Editorial

Ventral uncoforaminotomy

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chmieder et al. performed a cadaveric biomechanical study to measure the effects of unilateral or bilateral resection of the uncovertebral joint on cervical range of motion (ROM). The reported purpose of their experiment was to assess surgical effects on mechanical stability, because postsurgical spinal instability and recurrent disc herniations were reported as potential major untoward results of anterior cervical foraminotomy. They used cadaveric cervical spine specimens from an 80-year-old man, an 80-year-old woman, and a 59-year-old man, which were prepared as three C4–5 specimens and three C6–7 specimens. These authors measured ROM with ± 2.5 Nm loading in flexion, extension, lateral bending, and axial rotation. They concluded that unilateral uncoforaminotomy caused increased mobility at the single motion segment of the cadaver cervical spine in lateral bending and axial rotation toward the contralateral side, but with minimal effects on flexion or extension. Bilateral procedures increased the ROM in axial rotation for both directions.

A significant decrease in segmental stiffness was previously reported after staged removal of the uncinate process in cadaveric specimens, but in that study the uncinate process was removed after the completion of a conventional anterior cervical discectomy. Because it is always easier to criticize another’s work than to perform the original studies, we wish to start by earnestly commending the authors for their diligence and efforts in investigating the biomechanical effects of anterior cervical foraminotomy on the ROM in cadaveric cervical spines. That being said, we will address some limitations of this study from the standpoint of academic critique.

The first topic we will address is the obvious difference notable between live patients and cadaveric specimens, for which the authors certainly cannot be faulted. Jho’s surgical practice, anterior cervical foraminotomy is performed in approximately 200 to 250 patients per year. We have not performed any single cervical spine fusion surgeries for many years. In our clinical practice, we have often observed that patients improve significantly in lateral or axial rotation after surgery, but it has been consistently toward the surgical rather than the nonsurgical side, contrary to what this cadaver study showed. Patients sometimes want to undergo additional foraminotomy on the contralateral side for the relative restriction in lateral rotation toward the untreated side. It is merely speculative why this discrepancy occurs between our clinical experiences and this cadaveric study in the laterality of the increased ROM in axial or lateral rotation. It is possible that the tissue tensile strength at the surgically treated side was released by the surgical procedure in cadaveric specimens, resulting in improved rotation toward the contralateral side. An alternative explanation may be the variable interpretation of Schmieder and associates’ cadaveric results, because in their figures lateral bending and axial rotation are increased in 10 to 20% of specimens on either side, despite their conclusion that the increase was toward the contralateral side.

In our clinical experience, bone spurs at the neural foramen seem to act like a brake to limit lateral rotation toward the same side. Preoperatively, patients usually report neck or scapular pain along with limitation in ipsilateral rotation, in addition to the classic radicular symptoms. Anterior cervical foraminotomy removes the actual bone spurs that are narrowing the medial wall of the neural foramen. Radicular symptoms subsequently improve due to neural decompression, with improvement of paraspinal pain and lateral rotation toward the surgically treated side. We believe that removal of the bone spurs that act like a physical doorstop or brake allows improvement in ipsilateral rotation of the neck in addition to providing paraspinal pain relief. We have not observed a lateral tilt or curvature in postoperative x-ray films or magnetic resonance (MR) images. A live 80-year-old or even a 59-year-old person usually has degenerative changes that limit cervical spine motion, particularly in lateral rotation. People may have increasing difficulty sleeping on the abdomen as they age because the rotation of the head becomes limited. The preoperative ROM in these age groups is significantly limited, mostly due to a spondylotic bone spur formation in addition...
to soft tissue hardening. The cadaver specimens in this study must have had significant restriction in motion because of intrinsic degenerative processes. Therefore, a subsequent increase in axial or lateral rotation in their specimens after the procedure could reflect an improvement in ROM rather than impairment in stability, especially with the types of measurements they performed.

Although this study was purported to measure the effects of anterior cervical foraminotomy on spinal stability, the authors’ work involved measurements of the ROM rather than load-failure tests or stiffness-failure tests. Their results instead suggest the possibility of improved ROMs at the surgically treated level of the cervical spine, particularly in axial rotation and lateral bending. In addition, the amount of surgical tissue removal in the “anterior cervical foraminotomy” would undoubtedly have an impact on spinal stability, such that quantification of the surgical procedure would be crucial to experimental design for their stated purpose. Substantial removal of the uncovertebral joint will produce changes in spinal stability, particularly in younger age groups such as those less than 30 years of age. As the spine develops degenerative changes with aging, it becomes more rigid and “stable,” but restricts ROM, particularly lateral or axial rotation. However, spine stability and ROM are not necessarily equivalent measurements. We believe that the improvement of lateral rotation in older age groups is beneficial rather than harmful, and we have empirically observed improvement of motion in patients, along with pain relief and a stable spine after an appropriately chosen and performed anterior cervical foraminotomy.

