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Current Concepts in Posterior C1-C2 Fixation

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Historically, fixation into C1 has been limited by the inability to attach a stable, longitudinal construct to the adjacent motion segments. Over the past several years, the introduction of universal polyaxial screw/rod instrumentation for the posterior cervical spine has enabled the surgeon to individually anchor into C1 and C2, providing stability comparable to transarticular screws, versatility of incorporating the occiput and the subaxial cervical spine easily into the construct, with safer and less difficult screw insertion. There has been considerable confusion in the literature regarding screws placed into the C2 vertebra from a posterior approach, with the distinction between C2 pedicle screws and C2 pars interarticularis screws hinging on the anatomic definitions of the true pedicle and pars interarticularis. Additionally, the recent advent of the C2 intralaminar screw has been introduced as a safe, alternative option for purchase into the C2 vertebra. We present a detailed discussion of the current trends in posterior atlantoaxial fixation.
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KEYWORDS cervical spine, pedicle screws, C1-C2 fixation, intralaminar screws

There are many fractures and traumatic cervical injuries that require posterior C1-C2 fixation. Subluxation of the atlantoaxial joint, including transverse atlantal ligament rupture, fixed and unstable rotatory subluxation of C1-C2, unstable C1 Jefferson burst fracture, unstable odontoid fractures, and occipitocervical dislocations are some of the more common injuries requiring C1-C2 instrumentation. Historically, fixation into C1 has been limited by the inability to attach a stable, longitudinal construct to the adjacent motion segments. Gallie introduced a posterior wiring technique that was supported by a structural bone graft.[1] Since then, numerous techniques have been developed including double-looped wiring and Halifax clamps.[2] These constructs were fraught with failures, with nonunion rates approaching 15% secondary to the failure of the posterior, structural bone graft.[3] Then, Magerl designed the transarticular screw to be placed from the C2 pars interarticularis into the lateral mass of C1[4] (Fig. 1). He coupled that with posterior wiring between the spinous processes to provide three-point fixation of the atlantoaxial joint.[5]

Transarticular screw fixation provided a major advantage over the traditional wire/cable techniques as they are more stable biomechanically under both shear and rotational forces.[6] Additionally, postoperative halo immobilization is not required and provides extremely high fusion rates without the morbidity of halos. Magerl screws, however, do have several disadvantages and carry the distinction of being the most dangerous screw that a spine surgeon implants. They require surgical acumen and are technically demanding. The C1-C2 articulation must be perfectly reduced before attempting transarticular screw insertion, and it is impossible to obtain the steep cranial trajectory in many settings of a fixed cervicothoracic kyphosis. The use of biplane fluoroscopy is often considered for screw placement and preoperative parasagittal computed tomography (CT) reconstructions are mandatory to assess for a high-riding vertebral artery groove in C2, which precludes transarticular screw implantation up to 20% of the time.

Over the past several years, the introduction of universal polyaxial screw/rod instrumentation for the posterior cervical spine has enabled the surgeon to individually anchor into C1 and C2, providing stability comparable to transarticular screws, versatility of incorporating the occiput and the subaxial cervical spine easily into the construct, with safer and less difficult screw insertion. Recently, Melcher and coworkers[7] found that screw/rod systems were equivalent to trans-

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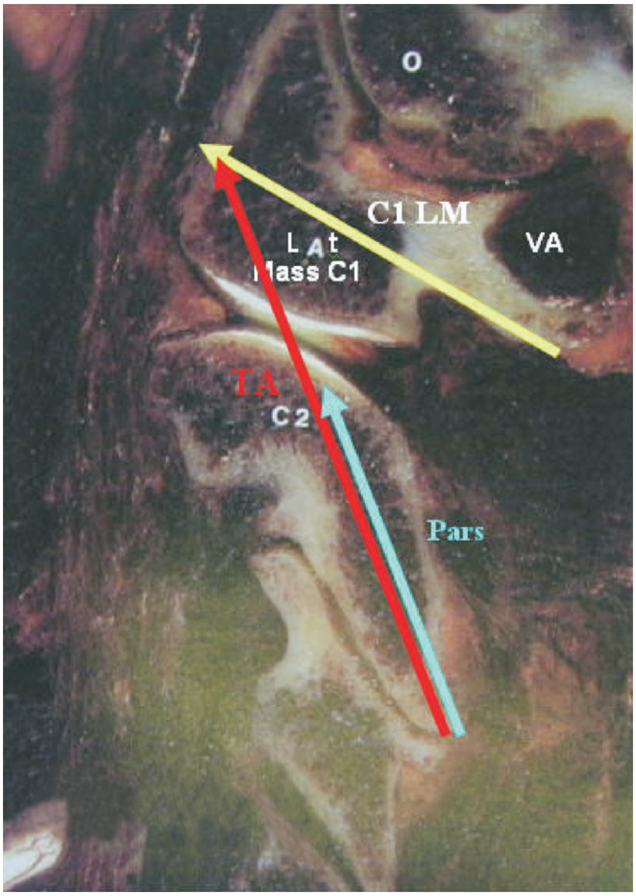

