

## *Bill Fielding and the Cervical Spine Research Society*

J. William Fielding became interested in the cervical spine several years after he finished his orthopaedic training. A Canadian by birth, he had learned orthopaedics at St. Luke's Hospital in New York in the tradition of Mather Cleveland, David Bosworth, and Frederick Thompson. Fielding had always had an interest in photography, and in the mid-1950s he began using cineradiography to study normal and abnormal motion in the cervical spine. He presented a dramatic paper at the 1959 meeting of the American Academy of Orthopaedic Surgeons in which he demonstrated how nonunions of odontoid fractures subject the upper cervical spinal cord to repeated and potentially catastrophic compression. This paper attracted a good deal of attention, which led him to expand his investigations into the mechanics of the upper cervical spine and to study how various traumatic, inflammatory, and congenital conditions can adversely affect that area. He subsequently published a number of papers on the upper cervical spine in which he elucidated the pathomechanics of rotatory atlantoaxial subluxations and dislocations, transverse ligament tears of the atlas, odontoid process fractures (especially in children), and other conditions of the upper cervical spine. He was not the first person, of course, to manifest an interest in abnormalities of the occipitocervical and atlantoaxial articulations, but this complex anatomic area had received relatively little attention. Fielding sought to increase the focus on this region. He did so by bringing a small group of like-minded people together in his suite at the 1973 annual meeting of the American Academy of Orthopaedic Surgeons to consider forming a society to study the cervical spine. Those present agreed that it was a good idea, and Dr. Fielding scheduled the first meeting of the Cervical Spine Research Society at the Essex House in New York in December of the same year, 1973. Besides Dr. Fielding, the founding members were Robert Bailey, Henry Bohlman, Edward Dunn, Alice Garrett, Ashby Grantham,

Robert Hensinger, Mason Hohl, Bernard Jacobs, Henry LaRocca, Donlin Long, Ian MacNab, Wesley Park, Joseph Ransohoff, Lee Riley, Richard Rothman, Henry Sherk, Edward Simmons, Wayne Southwick, Shannon Stauffer, Augustus White, and Thomas Whitesides.

Several of these individuals had also developed an interest in the upper cervical spine and their presentations at that meeting and published papers subsequently complemented what Fielding had already disclosed in other venues. Thomas Whitesides, for example, had developed a retropharyngeal approach to the atlantoaxial joint for treatment of fixed deformities that might require decompression of the cervical canal from the front. A previously reported technique consisting of a transoral decompression had proved unsuccessful because of a very high infection rate. Whitesides' approach avoided going through the oral mucosa and risking the contamination of the surgical field with a bacterial flora of the mouth and pharynx. Dr. Lee Riley, and Dr. Ian MacNab had also used a retropharyngeal approach to gain access to the atlas, axis, and skull base from the front, but their surgical approach had consisted of a dissection anterior to the carotid sheath instead of behind it. The different opinions on how to perform surgery in this difficult area might not have received the same level of educated discussion if it had not been for the forum that William Fielding had convened.

At the same meeting, Dr. Edward Simmons presented his work on osteotomy of the lower cervical spine for fixed flexion deformity due to ankylosing spondylitis. Dr. Simmons had accepted for treatment patients whose necks had fused in flexion of 90 degrees, so severe that even when they stood or sat fully upright, they could only look at their own feet. When viewed from behind, they appeared to have been decapitated. Simmons had performed a C7 laminectomy, and had forcibly extended the neck, cracking through the fused vertebral column

anteriorly. This maneuver brought the head up into its normal alignment. He had maintained correction by immediately placing the patients in a halo cast and he claimed to have avoided quadriplegia by performing the laminectomy and osteoclasis under local anesthesia. The fact that his patients could communicate with him during surgery made it possible for him to do a very controlled correction.

