positioning measurement of somatosensory-evoked potentials and motor-evoked potentials to ensure signal stability. After midline exposure of the suboccipital and upper cervical spine, the C1—C2 joints are exposed and arthrodesed, followed by packing of the joints with crushed cancellous allograft.

Instrumentation is placed using fluoroscopic guidance and consisted of either transarticular screws, or C2 pars screws with or without C1 lateral mass screws. Preoperative virtual planning aids in the decision of construct type, implant size, and screw placement trajectory. The occipital plate is then shaped and secured, leaving enough space for the allograft to fit caudally under its edge, while maintaining a large surface area for graft contact with the occiput. For cases in which a suboccipital decompression or foramen magnum decompression is required, this technique still allows for excellent graft-to-bone contact. At this point, the patient's head is manipulated into a neutral position. Rods are shaped and cut to the proper shape and length and affixed to the screw heads.

With the instrumentation in place, the superior surface of the C2 lamina is then contoured in a manner by which bony contact with the bone graft will be maximized. Specifically, a high-speed drill is used to create a shelf at the superior aspect of the C2 lamina and spinous process, leaving a small amount of bone ventrally to prevent the inferior aspect of the graft from telescoping into the spinal canal (Figure 1). All bony surfaces on the occiput, C1, and C2 that will be used for fusion are then decorticated.

A long tricortical iliac crest allograft piece is then measured and cut longitudinally with an oscillating saw such that its superior aspect would lie against the underside of the occipital plate and the inferior extent within the shelf created at the posterior elements of C2. A notch is created in the inferior aspect of the graft that allows it to straddle the C2 spinous process, thus maximizing contact between the graft and the posterior elements of C2.

A Songer-cable holder (DePuy Synthes; Raynham, Massachusetts, USA) is attached to the rod on either side and the L-shaped part of the attachment is rotated in place to compress the allograft against the back of the occiput, the C1 lamina, and the fusion surfaces of C2 (Figure 2). In the 5 initial cases, patients underwent fusion with the use of Songer cables passed through the allograft, attached to each cable holder, and tightened. After these cases, cable use was then discontinued when the authors realized that compression of the graft with cable holders alone was likely sufficient to achieve fusion. Finally, all other bony surfaces not covered by the graft are covered with crushed cancellous allograft (or crushed autograft if decompression is performed) and the instrumentation undergoes final tightening.