The procedure that appears to have been done to the specimen depicted in Fig. 2 is neither clear nor objective. The clarity could have been somewhat enhanced if orientation and a millimeter scale were provided for the surgical area along with a schematic drawing for the standardized surgical procedure used. Three-dimensional computed tomography (CT) scans obtained before and after each surgical procedure would have been a bonus. The general statement that the authors followed our surgical procedure is not sufficient for the quantitative description of their own surgical procedures. It is unclear whether the authors reviewed the details of procedures we reported previously.12 According to the x-ray films of specimens, the uncinate process is almost completely removed, which appears to be similar to the original surgical procedure that Jho reported in 1996.7 This procedure has since evolved surgically into the more efficient and specialized forms of anterior cervical foraminotomy used in our current clinical practice. (The term “surgiology” was coined by H. D. and D. H. Jho,12 and is defined as the “pathoanatomical study in the pursuit of scientific or artistic knowledge to improve a particular operative treatment.”)

Anterior cervical foraminotomy is a general encompassing term for surgeries performed in our practice for two major purposes: the first specific purpose is merely to enlarge a narrowed neural foram, and the second purpose is its use as a conduit to remove surgically treated pathological entities such as herniated soft disc fragments, bone spurs, or tumors.3–14 If the foraminotomy is performed for the specific purpose of enlarging a narrowed neural foram, postoperative imaging (either MR or CT studies) will show a normal-sized or slightly enlarged neural foram but nothing else. We called this procedure “anterior cervical foraminoplasty” because the narrowed neural foram, which most often is narrowed due to bone spurs along the medial foraminal wall, is remodeled to restore normal caliber. When anterior cervical foraminotomy is used as a conduit to remove the pathological entity, such as herniated disc fragments, medial bone spurs for spinal cord decompression, tumors, or ossification of the posterior longitudinal ligament, it may be performed as one of three different variations: an upper vertebral transcorporeal approach, a transunfal approach, or a lower vertebral transcorporeal approach.8,11 When a larger surgical conduit is required, a foraminoplasty is extended to a larger-scale opening. The medial osseous wall of the uncinate process is still preserved in an anterior cervical foraminoplasty or a transunfal procedure. The bone removed is 2 to 3 mm in thickness from the lateral margin of the vertebral column, and that portion is actually the medial wall of the neural foram. In an upper vertebral transcorporeal procedure, the anterior uncinate process is left completely intact. In a lower vertebral transcorporeal approach, the base of the uncinate is shaved laterally by 2 to 3 mm in thickness but is still well preserved. It is not certain what technique the authors adopted when it was stated that they followed our surgical techniques.

This paper asserts that surgical removal of the uncovertebral joint improves lateral or axial rotation in a 59-year-old or 80-year-old cadaveric cervical spine specimen. However, it is difficult for us to arrive at that conclusion by interpreting their results, in part due to the phenomenon of spontaneous tissue relaxation after repetitions of measurements. We note a significant relaxation of the specimen in a motion curve by repetitions in Fig. 1. From the first to the third measurement, the curve shows a progressive increase in motion, by approximately 20%. Postsurgical measurements were performed following initial baseline measurements and the completion of a surgical procedure. Thus, increases in ROM after a unilateral procedure could be confounded by the apparent tissue relaxation from repeated measurements rather than being completely attributable to the surgical procedure itself. The same confounding factor of tissue relaxation or fatigue could appear again in the increased motion measurements noted after bilateral procedures. Although the degree of tissue relaxation was approximately 20% in baseline measurements, subsequent increases in ROM recorded after the procedures were also a comparable magnitude of 10 to 20%. With these values, the number of specimens in this study is also clearly too small to produce an effective statistical analysis along with enhanced control measurements.

In addition, the segmental motion in the cervical spine is very small, particularly in a 59- or 80-year-old cadaveric specimen. With a very limited ROM, minute changes can tremendously affect percentages, such that even microscopic disruption at the tissue–resin interface can produce a significant effect on test results. With the surgical procedure used in this study, the authors demonstrated a 10 to 20% increase in axial rotation, but the actual degrees of motion for the baseline measurements were not addressed. When the original ROM is extremely limited, particularly in axial or lateral rotation, the significance of a 10 to 20% increase is unclear. Even the ROM in flexion and extension in one motion segment of the cervical spine in these age groups is very limited, perhaps only a few degrees at best.
Thus, a 10 to 20% change measured by these methods may in fact be no more than fractions of a degree, and these values were not clarified.