Dr. Robert Robinson, another founding member of the Cervical Spine Research Society, had published a paper with Dr. George Smith on anterior approaches to the cervical spine in 1955 in the *Bulletin of the Johns Hopkins Hospital*. His original paper, published as an abstract of a paper given on February 14, 1955, at a meeting of the Johns Hopkins Medical Society, was a brief report on how cervical disc degeneration can cause symptoms, how Dr. Smith and Dr. Robinson had performed surgery in patients for cervical disc degeneration, and how their 8 patients had fared postoperatively. Robinson and Smith had first worked out the details of the surgical approach on animals. They had dissected along the anterior border of the sternocleidomastoid and between the carotid sheath and the esophagus to reach the anterior aspect of the cervical vertebrae. They had identified the appropriate level by radiographs, and had removed the disc tissue from between the vertebral bodies. They achieved fusion by inserting a small piece of bone from the iliac crest between the vertebrae. They reported that 5 patients had good to excellent results, 2 had poor results, and one had been operated on too recently to evaluate the outcome. Two of their patients in this series had recurrent laryngeal nerve injury with vocal cord paralysis.

In subsequent papers, Dr. Robinson and his colleagues and former residents elucidated more details about the surgical approach and made anterior cervical spine surgery commonplace. Drs.

Riley, Southwick, Dunn, and Bohlman, all came from the Hopkins tradition of anterior cervical spine surgery. Dr. Wayne Southwick subsequently became the head of the Division of Orthopaedics at Yale. There, Dr. Augustus White and Dr. Manohar Panjabi (PhD) and many other orthopaedic surgeons who received their education at Yale and Hopkins benefited from learning Dr. Robinson's procedure either firsthand or from those who had. Dr. Donlin Long, also a founding member of the Cervical Spine Research Society, was a neurosurgeon at Hopkins and a colleague of Dr. Smith's. He also participated in the development of anterior cervical spine surgery there.

It is, however, not clear whether Smith and Robinson were the first American surgeons to perform anterior cervical spine surgery. Dr. Robert W. Bailey, of the University of Michigan in Ann Arbor, stated in his paper published in the 1960 *Journal of Bone and Joint Surgery*, that he had been doing this operation since 1952. He noted that LeRoy C. Abbott had suggested it to him after he (Abbott) had evaluated a patient with a destructive process involving two cervical vertebral bodies. Furthermore, in his paper Dr. Bailey stated "This paper recounts chronologically the development and application of an original procedure for anterior fusion of the cervical spine." Dr. Bailey's original 1952 patient had a giant cell tumor that had destroyed most of the C4 and C5 vertebral bodies. Bailey had performed a Hibbs posterior fusion from C3 to C7 to bridge a limited laminotomy of C4, done for a progressive quadriplegia. The patient got worse, however, and about 4 weeks later Bailey performed an anterior resection of C4 and C5 vertebral bodies. Massive bleeding ensued, but with packing and transfusions the patient not only survived but improved with regard to her quadriplegia. A month after removal of the tumor and almost all of the bodies of C4 and C5, Dr. Bailey operated upon the patient a third time. He reopened the neck anteriorly and inserted long autogenous iliac crest bone grafts from

C3 to C6. The patient recovered completely from a neurologic standpoint, but she died from a recurrence around a year later.

Dr. Bailey reported that the “use of the approach and the achievement of stability” in his original patient led him to carry out the same kind of operation in 17 other patients for varying indications such as postlaminectomy instability, fracture dislocations of the cervical spine, tuberculous destruction of cervical vertebrae, and tumors of cervical vertebrae. Interestingly, Dr. Bailey did not do any of his original anterior cervical fusions for disc degeneration. He claimed that his first patient was “of historical significance in that the patient had the first known fusion by this approach.” Bailey and Badgley had presented their paper at the 1959 meeting of the American Academy of Orthopaedic Surgeons and Dr. Robinson had been asked to discuss it. Robinson concluded his remarks by stating “the principles and practice of cervical spine surgery are gradually evolving. The work of Dr. Bailey and Dr. Badgley is a solid addition to this body of surgical knowledge.”

The third claimant to priority for anterior cervical spine surgery was Dr. Ralph Cloward. He submitted a paper to the *Journal of Neurosurgery* on September 3, 1970, in which he described his own anterior surgical approach to the cervical spine. He reported that he had begun work on devising an anterior approach at least two years earlier, first on cadavers and then on patients. By the time he made his report, he had operated on 61 patients. Cloward had used exactly the same surgical route that Robinson and Bailey had, but his actual fusion procedure differed considerably from theirs. He had done the operation only on patients who had symptoms related to disc degeneration and he had used cervical discograms to select patients for the surgery. In fact, he decided upon the anterior approach while devising an anterior route for cervical

discography. Cloward used a large drill to core out the disc and he performed an extensive anterior decompression. He then removed a plug of bone graft from the patient's iliac crest and tamped this into the site of the defect in the vertebral bodies and disc space. He reported that he did the operation under local anesthesia. One patient in his series "was considered worse" and all the others had done well despite various complications, some of which required additional surgery.

