Editorial

Lateral mass screw fixation of C-1

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The use of spinal instrumentation for the treatment of craniovertebral instability in children is slowly gaining acceptance, but questions remain about its applicability and appropriateness. The authors of previous reports have documented good to excellent success using various occipitocervical screw fixation devices. Given advances in technology and better understanding of pediatric craniovertebral disorders, there appears to be no doubt that that trend will continue.

Before critiquing the current paper written by Jea and colleagues, it would be constructive to create a list of important points, a manifesto as it were, that should be kept in mind before, during, and after placing pediatric craniovertebral instrumentation. I recognize this list is biased by my personal experience, but I believe it includes points on which most surgeons would agree. It is not meant to be dogmatic but is an effort to crystallize our thought process and try and keep our goal of successful fusion in perspective and our patients safe and healthy.

Our goals of treatment are as follows: 1) the unstable vertebral levels are appropriately identified; 2) the number of levels to be instrumented is kept to a minimum (motion preservation) and makes biomechanical sense; 3) the instrumentation is placed appropriately with an acceptable risk/benefit ratio; 4) the bone harvested for fusion contributes little, if any, morbidity and is fixated in an appropriate way; 5) fusion augmentation adjuncts are kept to a minimum, if possible; 6) there is minimal use of halo orthoses; 7) proper and timely documentation of successful fusion is made; 8) after fusion is achieved, the patient should be monitored during their growth period for alignment problems or juxtafusion disease; and 9) the instrumentation is cost effective.

With these goals in mind, let’s look at the current paper. Jea et al. report the cases of four patients under 8 years of age in whom C-1 lateral mass screws were used as part of either a C1–2 or occiput–C2 fusion for instability. To evaluate the value of lateral mass screws in this small case series, we must consider the benefits achieved in each patient.

The patient in Case 1 is a 3-year-old girl with atlantoaxial instability. This case illustrates five important points. First, as the authors point out, C-1 lateral mass screws in this case contribute to “load sharing;” that is, multiple fixation points are gained to distribute pull-out or distortional forces, but the authors do not remark that load sharing was a concern, so one is left to wonder the reason for the C-1 lateral mass fixation.

The patient in Case 2 is a 7-year-old girl with Down syndrome and atlantoaxial instability. This case illustrates five important points. First, as the authors point out, C-1 lateral mass screws can be technically demanding to place. In children, they are at least as demanding to place as C1–2 transarticular screws, in my opinion. Their pullout strength is optimal when bicortical purchase is achieved, which is not an easy or routine task. On the other hand, it is extremely uncommon to see a patient in whom at least one C1–2 transarticular screw could not be placed. This fact is demonstrated in a recent study published by Anderson et al. in which four patients had successful atlantoaxial arthrodesis with placement of only one C1–2 transarticular screw. Biomechanical evidence also supports that fact. This demonstrates that a far simpler construct is sufficient to provide enough rigidity to facilitate a successful fusion. The second point is cost. A single screw used for transarticular osteosynthesis costs about $500, and the cost of other constructs can be calculated from there. The third point concerns the anatomical space available for fusion after the instrumentation is implanted. With bulky constructs, such as the Harms hardware (that is, C-1 lateral mass screw and C-2 pars screw with a connecting rod), there usually is little space remaining to place the bone graft in children. In contrast, C1–2 transarticular screws leave ample space for placing a sufficient bone graft. Fourth, the authors fail to mention in any of the four cases what type of graft they used during their procedures, how they were implanted, and concrete radiographic evidence of fusion. To my eye, the reconstructed sagittal computed tomography (CT) scan in Fig. 5B of their article does not show a solid, continuous arthrodesis between the occiput and posterior arch of C-2. Fifth, the au-
thors state in their introduction that C1–2 transarticular screw fixation “is limited in the setting of an irreducible C1–2 subluxation.” It may be true that a safe transarticular screw pathway cannot be found in an extremely limited number of cases, but attempts at reduction using a preoperative halo (as used in this case) are usually much more troublesome and less likely to promote successful reduction in children than intraoperative reduction with fluoroscopy just before placement of the transarticular screw. Magnetic resonance (MR) imaging or CT evidence of a significant atlantoaxial pannus in this case would go a long way in determining whether this patient truly had an irreducible subluxation.

