A prospective randomized controlled trial of anterior compared with posterior stabilization for unilateral facet injuries of the cervical spine


1Combined Neurosurgical and Orthopaedic Spine Program, Department of Orthopaedics; 2Combined Neurosurgical and Orthopaedic Spine Program, Division of Neurosurgery, Department of Surgery, University of British Columbia; and 3Vancouver Spine Program, Vancouver General Hospital, Vancouver, British Columbia, Canada

Object. Unilateral facet injuries can be treated with either anterior or posterior fixation techniques with reportedly good outcomes. The two approaches have not been directly compared, however, and consensus is lacking as to which is the optimal method. The primary objective of this study was to determine whether acute postoperative morbidity differed between anteriorly and posteriorly treated patients with unilateral facet injuries.

Methods. Forty-two patients were prospectively randomized to undergo either anterior cervical discectomy and fusion or posterior fixation. The primary outcome measure was the postoperative time required to achieve a predefined set of discharge criteria. Secondary outcome measures included postoperative pain, wound infections, radiographically demonstrated fusion and alignment, and patient-reported outcome measures.

Results. The median time to achieve the discharge criteria was 2.75 and 3.5 days for anterior and posterior groups, respectively, a difference that did not reach statistical significance (p = 0.096). Compared with those treated using posterior fixation, anteriorly treated patients exhibited somewhat less postoperative pain, a lower rate of wound infection, a higher rate of radiographically demonstrated union, and better radiographically proven alignment. Nonetheless, the anterior approach was accompanied by a risk of swallowing difficulty in the early postoperative period. Patient-reported outcome measures did not reveal a difference between anterior and posterior fixation procedures.

Conclusions. This prospective randomized controlled trial provided level 1 evidence that both the anterior and posterior fixation approaches appear to be valid treatment options. Although statistical significance was not reached in the primary outcome measure, some secondary outcome measures favored anterior fixation and others favored posterior treatment for unilateral facet injuries. (DOI: 10.3171/SPI-07/07/001)

Key Words • anterior cervical fusion • posterior cervical fusion • prospective randomized trial • unilateral facet injury

Unilateral facet injuries include a spectrum ranging from facet subluxations to dislocations, to fractures, and to various combinations thereof. Nonsurgical treatment has been plagued by a high incidence of recurrent instability and long-term pain.5,16,17,27,28 Surgical fixation has therefore become increasingly favored for unilateral facet injuries, particularly those that are displaced. Despite their relatively common occurrence, however, there is no consensus regarding their optimal treatment.

Historically, these injuries have been surgically treated with posterior interspinous or oblique wiring and, more recently, with lateral mass screws affixed to plates or rods. Data from biomechanical studies have suggested that posterior fixation provides greater stability than anterior fixation in in vitro models of unilateral and bilateral facet disruption.6,7,21,24,31,32 High rates of union and satisfactory clinical outcome have been reported by a number of authors.5,10,29,30 Alternatively, anterior discectomy, fusion, and plate fixation have also been reported to result in high fusion rates and good clinical outcomes when used to stabilize acute facet injuries.12,13,23,25,26

Both posterior and anterior approaches have unique advantages and disadvantages, but a clear choice between the
two has not been established. In a prospective randomized trial of anterior and posterior fixation in 52 patients with cervical spinal cord injuries and a wide variety of spinal column injuries, Brodke and colleagues reported no significant differences in fusion rates, alignment, neurological recovery, or long-term pain between the two approaches. To our knowledge, a direct comparison between anterior and posterior approaches specifically for unilateral facet injuries has not been performed.

Therefore, the purpose of this study was to compare anterior and posterior fixation of unilateral facet injuries in a prospective randomized controlled fashion. As the primary outcome measure we chose the duration of time after surgery for patients to fulfill a set of predefined medical and physical mobilization criteria, which, once achieved, would signify their ability to be discharged from the hospital. Acknowledging that both anterior and posterior fixation techniques are widely used and have been reported to result in good long-term clinical and radiographically demonstrated outcomes, we believed that a significant difference in this particular primary outcome measure (which reflects early perioperative morbidity) would represent a compelling argument to change current treatment practices. Secondary outcomes included postoperative pain, wound complications, radiographically demonstrated fusion, and both generic and disease-specific health-related quality of life outcomes.