Dr. Cloward had presented his paper prior to publication at a meeting of the Harvey Cushing Society, and as is the custom, several members of the society had been asked to discuss it. The program chairman apparently had difficulty in finding people to do this because one of the discussers who finally reviewed the paper noted that he had been asked to substitute for Drs. Spurling and Dr. Mack who had previously been asked and declined to perform this service. Dr. John Raff took a light note in discussing Cloward's paper and said that "I am a great admirer of Dr. Cloward's prodigious energy and abundance of ideas, but so far I have not been able to bring myself to do either discograms or anterior cervical fusions. It is true that there are a number of very fine blind pianists, but I doubt that one can pound on the strings that make up the brachial plexus with the same abandon that one can pound on piano strings." He said that he thought most patients with pain caused by cervical disc degeneration got better with conservative treatment, and the operation was probably not necessary most of the time anyway.

Dr. William Scoville, the second discussor of Dr. Cloward's paper, objected to the operation because he had obtained results that were "extraordinarily good" with a posterior keyhole through the facets with uncapping and unwalling of the involved root." He noted the "simplicity and excellence of the results in the posterior keyhole" and the possibility that a fused cervical

interspace would stress adjacent interspaces both militated against Cloward's operation. Smith and Robinson and Bailey and Badgley clearly enjoyed a more enthusiastic response to their presentations from orthopaedists than Cloward received from his fellow neurosurgeons.

Drs. Robinson and Smith, Drs. Bailey and Badgley, and Cloward all seemed to have had the same idea at more or less the same time. Bailey probably did the first anterior cervical fusion but did not report it in the literature until 5 years after Robinson and Smith. Cloward's initial report on his approach and technique for anterior cervical discectomy was made in 1957, two years after Robinson and Smith, although clearly Cloward had done his first cases in 1955 and 1956. In the end, it probably makes little difference, because anterior surgery for the cervical spine appears to have developed in three places at once.

In the five decades that have elapsed since, anterior surgery for cervical spine disorders has assumed a major role in the treatment of disorders of this part of the vertebral column, and modifications to the pioneering techniques not unexpectedly have been developed. By the mid-1980s, almost any possible variation of the original concept had been considered and explored. Various modifications of the grafting techniques, outcomes assessments for single- versus multiple-level fusions, extension of the indications to treat virtually any condition that involved the cervical vertebrae (trauma, tumors, infections, degenerative conditions) all came under scrutiny.

Overall, surgical treatment of intractable symptoms caused by cervical disc degeneration had proved itself. In 1984, for example, Dr. Donald Gore of Sheboygan, Wisconsin, reported that he had achieved complete pain relief in 78% of 146 patients with discogenic neck and arm pain, and

only 4% of the 146 patients had experienced little or no pain relief. Ninety-seven percent of the disc levels had fused successfully. Dr. Gore's technique varied slightly from most of those previously described in that he used autologous fibular bone grafts for multi-level fusions instead of iliac crest grafts, but he had kept the essential features of the operation. He used an anterior exposure, removed completely the disc or discs that he had identified as symptomatic by radiograph and myelograph, and he had fused the disc levels by impacting autologous bone into the disc spaces. His series of patients and their excellent outcomes illustrated the usefulness and effectiveness of the anterior discectomy operation devised by Smith-Robinson, Bailey-Badgley, and Cloward 20 years before.