Figure 1 Lateral cadaveric specimen showing the sagittal trajectories for the C1 lateral mass (top arrow), C2 pars (right arrow), and C2 transarticular screw (left arrow). (Color version of figure is available online.)

articular screw-wiring constructs in reducing relative atlantoaxial motion.

The lateral mass of C1 is a very strong and safe anchor point for a screw and may be used to provide additional fixation points in occipitocervical constructs, thus increasing resistance to construct failure in the cervical spine without increasing the number of cervical levels fused.

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C1 Lateral Mass Screws

The atlantoaxial joint is challenging to stabilize because of the unique characteristics of the C1 and C2 vertebrae. The anatomical differences between C1 and C2 require special strategies as insertion of fixation points into these vertebrae are different from the remainder of the subaxial cervical spine. The lateral mass of C1 is not analogous to the lateral mass of the subaxial vertebrae. The most challenging aspect of implanting C1 lateral mass screws is the exposure of the C1 lateral mass and C1-C2 joint from a cranial to caudal direction as well as mobilization of the C2 nerve root (Fig. 2). Proper exposure of the C1 lateral mass proceeds in a rostral-to-caudal direction, opposite from the direction most spine surgeons are comfortable proceeding during insertion of transarticular C1-C2 screws.

Dissection of the posterior arch of C1 lateral to 1.5 cm from the midline is performed with caution because the vertebral artery runs in a groove on the superior surface of the posterior arch. It is typically protected by a thin rim of bone along the superior border of this posterior arch. Dissection of the posterior arch is performed subperiosteally and the dissection is carried laterally until the lateral mass is identified on the caudal aspect of the posterior arch. The presence of the venous plexus between the C1 and C2 articulation and nerve root is either cauterized prophylactically with a bipolar and mobilized caudally or dissected subperiosteally in a cephalad to caudad direction with the use of pledgettes or thrombin-soaked paddie. Subperiosteal dissection is performed from the inferior aspect of the posterior arch of C1, anteriorly down to the lateral mass of C1, which appears as a flat plateau. The medial wall of the lateral mass is identified using a forward angle curette to identify the medial aspect of the mass for screw placement. The medial aspect of the transverse foramen is identified as the lateral limit for screw placement. The entry point for screw placement is 3 to 5 mm lateral to the medial wall of the lateral mass, at the junction of the lateral mass and inferior aspect of the C1 arch (Fig. 3). A high-speed drill with a 3-mm round burr is used to remove a small portion of the inferior aspect of the posterior C1 arch overlying the entry point. This "groove" is made to create a recess for the screw head. Removing this lip from the inferior aspect of the C1 posterior arch also assists in accessing the vertical wall, which leads to the lateral mass. Failure to create

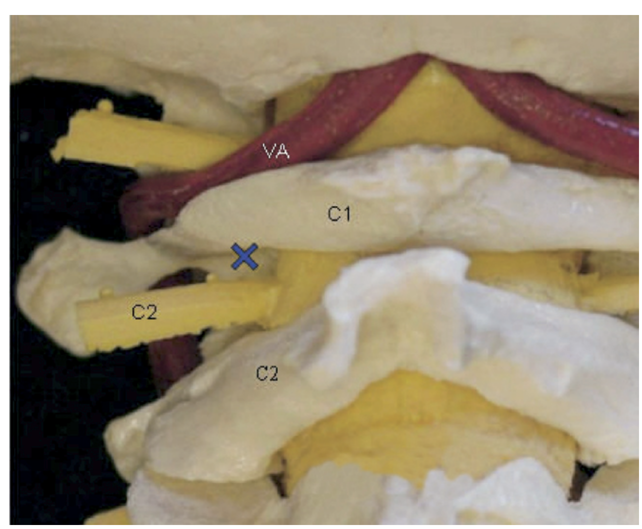

Figure 2 Model showing the various anatomy and structures at risk for C1 and C2 fixation. Vertebral artery (VA), C2 nerve root, and the starting point for C1 lateral mass screws (X). (Color version of figure is available online.)