Clinical Material and Methods

Study Criteria

All patients were recruited and cared for at the same Level 1 trauma center. Inclusion and exclusion criteria are listed in Table 1. We recruited individuals with an isolated acute unilateral facet injury that could be treated with either a single-level anterior discectomy or fusion, or a posterior cervical fusion, and with no other injuries (including spinal cord injury) that might affect mobilization. Prior to randomization in the trial and with the understanding that some facet injuries can be treated nonsurgically, the surgeon had to believe that surgery was warranted for the injury, and the patient had to consent to undergo surgical stabilization. All patients underwent a complete clinical evaluation and conventional imaging examination including radiographic, CT, and, when indicated, MR imaging. Patients with a complete facet dislocation who had met the clinical criteria for a safe, awake closed reduction underwent the procedure, which was performed using cervical tongs while the patient was under sedation. A study coordinator obtained informed consent from those deemed eligible to participate. The patients were then randomized according to a block randomization procedure. Approval to conduct this study was granted by the hospital and university human ethics committees.

Patient Demographics

Between 1998 and 2003, 20 patients were randomized to anterior and 22 to posterior stabilization procedures (Tables 2 and 3). Ten patients presented with a single root radiculopathy, six of whom were randomized to anterior treatment. No patient presented with less than Medical Research Council Grade 3/5 strength in the affected root, and all patients had complete recovery of the motor deficit. Patients with a spinal cord injury (multiple levels or bilateral symptoms) were excluded. There were 34 patients with fracture subluxations (nine isolated inferior facet fractures, 15 isolated superior facet fractures, and 10 other fracture subluxations); all of these subluxations were less than 25% of the body diameter on radiographs. Eight patients had purely ligamentous injuries without fracture as follows; the facet was completely dislocated in two, perched in two, and subluxed in four. In all cases the reduction was performed during the surgical procedure. In no case was there any neurological deterioration.

Surgical Procedures

The surgical procedures were performed by one of four fellowship-trained spinal surgeons. Patients randomized to an anterior procedure underwent anterior cervical discectomy and fusion with tricortical iliac crest autograft and anterior cervical plate fixation with a rigid, fully constrained titanium locking plate (Cervical Spine Locking Plate, Synthes; or Peak Plate, DePuy Spine). Patients randomized to a posterior procedure underwent lateral mass screw-plate fixation (Synthes), and/or interspinous and/or oblique wiring with 18- or 21-gauge wires. Nine patients were treated with posterior plating, eight with posterior wiring, and five with both techniques. At the time of the study design, there was no clearly superior posterior stabilization technique, and so the choice of wires and/or screws was left to the surgeon. Both anterior and posterior procedures required harvesting of autogenous iliac crest bone. A tricortical piece was harvested as a structural interbody graft in the patients treated anteriorly, and morcellized cancellous bone was harvested in patients treated posteriorly for placement along the posterior elements of the involved motion segment. In both cases, a standardized bone graft harvest technique was used with local anesthetic infiltration of the site before skin incision. A standard anesthesia protocol was established for all patients participating in the study, including local anes-

<p>| TABLE 1 |</p>
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<th>Study inclusion and exclusion criteria*</th>
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<td><strong>inclusion criteria</strong></td>
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<td>unilateral facet fracture, dislocation, or fracture dislocation between C-3 &amp; T-1 with subluxation of &lt;25% of anteroposterior diameter of caudal VB</td>
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<td><strong>exclusion criteria</strong></td>
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<td>associated spinal cord injury (radiculopathy not excluded)</td>
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<td>associated injury that would affect postop mobilization (for example, trauma to chest, abdomen, pelvis, or upper or lower extremity)</td>
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<td>associated compression fracture of subjacent VB &gt;10% of ant height</td>
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<td>narcotic or opioid allergy or addiction</td>
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<td>inability to understand use of self-controlled analgesia device</td>
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<td>preexisting conditions that would affect postop mobilization (for example, stroke, neurodegenerative disorder, or lower-extremity amputation)</td>
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<td>documented disc herniation on MR imaging</td>
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* ant = anterior; VB = vertebral body.
thetic wound infiltration at the graft harvest site, so that large discrepancies in the amount or nature of the anesthetic and analgesic agents would not occur.