Although Bailey and Badgley reported that they had used anterior fusion methodology to treat fractures and dislocations of the cervical spine successfully, others did not have that good experience. E. Shannon Stauffer and E. G. Kelley reporting from the Rancho Los Amigos in Downey, California, in 1977, for example, found that disruption of the posterior stabilizers in the neck preclude a successful use of anterior fusion with a bone graft either between adjacent bodies or to replace an entire vertebral body after a corpectomy. They reported that flexion deformity recurred and that the grafts dislodged. Experiences of this kind led to the development of internal fixation of the cervical spine with anterior plates secured with multiple screws to provide internal stability. In one of the classic articles on the subject, Georg Böhler suggested that after performing an anterior procedure with a bone graft "additional fixation is necessary" either with a Minerva jacket or internally with posterior or anterior osteosynthesis. Böhler preferred anterior osteosynthesis since it could be performed at the same time as the bone graft procedure. Böhler gave due regard to several earlier papers on this subject, particularly those by Orozco and Senegas and Gauzere, but most other reports cite his 1980 paper in *Spine* as the



beginning of anterior plating in the United States. The earlier plating systems required fixation with screws that engaged both the anterior and posterior cortices of the vertebral bodies, an issue that raised the question of risking the cervical cord. Later designs incorporated the use of expanding screw heads or locking screws so that a surgeon could use much shorter 14-mm screws to achieve fixation without needing to engage two cortices. The chance of spinal cord injury was thus much reduced.

Forty-five years after Smith and Robinson, anterior plating had gone through the same intense investigation by multiple surgeons in multiple centers. Plate designs had been extensively modified to minimize the possibility of esophageal perforation. Locking screws to eliminate bicortical purchase have become standard features. Donor site morbidity has been almost eliminated because of successful substitution of autograft by allograft, bone substitutes, and adjuncts such as bone morphogenic protein. Large series of such patients have now been reported and the outcomes appear comparable to those reported by Dr. Gore and others. Allografts, however, even when used with plates, have a tendency to collapse or subside. While this may not have an effect on the final outcome of the procedure or require revision surgery, it does cause concern. In response to the issue of subsidence of intervertebral allograft, with or without plating, several manufacturers now offer cervical spine cages. As used in the lumbar spine, they provide support to prevent collapse of the disc space and since they are filled with osteoinductive bone or other material, they promote fusion with stability. The evaluation of cages in the cervical spine and whether their use should be supplemented by anterior plating has occupied the attention of a number of investigators, and has been the subject of many presentations and publications in the Cervical Spine Research Society meetings and elsewhere. In the history of cervical spine surgery, it is not entirely clear that these frequent changes in

methodology have improved the outcomes or lessened the risk. Recent data may indicate better outcomes with anterior cervical spine plating techniques, however.

Dr. William Scoville, who discussed Ralph Cloward's anterior cervical fusion operation at the 1959 meeting of the Harvey Cushing Society, said that the possibility of accelerated adjacent segment degeneration "militated" against Cloward's technique. Scoville was prescient in this regard. Several studies since then have shown that levels adjacent to a fusion in the cervical spine degenerate very quickly because of increased biomechanical stresses at these levels.

Although anterior discectomy and fusion in the cervical spine has an excellent track record in providing long-term pain relief the adjacent level degeneration may well cause a recurrence of symptoms in some patients. In an effort to keep the benefits of pain relief provided by anterior discectomy but to avoid adjacent segment degeneration, many individuals have suggested replacing the disc with a prosthesis. Artificial disc technology therefore has become the next consideration in the more than 50-year history of anterior cervical spine surgery. Dr. Frank Phillips and Dr. Steven Garfin published a review article on the subject of cervical disc replacement in 2005. They reported that at that time the Food and Drug Administration had approved investigational device exemption studies of four models of disc prostheses and therefore a surgeon could only use these devices under carefully supervised and controlled conditions. Early reports suggest that total disc replacement preserves motion at the index level and does not cause adjacent-level hypermobility. Presumably the preservation of normal kinematics in the adjacent levels will delay the onset of degeneration and maintain satisfactory function and pain relief. Prosthetic wear, survival of the implant, and problems with revision surgery are issues that the investigators continue to address.

Multi-level surgical disc degeneration in patients with narrow spinal canals presents problems that differ somewhat from those described previously. The size of the spinal cord does not vary much from one person to another, but the spinal canal does. A wide and capacious spinal canal protects an individual from cord compression when discs herniate or osteophytes develop, but a narrow spinal canal makes an individual more likely to develop neurocompression. The resultant pressure on the spinal cord causes it to flatten and splay out laterally and patients with this problem develop symptoms and findings that range from very mild motor weakness and ataxia to virtual complete quadriplegia. These issues have been extensively worked out in meetings of the Cervical Spine Research Society since its inception.