To summarize, there are a number of improvements required for future studies on this topic. When the details of this work are examined, it seems akin to a pilot study because of the small number of samples involved and some of the subjective measurements made. Further study is undoubtedly required with a larger number of specimens to create a meaningful statistical analysis. A range of specimens that are representative of the patient population would be ideal, because specimens from younger age groups may certainly show different results from those obtained in older age groups. Specimen fatigue or relaxation factor should ideally be calculated by control specimens tested in the same number of measurements as surgical specimens. Whether a small increase in ROM is part of spinal instability can be tested by additional load-failure measurements. As mentioned, we have noted in our clinical observations that an increase in lateral or axial rotation toward the surgically treated side reflects improved ROM for the patient rather than symptoms of instability. As with any other surgical procedure in the spine, however, substantial tissue removal during anterior cervical foraminotomy can theoretically produce spinal instability; thus, precautions must be taken during surgery to avoid doing so. In experimental conditions, the surgical procedure itself should be quantified to ensure an objective assessment.

Nonetheless, we recognize the challenges involved in these studies and sincerely commend the authors for their labor involved in meticulously documenting the small increase in axial rotation after an anterolateral surgical procedure at the segments of C4–5 and C6–7 in cadaveric specimens. Even considered parsimoniously, this work has at least brought attention to the need for further studies on the biomechanical effects of anterior cervical foraminotomy.

References


RESPONSE: We greatly thank Dr. Jho for his interesting editorial in response to our study and for his expert comments. We would like to reply by pointing to some aspects of our study as well as his remarks.

Concerning the question about the technical methods we used, we know that there have been adjustments and changes in the techniques used over the past years. Under the special circumstances in the biomechanical laboratory we wanted to perform an upper anterior uncoforaminotomy by using a 4-mm drill. In C4–5, as is visible on the radiographs, only the very lateral portion of the uncinate process was trimmed. In C6–7, with more pronounced degenerative changes present, more bone had to be removed to gain access to the neural foramen, but we did not remove the uncinate process entirely. We agree that quantification is not possible due to the number of specimens, but also due to an individualized approach for each specimen when decompressing the neural foramen. We did not perform transcorporeal approaches. We agree that 3D CT scans, which we routinely perform in all patients in our department, would have been beneficial to clarify and quantify our approach.

We disagree, however, that instability should be measured in a load-failure experiment. Stability can be quantified by load deformation characteristics. From this the ROM is a measure for stability or instability, which allows the comparison of different injury states to the intact situation. Therefore, an ROM that results from applied load is a parameter that can be correctly quantified as a measure of instability. Thus, this method is appropriate to quantify the effect of a simulated defect like the uncoforaminotomy in this study. Instability is much discussed among spine surgeons. Nevertheless, there is no clear agreement about the definition of the term “instability.” Therefore, this expression sometimes can lead to confusion. This is the major reason that we did not use the term instability in this paper when we referred to the observed changes.

We are aware of the fact that multiple testing procedures may lead to relaxation of the spinal segment. However, just a few cycles have little influence. In a study performed by the senior author (H.J.W.), it was shown that within the first three cycles changes take place, but then the influence is limited.1 That was why we used the third cycle for calculations.

In terms of pathophysiological changes, we agree that
lateral bone spurs can limit segmental motion. Whether this is an improvement or a problem for the patient is beyond the scope of this study. Nevertheless, we have observed pseudoradicular pain in patients who are otherwise fine after surgery within the intermediate follow-up evaluation period (after 34 months; 90 of 256 patients who have undergone surgery so far). Furthermore, we also had to perform three one-level fusions due to spinal instability (Pechlivanis et al., unpublished data). We also have observed a number of patients (eight [29%] of 28) in this group who developed a spontaneous fusion of the treated level without clinical deterioration when followed for 2 years with CT or MR imaging studies (unpublished data). In addition, it seems contradictory in the editorial that on the one hand the authors state that the ROM in one cervical level is small, but on the other hand the patients who have undergone one-level surgery report a significant improvement in their overall motion.

Once again, we would like to thank Dr. Jho for the constructive and well-balanced comments to our study, and we agree that further evaluations would be beneficial for the understanding of this procedure, which we still consider to be a very good minimally invasive alternative to other motion-preservation procedures. (DOI: 10.3171/SPI-07/11/533)

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