Postoperative Care

All patients were provided a self-controlled analgesia device for postoperative pain management. All patients were mobilized with cervical orthoses (Guilford, Inc.) and were trained by the occupational therapists in brace application. A standard physiotherapy regimen was adhered to by all physiotherapists working with the patients, which included training in the tasks of mobilizing from a reclining to standing position, walking with and without assistance, and stair climbing. Outpatient physiotherapy was not routinely prescribed on discharge from the hospital.

Data Collection

Primary Outcome Measure. The primary outcome measure of this study was the duration of postoperative time required for a patient to achieve a standard set of discharge criteria as determined by an independent observer rather than the surgeon. The discharge criteria were as follows: 1) The patient is medically stable, meaning that he or she is hemodynamically stable, cognitively intact (that is, not delirious), tolerating oral intake, and does not have signs of systemic sepsis (fever or tachycardia). 2) The surgical

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mean 37.5 ± NA 2.75‡‡ 2.6 ± 2.1 ± NA −8.8 ± 46.8 ± 52.3 ± 85.2 ± 85.8 ±

* NA = not available; R = presence of nerve root injury in association with osteoligamentous facet injury.
† Denotes the motion segment injured.
‡ Fusion was believed to have occurred based on the presence of bridging bone at the ends of the interbody graft and no motion on flexion and extension radiographs 1 year after injury.
¶ Negative values denote lordosis; positive values, kyphosis of the motion segment. Note that 15 of the 17 patients in whom the sagittal alignment could be measured had lordosis: of the remaining two patients, one was neutral and the other had kyphosis. The mean sagittal alignment was in lordosis.
|| A score of 50 represents the mean for the normal population.
** A score of 100 is the optimal score.
†† Sagittal alignment could not be assessed in this patient because the posterior aspect of the T-1 body could not be properly visualized.
‡‡ Represents the median value.
wound is not infected, and if there is drainage from the wound it can be managed by the patient and/or home care staff with dressing changes. 3) The patient has an acceptable level of pain control on oral analgesics. 4) The patient is independently mobilizing, meaning that he or she can independently roll in bed, move from lying to sitting and then

TABLE 3

<table>
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<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
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<th>No. Days to Achieve Discharge Criteria</th>
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mean 33.0 ± 3.1 NA 3.5†† 3.6 ± 0.5 3.0 ± 0.4 NA 1.6 ± 1.9 46.9 ± 2.0 49.3 ± 2.3 83.9 ± 3.9 81.7 ± 3.5

* IV = intravenous; MRSA = methicillin-resistant Staphylococcus aureus.
† Fusion was deemed to have occurred (yes) based on the absence of motion on flexion and extension radiographs.
‡ Note that seven of 19 patients in whom sagittal alignment could be measured had lordosis; one patient was neutral and 11 had kyphosis. The mean sagittal alignment was in kyphosis.
§ Motion present on the 3-month flexion and extension radiograph, but unchanged neutral alignment with no hardware loosening at the 1-year time point.
|| Fusion and sagittal alignment could not be assessed in this patient because of poor visualization of the caudal end of her subaxial cervical spine.
** Fusion confirmed on CT scan.
†† Median value.
from sitting to standing positions, walk 50 meters, and ascend two flights of stairs.

The date and time at which the patient achieved these criteria was recorded, and the duration of time required to meet the discharge criteria was calculated from the time that the patient came out of the operating room, rounded to the nearest half day. Other variables, such as waiting for emergency operating room time, support available at home, and so forth, increased the total hospital length of stay beyond that determined by the discharge criteria.

Secondary Outcome Measures. Patients rated the extent of neck pain based on the VAS on the 1st, 2nd, and 3rd postoperative days (if still in the hospital). An occupational therapist evaluated changes in voice or difficulties in swallowing, and monitored patients reporting difficulties again at the 3- and 6-month postoperative points to determine progress. Wound problems were noted and any required interventions documented (for example, oral or intravenous antibiotics, irrigation, and debridement).

