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Cost effectiveness of subaxial fusion—lateral mass screws versus transarticular facet screws

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As health care reform continues to evolve, demonstrating the cost effectiveness of spinal fusion procedures will be of critical value. Posterior subaxial cervical fusion with lateral mass screw and rod instrumentation is a well-established fixation technique. Subaxial transarticular facet fixation is a lesser known fusion technique that has been shown to be biomechanically equivalent to lateral mass screws for short constructs. Although there has not been a widespread adoption of transarticular facet screws, the screws potentially represent a cost-effective alternative to lateral mass rod and screw constructs. In this review, the authors describe an institutional experience with the use of lateral mass screws and provide a theoretical cost comparison with the use of transarticular facet screws.
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Key Words • **lateral mass screw** • **cervical spine** • **facet screw** • **fusion** • **cost effectiveness**

Instrumented subaxial cervical fusion is a well-established technique among orthopedic and neurosurgical spine surgeons. Several techniques for subaxial rigid fixation have been described,[5,9–11,15,17,19,24,25] but the use of lateral mass screw and rod constructs has been the most widely described and accepted.[5,6,8,12,17,18,20,24] Although the use of subaxial cervical facet screws for instrumented fusion is not a new concept,[5,10,11,15,19] there has not been a similar widespread acceptance of this technique. Despite the limited data in the clinical literature on the use of subaxial facet screws,[5,10,11,15,19] the available biomechanical data suggest comparable biomechanical properties to lateral mass screw and rod fusion techniques.[5,10]

With increasing scrutiny on spinal instrumentation and reimbursement, significant emphasis has been placed on identifying cost-effective interventions. Recently, several authors have demonstrated a clear cost-effective benefit of certain spinal surgical procedures.[1–3,14,21,22] This type of cost analysis measurement provides some objective data for both patient and provider when considering surgical and nonsurgical options, but it is difficult to extrapolate a similar formula to compare 2 surgical procedures with a similar outcome goal. Nevertheless, a pure cost analysis of the various contributing components can be measured. We retrospectively reviewed the instrumentation costs alone for subaxial rigid fixation with lateral mass screw and rod constructs. A theoretical comparison was then made to the similar, yet less well-recognized surgical alternative of subaxial facet screws.

Methods

Study Population

Permission to perform the study was obtained from the University of Utah Institutional Review Board. The neurosurgical operative database was queried to identify adults (≥ 18 years of age) who had undergone posterior subaxial spinal fusion procedures in which lateral mass screws were used from 2007 to 2009. Patients who underwent fusion procedures involving the occiput to axis and those who were treated for an acute comminuted facet fracture were excluded from review. The patients' medical records, operative reports, CT scans, and MRI studies were retrospectively reviewed.

Cost Analysis

Instrumentation cost was analyzed based on the direct instrumentation charge to the hospital. Per negotiated fees with all spine instrumentation vendors, lateral mass screws are reimbursed at $645 per screw, locking caps at $100 each, and rods at $150 each. Thus, the cost of instrumentation for a single-level fusion (4 screws, 4 caps, 2 rods) is $3280 and that of a 2-level procedure (6 screws, 6 caps, 2 rods) is $4770 (Table 1). The cost of each cortical screw used for transarticular facet fixation is $18.

Abbreviation used in this paper: ACDF = anterior cervical discectomy and fusion.

TABLE 1: Actual and estimated instrumentation costs for subaxial cervical spine fusion in 65 patients*

	Implant Cost ($)	
Factor	Lateral Mass Screws & Rods	Facet Screws
1 level	3,280	36
2 levels	4,770	72
3 levels	6,260	108
4 levels	7,550	144
mean cost per patient	6,393	76
total cost of instrumentation	415,540	4,932

* Costs are actual costs for lateral mass screws and estimated costs for facet screws.