In Case 3, Jea and colleagues treated a 2-year-old girl with Down syndrome and “occipitoatlantoaxial” instability. The case demonstrates the difficulties inherent in identifying the proper levels to fuse. Figure 3 upper clearly shows atlantoaxial instability, but it is not clear whether occipitoatlantal instability is also present. How did the authors determine that? Were dynamic plain x-ray films obtained? What exactly did the MR imaging demonstrate to cause the authors to establish that diagnosis? Were there anatomical issues at C-1 that led them to include the occiput in the construct? I pose these questions because including the occiput in a C1–2 fusion adds another important motion segment to the construct and should not be done with impunity. The authors fail to mention the reason for including the occiput in the construct aside from stating that “MR imaging results confirmed the diagnosis of occipitoatlantoaxial instability with spinal cord compression at C1–2.”

In Case 4, an 8-year-old boy with atlantooccipital dislocation sustained a VA injury during placement of one of the C-1 lateral mass screws; this case illustrates the risks of placing atlantal instrumentation in children. The authors should be congratulated for pointing out technical features that led to the complication and their handling of it; however, this case underscores another important issue—determining whether a fusion is successful. The goal of surgery is successful arthrodessis across a fused level, not lack of hardware failure. There is always a race between the hardware failing and the fusion taking. If the surgeon places hardware alone, given enough time, that hardware will fail. Thus, a documented lack of motion at the instrumented level on a postoperative flexion/extension x-ray film is not enough to determine whether the fusion is successful. Continuous, solid bridging bone between the fused levels must be observed. Typically, for atlantoaxial arthrodessis with C1–2 transarticular screws, a plain lateral radiograph is sufficient for documentation. For occipitocervical fusions, and perhaps for C1–2 fusion in which bulky hardware has been placed, a thin-cut CT scan with sagittal and coronal reconstructions is necessary. As mentioned previously, when examining Fig. 5B, the postoperative image in this case, it is difficult to determine whether there is a solid arthrodessis.

In their discussion, Jea and associates rightly claim that bone and wire atlantoaxial fusion techniques have historically led to lower fusion rates than those in series incorporating screw fixation devices. They have, however, inexplicably included a reference to one paper in which the investigators successfully used C1–2 transarticular screws and a rib-and-cable fusion in two children 18 and 22 months of age. That paper would seem to support the use of screw fixation, not undermine it.

Overall, Jea and colleagues should be commended for their handling of four difficult cases and their willingness to place craniovertebral instrumentation without the use of halo orthoses. Our group has extensive experience with the techniques outlined in this paper including C-1 lateral mass screw fixation in young children, and we understand the difficulties inherent in these procedures. My personal observation is that spine surgeons treating adults have embraced C-1 lateral mass screw fixation as a less risky and less technically demanding procedure than C1–2 transarticular screw stabilization. Biomechanical testing has shown that the Harms-style construct and C1–2 transarticular screws are similar. Why place C1–2 transarticular screws at all, especially in children? My answer is that once you get past the initial learning curve, C1–2 transarticular screws are a versatile, cost-effective, and elegant way of managing a wide variety of atlantoaxial or occipitocervical instability issues. Postoperative growth concerns, while not substantial according to the authors of one study, are also minimized using this technique. Obviously, the surgical technique one adopts is determined by one’s training, the synthesis of the available literature, and the risk tolerance. But if two procedures (C1–2 transarticular screw and C-1 lateral mass/C-2 pars screw fixation) have similar risks and effectiveness, why not employ the most straightforward one? It is hoped that further discussion of this topic, along with refinement of craniovertebral screw fixation techniques, will lead to consistent, high-quality care for patients in need of occipitocervical arthrodessis.

References


RESPONSE: We would like to thank Dr. Brockmeyer for his review of our paper and for his helpful suggestions. We appreciate his manifesto regarding pediatric craniovertebral instrumentation. We would like to take this opportunity to respond to Dr. Brockmeyer’s comments initially as follows.

Segmental Instrumentation is Always More Biomechanically Sound and Stronger Than Nonsegmental Instrumentation

The integrity of a spinal construct is proportional to the