Patient statuses were reviewed clinically and radiographically at 6 weeks and 3, 6, and 12 months postoperatively. Radiographic evaluation at each visit consisted of upright anteroposterior and neutral lateral x-ray films. Flexion and extension x-ray films were also obtained, first at the 3-month postoperative follow-up and at subsequent visits if necessary. Computed tomography scanning was performed when fusion status was questionable based on a clinical and plain radiographic assessment. An independent, fellowship-trained spine surgeon who was not directly involved in the surgical treatment of the patients and who was blinded to their clinical outcome conducted all radiographic evaluations.

In cases of posterior fixation, fusion at 1 year was confirmed by the absence of motion on flexion and extension radiographs and by the presence of facet fusion on a CT scan if necessary (Fig. 1A and B). In cases of anterior procedures, fusion was determined according to the presence of osseointegration of the interbody graft at its rostral and caudal margins on the 1-year postoperative radiograph and by the absence of motion on flexion and extension radiographs (Fig. 1C and D). Criteria for a definite pseudarthrosis applied to both groups included progressive kyphosis, loosening of fixation, or breakage of hardware. Sagittal alignment of the injured segment was evaluated on the 1-year postoperative lateral radiographs (Fig. 2 inset).}

Clinically, patients were evaluated using the SF-36 and the NASS cervical spine questionnaire 12 months postoperatively. Independent research assistants not involved in the patients’ clinical care administered all clinical outcome measures.

Statistical Analysis

Statistical comparisons were performed using either a Student t-test for data distributed normally or a Mann–Whitney U-test for data lacking normal distribution.

A power analysis was conducted to determine sample size. A clinically relevant change in the primary outcome measure (time to achieve standard discharge criteria) was arbitrarily defined as 2 days. A 2-day difference in the postoperative time required to discharge such patients might influence the manner in which a spinal surgeon decided to operatively manage these injuries. A locally developed and prospectively maintained database was used to retrospectively evaluate the length of stay in patients who had undergone surgical treatment of facet dislocations. On review of the database, which included patients with both unilateral and bilateral facet injuries, the mean length of stay was 6.2 ± 1.98 days (mean ± standard deviation). Basing the sample size on a two-tailed t-test for independent means with an α of 0.05 and a β of 0.1 (power of 0.90), the n per group was calculated to be 21.

Results

There was no statistically significant difference between the groups with respect to age (p = 0.34, Student t-test), sex distribution (p = 0.73, Fisher exact test), or injury level distribution (p = 0.51, chi-square test). There were no differences in medical comorbidities or associated injuries between the two treatment groups. The mean operating room time in the posterior treatment group was 103 minutes, compared with 134 minutes in the anterior treatment group (p = 0.0002), although this time includes patient positioning and setup and thus may not accurately reflect skin-to-skin time. No patients required blood transfusion, and the average intraoperative blood loss was minimal (< 100 ml).

Primary Outcome: Time to Achieve Discharge Criteria

In the 20 patients treated anteriorly, the median time to achieve discharge criteria was 2.75 days, ranging from 1 to 24 days (Table 2). In the 22 patients treated posteriorly, the median time to achieve discharge criteria was 3.5 days, ranging from 1.5 to 42 days (Table 3). This difference was not statistically significant between the two groups (p = 0.096, Mann–Whitney U-test).

Although the majority of patients in both groups achieved the discharge criteria within the first 2 days postoperatively, a small number of patients required extended periods of time before they were ready for discharge (Fig. 3). Four of 22 patients randomized to posterior surgery had infection of the neck wound. One deep infection with methicillin-resistant Staphylococcus aureus required operative irrigation and debridement as well as 6 weeks of intravenous antibiotics, whereas three superficial infections with methicillin-sensitive S. aureus required oral antibiotics. As discharge criteria required the absence of infection and a wound that could be managed with simple dressing changes at home, individuals with wound infections did not meet the criteria until the wound was intact and they had finished their course of antibiotics. There were no neck wound infections in the anteriorly treated group, although one patient had a methicillin-sensitive S. aureus infection of the anterior iliac crest harvest site 3 weeks after discharge and was successfully treated with oral antibiotics. One anteriorly treated patient, an 86-year-old man, had a prolonged course in the hospital due to a variety of medical complications.