Several British neurologists, e.g., S. Nurick and W. R. Brain, studied the relationship of a congenitally narrow cervical spinal canal with spondylosis and myelopathy during the middle years of the last century. They differed somewhat on the ultimate cause of the loss of cord function. Nurick had concluded that compression produced cord injury and Brain believed that ischemia had a more prominent effect. Recent studies suggest that Nurick was more likely correct. Nurick also made a useful contribution to the evaluation of patients with myelopathy by devising the “Nurick Grading System” (zero meaning no myelopathy, and 5 meaning chairbound or bedridden). Most orthopaedic surgeons who treat and write about cervical spondylotic myelopathy (CSM) use this classification system to determine their surgical indications and results.

Despite a large body of published information, indications for operating on patients with CSM and what kind of operation to perform still remain somewhat controversial. Nurick in 1972 compared treatment with a supportive collar to laminectomy and surgical decompression. He

concluded that surgical decompression “should be reserved for those whose disability is progressive, particularly for those more than 60 years old.” Dr. L. Simon and T. Lavender, who were cited by Nurick, performed multilevel laminectomies in their CSM patients with removal of inbuckled and thickened ligamentum flavum to achieve an improvement rate of 70% in their patients. Multilevel laminectomy, however, removes the attachment of the stabilizing extensor muscles and ligaments. In addition, if the surgeon carries the laminectomy far enough laterally, he also destabilizes the cervical vertebrae further by removing part of the facet joints. Patients who have had this kind of surgery not infrequently develop swan neck deformities with multiple subluxations and recurrent symptoms. To avoid the effects of instability caused by laminectomies, Japanese surgeons had developed the technique of laminoplasty. Kiyoshi Hirabayashi, for example, presented several papers at meetings of the Cervical Spine Research Society in the 1970s and 1980s describing the technique for this procedure. He found that the development of the high-speed air drill had made it possible to create deep grooves in the laminae bilaterally at the point at which the laminae merge into the facet joints. By cutting completely through the laminae on one side, he could crack the laminae on the other side to raise multiple laminae together, hinging them open like a door. In fact, he called the operation “the expansive open-door laminoplasty.” Hirabayashi found that laminoplasty achieved decompression of the spinal cord and also maintained stability of the neck. The Japanese surgeons also confronted a condition known as ossification of the posterior longitudinal ligament (OPLL), which occurs rarely in North America. They had developed strategies, including laminoplasty, to deal with severe narrowing of the cervical spinal canal caused by OPLL. Laminoplasty techniques varied, but the basic procedure purportedly yielded better outcomes than laminectomy in the Japanese literature.

Laminoplasty, however, often results in marked loss of neck motion and persistent neck pain. It was thus natural for the intellectual descendants of Dr. Robinson to consider decompression of the cervical spinal canal from the front. Dr. Harry Herkowitz, of Royal Oak, Michigan, in 1988 compared the outcomes of surgery in patients with multilevel spondylotic radiculopathy treated with one of three kinds of operations, laminectomy, laminoplasty, or multiple anterior discectomies and fusions as done by Dr. Robinson. Dr. Herkowitz found that laminectomy alone produced the least satisfactory outcomes, and Robinson's fusions produced the best. He also found that laminoplasty was associated with postoperative limitation of neck motion. Since Dr. Herkowitz published his paper on anterior cervical fusion for the treatment of cervical spondylotic radiculopathy, a number of other authors have weighed in on the subject. Dr. Sanford Emery and Dr. Henry Bohlman of Case Western Reserve in Cleveland, for example, published an important paper on the subject in the *Journal of Bone and Joint Surgery* in 2005. Their indications for the operation began with mild weakness and the demonstration of withdrawal reflexes in patients with demonstrable cervical spinal stenosis on an MRI. This combination of complaints and findings they felt justified surgery because as far as historical controls had shown, the cervical spondylotic myelopathy inevitably worsens, albeit unpredictably.