Results

We identified 65 patients in whom the inclusion/exclusion criteria were met. As summarized in Table 2, the mean age of treated patients was 54 years (range 20–88 years), and 66% (43 patients) were male. A mean of 3.2 (range 2–5, total 200) levels were fused, and the most common indications for treatment (in 19 patients) were nonunion from previous ACDF and cervical spondylosis. Other preoperative indications were traumatic injuries in 10 patients, cervical myelopathy in 11 patients, and tumor, infection, and deformity in 2 patients each.

The actual total instrumentation cost to the hospital for the 65 patients undergoing subaxial cervical spine fusions with lateral mass screw and rod constructs was $415,540, while the mean direct cost for instrumentation alone per patient was $6393 (Table 1).

A similar calculation was performed to generate a direct comparison for hospital instrumentation costs if posterior fusion had been performed using transarticular facet screws. The total potential instrumentation cost to the hospital for the 65 patients undergoing transarticular facet fusions was $4932, with a cost of $36 per level treated and an average cost per patient of $76. Regardless of the number of levels fused, the average direct cost of instrumentation for transarticular facet screws would be less than 2% of the direct instrumentation costs of lateral mass screw and rod constructs.

TABLE 2: Demographic and surgical data acquired in 65 patients who underwent subaxial cervical spine fusion

Variable	Value
age (yrs)	
mean	54
range	20–88
sex	
male	43 (66.2%)
female	22
preoperative diagnosis	
cervical spondylosis	19
cervical myelopathy	11
nonunion	19
infection	2
tumor	2
trauma	10
deformity	2
mean no. of levels fused	3.1

Illustrative Cases

Case 1: Facet Screws

This 65-year-old woman with a history of hyperlipidemia and C3–4 ACDF, recurrent bilateral upper-extremity pain, and occipital headaches subsequently underwent plate removal at C3–4 followed by C4–5 anterior fixation. She initially had pain relief for several months; however, symptoms of recurrent neck pain and occipital headaches gradually developed. A CT scan (Fig. 1A) showed evidence of nonunion at the C4–5 level. She subsequently underwent a C4–5 posterior fusion in which transarticular facet screws were placed. At follow-up approximately 1 year after her posterior fusion, the patient had no evidence of adjacent-segment disease or other new cervical pathology; her preoperative upper-extremity pain and headaches had resolved. Computed tomography (Fig. 1B and C) revealed incorporation and bridging of bone across the C4–5 discectomy and graft.

Case 2: Lateral Mass Screws

This 40-year-old woman with a history of hypothyroidism underwent C5–6 ACDF for symptoms of neck and left arm pain. She initially had good pain relief, but 9–12 months after her initial surgery, she had persistent worsening of neck pain with pain radiating into her left arm. At that time there was radiographic evidence of resorption and nonincorporation of the bone graft and a broken screw at C-6 (Fig. 2 left). In addition, 5 mm of motion was demonstrated on flexion-extension plain radiographs. The patient had participated in a trial of a bone stimulator, but this was discontinued shortly thereafter because of her discomfort and concern. The patient underwent C5–6 posterior spinal fusion with lateral mass screws and a left C5–6 laminoforaminotomy. Seven months after the posterior fusion, she experienced mild paraspinal discomfort, but otherwise her neck and arm pain had resolved. A CT scan obtained 1 year after the posterior procedure showed incorporation of the interbody bone graft and an intact posterior fusion construct (Fig. 2 right).