Postoperative Pain

The mean pain score in patients who underwent anterior rather than posterior surgery was 2.6 ± 0.5 (compared with 3.6 ± 0.5) on postoperative Day 1 and 2.1 ± 0.5 (compared with 3.0 ± 0.4) on postoperative Day 2. Although the anteriorly treated patients had slightly lower pain scores,
this difference did not reach statistical significance (p = 0.15 for both days, Student t-test).

Patient-Reported Outcomes 12 Months Postoperatively

Fourteen (70%) of the 20 patients randomized to anterior surgery and 19 (86%) of the 22 randomized to posterior surgery completed the 1-year self-reported outcome packages. The remainder were either lost to follow-up or refused to send in the outcome packages. There were no statistically significant differences between the patients treated anteriorly and those treated posteriorly for the SF-36 mental and physical scores and for the NASS cervical and neurological scores.

Patient Complications

Eleven of 20 patients treated anteriorly and none of the posteriorly treated patients reported difficulties with swallowing or changes in their voice at the time of discharge. Ten described resolution of these symptoms at the 6-week follow-up, and one described resolution at the 3-month fol-

Fig. 1. A and B: One-year postoperative flexion and extension radiographs obtained in a patient randomized to posterior fixation, showing fusion. Note the absence of motion. C and D: Flexion and extension radiographs obtained in a patient randomized to the anterior fixation group, demonstrating osseointegration of the interbody graft at its rostral and caudal borders and the lack of motion (signs of fusion). Signs of pseudarthrosis included progressive kyphosis, loosening of fixation, and hardware breakage. Arrows indicate flexion.
low-up. With the exception of the aforementioned 86-year-
old man randomized to anterior surgery, there were no oth-
er major medical complications.

**Radiographic Evaluation**

Eighteen (90%) of the 20 patients randomized to anteri-
or surgery had undergone complete radiographic follow-up
at the 1-year postoperative time point, and all were deemed
to have fusion (fusion rate of 100%). Nineteen (86%) of
22 patients randomized to posterior surgery had complete
radiographic follow-up at the 1-year postoperative time
point; 17 were deemed to have a solid union based on the
absence of motion on flexion and extension radiographs or
facet fusion on CT scan, whereas two patients suffered a
pseudarthrosis (fusion rate of 89%). The imaging obtained
in these two patients and their case descriptions are fea-
tured in Figs. 4 and 5. There was no statistically significant
difference between the fusion rate in the anterior and pos-
terior group (100% compared with 89%, $p = 0.49$, chi-
square test).

In patients with complete radiographic follow-up at the
1-year postoperative mark, the mean sagittal alignment of
the injured motion segment in those treated anteriorly was
$8.8 \pm 1.4^\circ$ of lordosis, ranging from $5^\circ$ of kyphosis to $20^\circ$
of lordosis. In those treated posteriorly, sagittal alignment
was a mean of $1.6 \pm 1.9^\circ$ of kyphosis, ranging from $11^\circ$ of
lordosis to $19^\circ$ of kyphosis. The extent of kyphosis in the
patients treated posteriorly ($1.6^\circ$) was significantly different
from the average lordosis ($8.8^\circ$) in those randomized to an-
terior surgery ($p = 0.0001$, Student t-test).

Of the 19 patients in the posteriorly treated group who
had radiographs on which sagittal alignment could be mea-
sured, 11 were treated with lateral mass plates and screws,
wheras eight were treated with interspinous and unilat-
er oblique wiring alone. Two of the 11 patients with lateral
mass screws and plates were also treated with interspinous
wiring. The mean sagittal alignment in patients treated with

![Fig. 2. Radiograph and bar graph revealing sagittal alignment. The bar graph demonstrates the sagittal alignment of patients randomized to anterior (gray bars) or posterior (white bars) fixation as measured from a lateral radiograph obtained at the 1-year postoperative time point. The sagittal alignment of each patient is represented in ascending order as an individual bar in this figure (bars for posteriorly treated patient in Case 8 and the anteriorly treated patient in Case 16 are not visualized because their sagittal alignment was 0). The Gore method of measuring sagittal alignment was used (inset), which measures the angle between lines drawn tangentially to the posterior vertebral bodies. Positive angles denote kyphosis, and negative angles denote lordosis. Note that only one of 17 anteriorly treated patients was in kyphosis, whereas 11 of 19 posteriorly treated patients were in kyphosis. The kyphosis of the posteriorly treated patient within the inset is denoted by the asterisk.](image)
Discussion