### ***Trauma***

The freedom of motion in the cervical spine and its exposed position predispose it to injury. Panjabi and White described the six degrees of freedom of the cervical spine in their book *Clinical Biomechanics of the Spine*, and they showed how the vertebrae move about axes of motion in the sagittal, coronal, and axial planes. The anatomic configuration of the seven cervical vertebrae permit a good deal of mobility, therefore, but when the neck is subjected to

forces beyond the capabilities of its ligamentous and muscular restraints, dislocation and fracture can occur. Thereafter, stresses that the spine could have tolerated prior to injury cause abnormally large displacements, and the cervical spine is by definition unstable. Instability of the cervical spine has very grave consequences because it surrounds and protects the cervical spinal cord. Injury to the cord, of course, can result in one of several patterns of neurologic impairment, such as complete, central cord, Brown-Sequard, posterior column, or anterior cord lesions. The orthopaedic and neurosurgical literature of the past century has visited and revisited the issue of cervical spine injury many times and in many ways and hundreds of papers have been published on the issues related to the subject of cord injury after fracture and dislocation in the cervical area.

For example, Jeffrey Jefferson published his paper on fractures in the first cervical vertebra in *Lancet* in 1927. He determined that the vertebral ring breaks apart centrifugally because of axially-directed forces and he found that even considerable displacement did not prevent uncomplicated healing with minimal neurologic impairment. “Jefferson’s fracture” therefore is regarded by many as a stable injury that does not need aggressive surgical intervention.

In contrast, fractures of the odontoid process of the axis vertebra have a much greater chance of causing neurologic deficits. Immobilization of this injury with a Minerva jacket cast or in a halo fails to achieve healing of the fracture in adults in up to 40% of patients. Dr. Charles Clark and Dr. Augustus A. White in 1985 reviewed a group of patients with this injury in a multicenter study under the auspices of the Cervical Spine Research Society. Using the classification system devised by Lewis Anderson of the Campbell Clinic in Memphis, they found that Type 2 injuries at the base of the dens fail to heal in a halo in at least a third of the patients reviewed. (Dr.

Anderson was a member of the Cervical Spine Research Society.) Posterior fusion of C1 and C2, however, resulted in satisfactory union of Type 2 dens fractures in 96% of the patients Clark and White reviewed. Clark and White also stated that “that (fusion) appears to be the treatment of choice.” The fusion technique for C1-C2 instability, however, has also been the subject of scrutiny. Mixter and Osgood in Boston in 1910 described a method in which they passed a suture under the posterior arch of the atlas and tied it down over the spinous process of C2. This method became the basis of the “Gallie fusion” described by W. E. Gallie of Toronto just before World War II in 1939. Despite the use of a bone graft, Gallie fusions failed to unite often enough to justify the development of the Brooks fusion. Arthur Brooks, of Nashville and Irwin Jenkins, of Decatur, Alabama, had passed two wire sutures under the posterior arches of both C1 and C2 and had tied these down over an “H graft” in 15 patients. They found that only one of the patients failed to fuse. The Gallie and Brooks fusions, however, could not be used in patients without a C1 posterior arch, and besides that, they lacked the ability to immobilize C1 and C2 completely. F. Margl, of St. Gallen, Switzerland, published an alternative technique in 1987. His procedure consisted of passing threaded screws from the outer edges of the C2 lamina across the atlantoaxial facet joints, ending in the lateral mass of C1. The fixation of C1 and C2 in this way immobilized an odontoid fracture well enough to achieve nearly 100% healing of Type 2 dens fractures. Any C1-C2 fusion technique, however, necessarily results in limited rotation of the head. To overcome this objection, Japanese, Swiss, and German surgeons elected to use screw fixation of the odontoid process from the front. To achieve this, they passed one or two cannulated screws from the distalmost part of the axis vertebral body upwards across the fracture in the dens and then up to the tip of the odontoid process. They reported solid healing of the odontoid process fractures in nearly 100% of patients without loss of neck motion and without using prolonged external immobilization in a halo brace or Minerva jacket.