Discussion

Several authors have demonstrated the clear long-term cost effectiveness of certain spinal procedures.[1,3,13,23] As health care reform seeks ways to curb Medicare costs, similar studies that demonstrate clear patient benefit in a cost-effective manner will be crucial. In our retrospective review of patients treated with posterior spinal fusions (lateral mass screw and rod constructs) over a 2-year period, we calculated a direct cost of instrumentation to the hospital of $415,540. This amounted to an instrumenta-

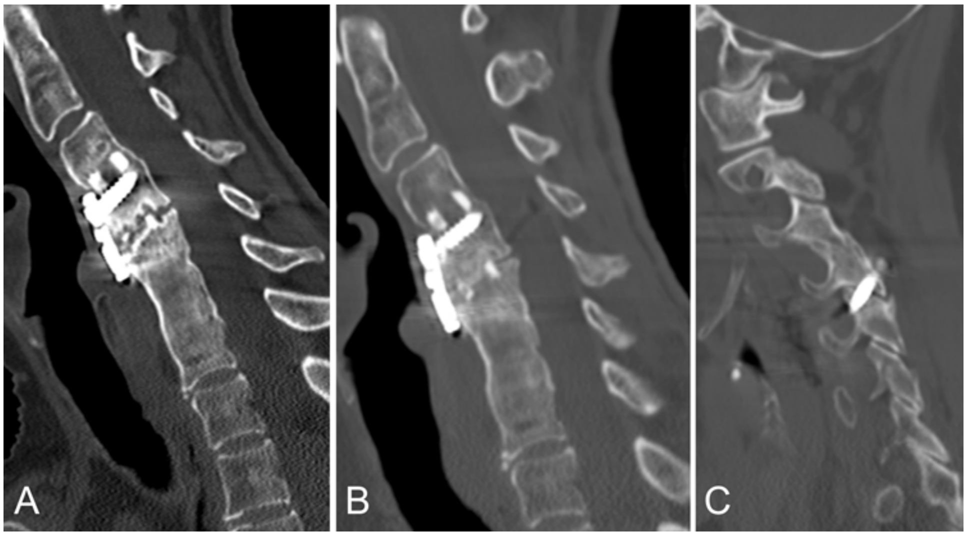

Fig. 1. A: Sagittal CT scan of the cervical spine showing status after a C4–5 ACDF with persistent lucency through the C4–5 level and endplate irregularity consistent with nonunion at C4–5. There is evidence of previous osseous fusion at the C3–4, C5–6, and C6–7 levels. B and C: Sagittal CT scans obtained about 1 year after posterior fusion with transarticular facet screws, demonstrating incorporation and bridging of bone across the C4–5 discectomy and graft.

tion cost of $3280 per level for lateral mass screws and rods compared with a theoretical direct instrumentation cost of $36 per level for transarticular facet screws. A prospective study comparing facet screw fixation and lateral mass fixation is currently underway, yet the comparative data on direct and indirect costs in drawing more meaningful cost-effective conclusions are not yet available. This comparison of instrumentation costs is intended to draw attention to a theoretical cost savings and does not account for real-world patient selection, but it does provide an interesting example of industry-driven costs and the potential for cost savings.

Realization of a cost-effective benefit occurs earlier if total care costs can be minimized.[7] Glassman et al.[7] have noted that realization of the cost effectiveness of single-level instrumented posterolateral lumbar fusion improves with longer patient follow-up, as the 5-year quality-adjusted life year is markedly improved compared with the initial 2-year data. Although further investigation is needed, based on direct instrumentation costs alone, the routine utilization of transarticular facet screws could potentially provide a more rapid realization of the cost effectiveness of subaxial decompression and fusions as related to quality-adjusted life year. Consequently, this increased cost awareness among spine surgeons has changed the way spinal instrumentation is negotiated and paid for by hospitals and surgical centers. While the surgical fees for most neurosurgical procedures have remained stable over the past 20 years, reimbursement for both cranial and spinal procedures has either decreased or remained flat, with a significant decrease in real-world value (http://www.cms.hhs.gov).[4,16] Spine surgeons continue to face shrinking reimbursement amounts for surgical fees from both Medicare and private insurers,[23] but most spinal instrumentation is usually reimbursed directly through the hospital at 100% of the negotiated fees.

Fig. 2. Left: Lateral radiograph demonstrating lucency along the intervertebral disc graft and bilateral screws at C-5 and C-6 consistent with hardware failure. There is a fracture of the right C-6 screw. Right: Sagittal CT scan demonstrating fusion of the interbody graft at C5–6. The posterior fusion construct is intact.