The relevance of our study relates to the relatively high incidence of these injuries in clinical practice, the controversy regarding either anterior or posterior surgical treatment, and the lack of a direct comparison between anterior and posterior fixation for these injuries. There was no significant difference in the postoperative time to achieve discharge criteria between the anterior and posterior fixation groups (p = 0.096, Mann–Whitney U-test), and thus the primary outcome measure in this prospective randomized clinical trial was negative. Although our primary outcome did not reveal a significant difference, for the first time we have provided level 1 evidence that both the anterior and posterior fixation approaches are valid treatment options for this relatively common injury.

The primary outcome in this study was chosen based on much thought about what would be relevant to a spinal surgeon facing the decision of whether to treat this injury anteriorly or posteriorly. At the time we designed the study, available literature indicated that the longer-term clinical and radiographic outcomes of anterior and posterior fixation for these cervical injuries were fairly similar. Therefore, we did not choose these more common end points (for example, the fusion rate at 2 years) as our primary outcome measure. Rather, we believed that an outcome measure reflecting the acute postoperative morbidity and speed of in-hospital recovery would be an important factor in the clinical decision to stabilize this injury anteriorly or posteriorly, particularly if a clear difference could be shown with regard to acute postoperative pain, easier mobilization, and a shorter length of stay. We acknowledge that this outcome measure is not widely used (as opposed to long-term fusion rate or patient-reported outcome). However, the worldwide explosion of interest in minimally invasive surgical techniques that aim to reduce perioperative pain and morbidity and to shorten the length of postoperative hospital admission would strongly suggest that a primary outcome measure that reflects acute postoperative morbidity is extremely relevant to the spine community. In this regard, we established a set of discharge criteria a priori that reflected the recovery of the patient in the acute postoperative phase and elected to evaluate which treatment group (anterior compared with posterior) achieved these criteria first. In accordance with the appropriate design of a prospective randomized trial, we powered the study and determined the target number of patients based on this primary outcome measure.

With respect to the secondary outcome measures included in the study, a weak trend toward less pain in the anteriorly treated patients in the first 2 days after surgery was noted (p = 0.15). We observed an increased incidence of wound infections in the posteriorly treated patients. Wound infections were diagnosed based on the observation of wound drainage, fever, and positive wound cultures before discharge from the hospital. The prolonged times required to achieve the discharge criteria in four patients in the posterior group were related to wound infections; three superficial and one deep (requiring operative debridement). The incidence of wound infections (four [18%] of 22) was higher than we expected; however, this rate of deep infection parallels that reported by other authors.10,22,29,30 There may be several reasons for the higher-than-expected superficial wound infection rate in the posteriorly treated patients. Those who arrive in the hospital after an unanticipated trauma are inherently less “clean” than those who come for a scheduled elective procedure for a degenerative condition. Early discharge may have contributed to the infection rate. All of the patients in this study wore the Guilford collar postoperatively, and most wore a collar from the accident scene to the operating room. We can conclude that in the management of such injuries via an anterior approach, wound infection problems are extremely rare.

With regard to the primary analysis, posteriorly treated patients with superficial wound infections were considered to have achieved the discharge criteria only once they had completed oral antibiotics. This strategy was most consistent with the predefined discharge criteria in the primary outcome measure. We also considered how results of the primary outcome analysis might be altered if one were to view these posteriorly randomized patients as having fulfilled the discharge criteria once they started taking oral antibiotics, even though in our opinion, this stage would not technically make them medically or surgically stable. If the time to achieve discharge criteria in these posteriorly treated patients was reduced from 17, 18, and 28 days to 3, 4, and 7 days, respectively, to account for the 2 weeks of ad-
ministered oral antibiotics, the analysis of the primary outcome measure remains negative with a weakened trend toward a statistically significant difference between the two groups (p = 0.17 instead of p = 0.096). An iliac crest graft harvest site wound infection developed in one anteriorly treated patient a number of weeks after he had fulfilled the discharge criteria and had returned home. We did not believe it appropriate to go back and alter his score on the primary outcome measure, just as we did not alter the score of the posteriorly treated patient who later underwent an anterior revision for pseudarthrosis. If, however, one were to add the 3 weeks of the oral antibiotic regimen followed by this anteriorly treated patient to the time required to fulfill the discharge criteria (making it 24 days instead of 3), again, the analysis of the primary outcome measure remains negative, with a weakened trend toward a statistically significant difference between the two groups (p = 0.16 instead of p = 0.096).