Fractures through the base of the neural arches of the second cervical vertebrae cause a traumatic spondylolisthesis of the second vertebra. In the late 19<sup>th</sup> and early 20<sup>th</sup> centuries, dissections of individuals executed by hanging showed that many of these people had sustained this kind of injury. Good hanging technique required that the executioner place the knot in a submental position beneath the chin and that the victim should drop far enough to produce sudden and extreme hyperextension of the head on the neck. The resultant combination of forces should break the axis at the base of the neural arches and cause enough injury to the cord at that level to produce a quick and relatively painless death. Authors writing about the injury had often referred to it as “the hangman’s fracture.” In recent times, the sudden and extreme hyperextension of the head, which occurs in head-to-windshield crashes or in diving accidents, can replicate the hangman’s lesion, although without enough force to cause upper cord injury. Dr. Richard C. Schneider, a neurosurgeon at the University of Michigan Medical School, made the connection between the two mechanisms of injury in a classic paper in the *Journal of Neurosurgery* in 1965. In persons with minimally displaced or undisplaced fractures, support in a halo, or even in an external brace or cast, will provide enough support to let the fracture heal without surgery. Occasionally, however, patients need internal fixation. The fracture can be fixed internally with an anterior plate and screw construct or posterior wiring and bone graft from C1 to C3.

In the recent past, a number of authors have published reports on cranial cervical dissociation, caused usually by a high-speed vehicular crash or by a vehicle striking a pedestrian. The alar ligaments, anterior and posterior longitudinal ligaments, the tectorial membrane, and the cruciate ligament must all rupture once for the head and neck to come apart from each other, and the



presence of such injuries implies great forces which must act in different directions in extremely rapid sequence. Injury to the spinal cord at this level hardly permits life to continue, but if a patient does arrive alive in an emergency room with an occipital cervical dissociation, treating physicians might not recognize it if no fractures have occurred. *A Review of Spine Injuries*, by Robert Bucholz et al., and Vincent Traynelis et al., suggest that the injury occurs in over 1% of spinal trauma patients and that therefore physicians have tended to underdiagnose it. Traction with a halo or even with a halter can pull the head further from the atlas and axis since their restraining ligaments no longer connect the head to the upper cervical spine. Those who have had experience with this injury suggest that one should perform occipital cervical fusion as soon as the patients can tolerate that level of surgery. A surgeon can select one of several available methods such as contoured plates and screws, bent rods, or bone grafts wired to the occiput and neural arches of C1 and C2, and plates secured to the occiput with short screws to the atlas, axis, and subjacent vertebra with pedicle screws. Anterior fusion using bone graft has apparently resulted in infections in a high percentage of cases and since the posterior fusion is easier and carries less risk, most surgeons elect to do the fusion of the occiput to the cervical spine from the dorsal side.

Subaxial cervical spine injuries in adults occur much more often than atlantoaxial trauma. In children, the most common cervical spine injury, however, is a separation of the odontoid process from the body of the axis at the level of a synchondrosis in that location. Unrecognized and untreated the fracture may not heal. Dr. Robert Hensinger has proposed this sequence of events to explain the development of an “os odontoideum” in which the odontoid remains separated and unattached to the body of the axis. An os odontoideum produces pronounced anterior and posterior instability of the atlantal ring on the axis with a potential for severe

damage to the upper cervical cord. Prevention of an os odontoideum requires that treating physicians recognize the dens separation in young children and that they provide adequate treatment with about six weeks of immobilization with the dens in the reduced position.

A milestone in the evaluation and treatment of cervical spine injuries occurred with the publication of Dr. Henry Bohlman's paper on acute fractures and dislocations of the cervical spine in the *Journal of Bone and Joint Surgery* in 1979. Dr. Bohlman was the son of Dr. Harold Bohlman, who had invented the hip replacement, which later became the Austin-Moore prosthesis. Dr. Henry Bohlman, while a research fellow in Dr. Robert Robinson's Department of Orthopaedics in Johns Hopkins in Baltimore, had begun the study of cervical spine fractures and dislocations in Baltimore between the years 1950 through 1972. In all, he collected records and radiographs of 300 patients seen in Baltimore hospitals during that time. His review of this large group of individuals revealed that one third (100 out of 300) did not have the diagnosis of cervical spine injury made in the emergency room. Head injuries, alcoholism, and multiple other injuries may have precluded the treating physicians from eliciting a history of neck pain, but subsequent to his report virtually all trauma physicians now recognize the need for "screening" cervical spine radiographs for all ER patients admitted to a hospital. The number of radiographs and what views to take and whether the patient should have an MRI remain matters of discussion, but the need to consider what has happened to the cervical spine is acknowledged as a necessary part of trauma protocols.