Takayasu et al.[19] have reported on a series of 25 patients treated with cervical transarticular facet fusion. The authors placed 81 cervical transarticular facet screws and reported no neurovascular complications in 4–60 months (mean 25 months) of follow-up. While the criteria used to assess fusion were not indicated, the authors reported that in all cases bony fusion was achieved and there was no evidence of instrumentation failure. There are limited published data on the cost effectiveness of posterior subaxial fusions. Takayasu et al. did not provide any data related to hospital or patient charges, but they did report that neurovascular complications were absent and reoperation was unnecessary, and that radiographically documented fusion was present in all cases. Although these findings represents only a single case series, the potential implications for cost savings based on a lack of reported complications alone supports the need for further prospective studies investigating the cost-effective potential of this technique.

Integrating cost savings by cutting instrumentation costs is not a new concept. While many spine surgeons retain the ability to choose the most appropriate instrumentation system for each procedure, there are many surgeons who face significant administrative challenges when it comes to choosing instrumentation. The negotiation of instrumentation prices by hospitals and surgical centers has in part shifted some of the burden of decreased reimbursements onto instrumentation companies. While this type of mass negotiation may not account for surgeon preferences, it has provided an impetus to instrumentation companies to identify their own cost-saving strategies.

In our case illustrations, we described the case of a patient treated with transarticular facet screws for a C4–5 nonunion and a similar case treated with lateral mass screws and rods for a C5–6 nonunion. Both patients had improvement of their neck pain, and by 1 year a solid bony fusion was achieved (Figs. 1B and C and 2 right). The total cost to the hospital and total hospital costs billed to the patient undergoing placement of transarticular facet screws were $8536 and $31,426 compared with $10,582 and $32,232, respectively, for the patient who underwent lateral mass screw and rod fixation. This simple comparison does not account for indirect patient costs but does illustrate a clear potential for both cost savings to the hospital and a cost savings to the patient.

Although the results of this analysis demonstrate a clear potential for direct cost savings, there are several limitations of our study to consider. First, this is a retrospective review of patient records and radiographic data, accounting only for the direct costs of instrumentation and not evaluating any potential differences in indirect or other hospital costs. Our study evaluated only direct instrumentation costs, while multiple other factors may contribute to additional operative costs including percutaneous placement of transarticular facet screws and/or the use of image guidance. Second, this study does not evaluate any objective outcome measures comparing the respective treatment procedures or provide any comparison of the effectiveness of each treatment. Furthermore, while this analysis is intended only for a direct cost evaluation, these results do not account for real-world patient selection (such as body habitus, comorbidities, and deformity correction), and interpretation of the results must account for these limitations. Despite these limitations, this type of incorporation of cost-effective instrumentation into surgical practice will no doubt continue to evolve.

Conclusions

In a theoretical analysis of direct instrumentation costs for posterior cervical subaxial fusions, we identified a significant direct instrumentation cost difference for transarticular cervical facet fixation versus lateral mass screws and rods. While subaxial facet screws may represent a suitable alternative to lateral mass fixation in carefully selected patients, further outcomes studies investigating comparative objective outcomes measures are needed. Despite the inherent limitations of this type of comparison, it seems only logical with declining reimbursements, identifying more affordable instrumentation options represents a cost-effective step toward curbing further cuts in physician fee reimbursements. Future studies that incorporate prospective design and outcome analysis in addition to cost analysis are planned.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Schmidt, Ray, Bisson. Acquisition of data: Ray, Ravindra, Jost. Analysis and interpretation of data: Ray, Ravindra, Jost. Drafting the article: Ray. Critically revising the article: Schmidt, Bisson. Reviewed submitted version of manuscript: Schmidt, Ravindra, Bisson. Approved the final version of the manuscript on behalf of all authors: Schmidt.

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