Laryngeal and/or esophageal symptoms were detected on a very detailed screening instrument that was developed by one of the occupational therapists and administered to the patients postoperatively. Given the stringency of the screening checklist, we were surprised that only 11 of 20 anteriorly treated patients screened positive for these symptoms. Anyone who screened positive was followed up by the occupational therapist to document the course of these symptoms. None of these patients reported persistent laryngeal and/or esophageal symptoms at the 3-month follow-up, with most having had their symptoms resolve by 6 weeks, suggesting that the symptoms were generally self-limiting in nature.

Radiographic evaluation in the patients generated some hypotheses with respect to differences between anterior and posterior treatment of these injuries. No cases of pseudarthrosis were observed in the anteriorly treated group, whereas two were documented in 19 posteriorly treated patients; however, we recognized that the difference in fusion rates (100% for anteriorly treated and 89% for posteriorly treat-

Fig. 4. Case 10. Images obtained in a 20-year-old man who sustained a unilateral C4–5 facet subluxation in a judo competition, showing pseudarthrosis of posterior fusion requiring anterior discectomy and fusion. A preoperative CT scan (A) shows the subluxed facet (arrow) and a T2-weighted MR image (B) shows the disc and posterior soft tissue disruption, without significant disc herniation. He underwent a single-level posterior lateral mass plating and fusion with autogenous bone graft (C). Six months later, he had persistent neck discomfort, and lateral radiographs showed increased kyphosis at the motion segment and no obvious union of the facet joints (D). Computed tomography scans (E and F) confirmed the absence of an osseous union across either of the facets. He underwent an anterior C4–5 cervical discectomy and fusion 6 months after the posterior procedure, and a flexion and extension radiograph (G) obtained 6 months later demonstrated consolidation of the graft and no motion. His clinical outcome was excellent.
ed) did not reach statistical significance. It is interesting that data from in vitro biomechanical tests that typically model more severely unstable cervical spine injuries and even a recent biomechanical comparison in a unilateral facet injury model have consistently demonstrated that posterior fixation is superior to anterior plating. Our findings highlight the difference between a biomechanical study of immediate stability and the biological outcome (fusion) not assessed by these basic science studies.

The positive radiographic results of anterior fixation should be qualified by an important caveat. Johnson and colleagues reported that flexion-distraction injuries, which included an endplate fracture (typically the superior endplate of the caudal vertebra), had an almost two thirds chance of mechanically failing when managed with single-segment anterior fusion alone. We therefore advocate posterior or combined fixation for unilateral facet fractures in the presence of an endplate fracture of the subjacent vertebrae. Moreover, we recognize the technical difficulties that can be associated with reducing unilateral dislocations via...
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an anterior approach, and a surgeon might therefore choose to accomplish this reduction via a posterior approach. Furthermore, one should acknowledge that although the swallowing difficulties associated with an anterior approach are typically self-limiting, they can be the source of great morbidity in an elderly patient, in whom an alteration of swallowing mechanics can predispose to an aspiration pneumonia.

Results of an analysis of radiographic sagittal alignment have suggested that there is a difference between the anterior and posterior treatment groups. In the distribution of sagittal alignment shown in Fig. 2, 11 of 19 patients treated anteriorly were actually kyphotic across the injured segment, whereas only one of 18 patients treated anteriorly was kyphotic. If one were to consider that the single cervical motion segment normally possesses at least 5° of physiologic lordosis, then 15 of 19 patients treated posteriorly had relative kyphosis. Conversely, only three of 18 patients treated anteriorly had relative kyphosis.