Dr. Bohlman's study also confirmed the futility of laminectomy in treating patients with anterior cord syndromes or complete spinal cord lesions. "The concept that laminectomy is contraindicated in these patients is supported by the high mortality rate and frequent loss of

motor function...after this procedure.” The study also showed that patients with flexion injuries and disruption of the posterior tension band should have a stabilizing posterior fusion, whereas patients with hyperextension injuries with disruption of the anterior column through an intervertebral disk should have an anterior discectomy and fusion if external support fails to maintain stability. Burst fractures or other compression injuries of the anterior column, he concluded, strongly justify anterior corpectomy and fusion with a bone graft. This procedure would replace the vertebral body after removal of bone and disc fragments from the spinal canal.

Techniques for posterior fusion surgery have evolved since Bohlman’s paper was published. Exposure of the posterior aspect of the subaxial cervical vertebrae is not difficult and once a facet dislocation has been reduced, one of a number of techniques can be used. Throughout the middle years of the 20<sup>th</sup> century, various posterior wiring and grafting constructs were used to restore the posterior tension band side of the cervical spine. In later years, however, Raymond Roy-Camille, of Paris, and other European cervical spine surgeons devised plate-and-screw techniques for use in creating posterior stabilization. Once a surgeon has reduced the cervical spine fracture and/or dislocation, placing a narrow plate over the lateral masses of adjacent vertebrae and screwing them in place with short screws is a relatively straightforward and easy operation. It becomes more difficult and far more hazardous when the surgeon decides to secure fixation with pedicle screws in the cervical spine. Fluoroscopic control is not always certain, and in the past several years computerized navigation systems have been developed to increase the accuracy of pedicle screw insertion in this location. Dr. Todd Albert and Dr. Alex Vaccaro, of the Rothman Institute in Philadelphia, have in particular also been pursuing and developing this technology. Their enthusiastic reports regarding its use have not yet led, however, to its adoption

by the majority of cervical spine surgeons. It may well, however, become the most reliable guidance modality in the future.

Since it was founded in 1973, the Cervical Spine Research Society has conducted 32 annual meetings. A review of the programs reveals the gradual evolution of basic science research, diagnostic methodology, and surgical techniques all refined by the intense peer review provided by the questioning of presenters from the floor. The Cervical Spine Research Society has also published the definitive book on the cervical spine (entitled *The Cervical Spine*). This text is now in its fourth edition. Dr. Charles Clark, of the Department of Orthopaedics at the University of Iowa, serves as the current editor. Also, the Society has published an atlas of surgical exposures and procedures, and Dr. Harry Herkowitz, of Royal Oak, Michigan, has recently served as editor of the second edition.

In 1982, at the 10<sup>th</sup> annual meeting, the Society decided to begin presentation of instructional courses on cervical spine surgery and research. Dr. Joseph Epstein, a New York neurosurgeon, suggested at that time that the Society begin to do this. The late Dr. Henry LaRocca of Tulane accepted the position of course Chairman, and the first course was held in Palm Beach, Florida in December 1983. It unexpectedly attracted over 100 attendees. The success of this endeavor has led to the presentation of multiple courses given biannually.

The Cervical Spine Research Society meetings attracted the participation of numerous European and Japanese spine surgeons, and many of these became members. In fact, the German, Swiss, French, Italian, Greek, and Portuguese members decided to establish a European section of the organization. It also meets annually, although at a different time of year, and North American

and European members often attend both meetings. Japanese physicians and surgeons have also presented many outstanding papers at the Cervical Spine Research Society meetings on subjects with which they have great familiarity such as ossification of the posterior longitudinal ligament, myelopathy, spinal stenosis and laminoplasty.

The broad diversity of professional backgrounds, the international membership, the books, the published research and the educational courses naturally led to the development of a very healthy treasury for the Cervical Spine Research Society. Industry and individuals, furthermore, have contributed to it and it has been able to develop enough resources to support several reasonably large research grants annually. More recently, it has also organized and developed traveling fellowships for young cervical spine surgeons. The Cervical Spine Research Society is an outstanding example of what a small, focused organization can achieve. Dr. Fielding, whose idea it was, fostered it by acting in a selfless manner, helping out, offering criticism and advice, but never really taking any credit. He died in 1998.