A potential explanation for the kyphosis in the posteriorly treated patients is the disruption of the disc anteriorly, which has been shown in MR imaging studies frequently to occur in association with these unilateral facet injuries. The posterior instrumentation used in this study (wiring and/or lateral mass screws with plates) may not have been able to prevent the kyphotic collapse across the degenerated disc, a phenomenon clearly demonstrated in radiographic studies of rotationally unstable cervical spine injuries. Contemporary lateral mass fixation systems in which the lateral mass screws are rigidly connected to the rod may be more effective in preventing such kyphotic collapse, although to our knowledge this somewhat intuitive concept has not been clearly established in the literature. Given these potential risks and the young age of the majority of patients in the present study, the goal of maintaining a lordotic sagittal alignment across the injury segment may not be trivial. Long-term follow-up of larger cohorts will be necessary to determine whether kyphosis over time will cause reduced generic and disease-specific outcomes. At a 1-year follow-up, patient-reported generic and disease-specific outcome measures revealed no significant differences between the two treatment groups.

One of the potential weaknesses of this study is that in both the anterior and posterior treatment arms, a number of different fixation constructs were used. In the patients randomized to anterior fixation, we utilized two different anterior cervical locking plates (Synthes anterior cervical locking plate and DePuy peak plate). In both of these systems, the screws lock rigidly to the plate, unlike the newer “dynamic” cervical plating systems in which some motion can occur between the screws and the plate. Thus, “dynamization” of the motion segment was not permitted by either of the cervical plating systems used, and so we believed that it was reasonable to include patients treated with both in the anterior arm of our study. In the posterior arm, patients were treated using interspinous or oblique wiring, lateral mass plates and screws, or both. When we designed the study, wire fixation and lateral mass fixation techniques were both being applied somewhat commonly at our institution, and the available scientific literature suggested that they were fairly equivalent. Clinical studies of posterior wiring techniques by Benzel and Kesterson, Feldborg Nielsen et al., and Cahill et al. revealed fusion rates of 96 to 100%, whereas fusion rates of 93 to 100% have been reported by Fehlings et al. and Graham et al., who used lateral mass fixation. We therefore believed that it was not necessary to restrict the type of fixation used in the patients randomized to the posterior treatment arm. Data from a subsequent retrospective analysis of a larger but more heterogeneous cohort of patients with cervical flexion-distraction injuries treated using wire fixation, lateral mass fixation, or both revealed no significant difference in fusion rates between the two treatment groups.

In summary, this study was ultimately conducted to determine whether anterior or posterior fixation was superior in the surgical management of isolated unilateral facet injuries, with the primary determinant of superiority being the time required to achieve discharge criteria in the early postoperative period. Although not powered as an equivalence study, we have provided level 1 evidence that both anterior and posterior treatments are reasonable alternatives. The patients included in the study had isolated unilateral facet injuries without spinal cord injury and without any other major injuries that would affect postoperative mobilization; a statistically significant difference in this primary outcome measure was not established. A number of the secondary outcome measures were found to vary between the two treatment groups, however. Compared with patients treated posteriorly, those who underwent anterior fixation fulfilled the discharge criteria sooner (2.75 days compared with 3.5 days), although not significantly so (p = 0.096); reported less pain on each of the first 2 postoperative days, although not statistically significantly so (p = 0.15); experienced far fewer neck wound infections (none compared with four in the posterior group); achieved union in all cases (as opposed to two pseudarthroses in the posterior group); healed with a more lordotic sagittal alignment (~ 9° lordosis compared with 1° kyphosis); and more frequently had signs of dysphagia and voice changes in the early postoperative period.

Conclusions

This prospective randomized evaluation of anterior compared with posterior fixation for unilateral facet injuries of the cervical spine revealed no significant difference in the time required for patients in either treatment arm to fulfill the predetermined discharge criteria (primary outcome measure). A number of secondary outcomes suggested differences between the anterior and posterior fixation groups, although these observations generate more hypotheses rather than serve as conclusive evidence of an advantage for either approach. Having completed this study it is our opinion that both posterior and anterior surgical approaches are viable alternatives for treating these injuries, although they have different risk profiles. Further follow-up will be required to determine the long-term clinical significance of the radiographic differences between the two groups of patients.

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