Banked fibula and the locking anterior cervical plate in anterior cervical fusions following cervical discectomy

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Eighty-eight consecutive patients underwent anterior cervical discectomy (ACD) with banked fibula fusion and internal fixation using the locking cervical plate. Pathology included cervical spondylotic radiculopathy in 48, cervical spondylotic radiculomyelopathy in 30, cervical facet dislocations with associated disc herniations in six, and autologous iliac crest graft collapse pseudoarthrosclerosis with recurrent symptoms in four patients. Operations were single-level banked fibula fusion with plating in 37, multilevel banked fibula fusion with plating in 45, and combined single-level ACD banked fibula fusion with plating and posterior fusion in six patients. The only perioperative complication was transient hoarseness. There were no transfusions, infections, neurological injuries, or deaths. The mean time in the hospital for the nontraumatic cases was 1.8 days. The mean follow up was 22 months (range 12–30 months). There has been no motion at the fused level on flexion/extension films, no kyphosis, no screw plate backout, and no banked fibula has suffered graft collapse. Following a high-speed motor vehicle accident 6 months after a multilevel fusion, one alcoholic man suffered a fractured plate with transient worsening of neck pain, and the plate has remained in place for an additional 11 months of follow-up care. Compared to 100 consecutive autologous iliac crest fusions performed by the same surgeon, there were significantly fewer graft-related complications (p < 0.001). There was a significantly greater chance of autologous iliac crest collagen with the passage of time as compared to banked fibula. Time until return to work was shorter by 5 weeks for the plate/banked fibula group (p < 0.05). When fusion is considered following ACD, the combination of banked fibula and locking cervical plates is significantly superior to autologous iliac crest grafts.

KEY WORDS • banked fibula • locking cervical plate • cervical discectomy • cervical spondylosis • cervical fusion

Anterior cervical plate and screw internal fixation following bone fusion has become increasingly popular. The Caspar technique has demonstrated outstanding results, with a fusion rate approaching 100% for more than 10 years. Posterior cortical purchase by the Caspar screw during placement is advocated and appears to carry only a theoretical risk of neurological injury when done properly under fluoroscopic guidance. Technical complications secondary to screw loosening, screw fracture, plate failure, or faulty plating do occur, and reoperation rates of 5% to 10% have been reported. A more recent development by Morscher, et al., is the cervical spine locking plate that does not require purchase on the posterior cortex and thus makes the procedure a little easier. A preliminary report strongly suggested that the locking cervical plate does lessen screw backout, plate backout, and graft extrusion (S Shapiro, et al., unpublished data).

The locking cervical plate combined with banked fibular grafting may reduce complications associated with anterior cervical fusions. Therefore, we analyzed 88 consecutive cases of anterior cervical fusion performed with...
banked fibula and locking cervical plates that have been followed for a minimum of 12 months and compared this to 100 consecutive autologous iliac crest fusions performed by the same surgeon.

**Clinical Material and Methods**

**Patient Population**

This study included 88 consecutive patients who underwent ACD and banked fibula fusion with internal fixation using the locking cervical plate between January 1991 and September 1993. The comparison group consisted of patients who underwent 100 ACD autologous iliac crest fusions performed between January 1988 and December 1990 by the same surgeon. Pathology in the banked fibula group included cervical spondylotic radiculopathy in 48, cervical spondylotic radiculomyelopathy in 30, cervical facet dislocations with associated disc herniations in six, and autologous iliac crest graft collapse pseudoarthrosis with recurrent symptoms in four patients. The pathology in the autologous iliac crest fusion group consisted of cervical spondylotic radiculopathy in 63 cases and radiculomyelopathy in 37 cases. The mean age of the patients was 52 years (range 22–76 years). The mean follow up was 22 months (range 12–30 months) for the banked fibula group and 56 months for the autologous iliac crest group. Operations were single-level banked fibula fusion with plating in 37, multilevel banked fibula fusion with plating in 45, and combined single-level ACD banked fibula fusion with plating and posterior fusions in six patients. All grafts were of Smith–Robinson type geometry. Soft cervical collars were used for 2 to 6 weeks in all ACD banked fibula locking cervical plate fusions. Rigid cervical collars were used for 6 weeks to 3 months in the iliac crest noninstrumented fusions. Diagnostic films were obtained on an outpatient basis at 6 weeks, 12 weeks, 1 year, and as indicated after 1 year.

**Results**

**Single-Level ACD Banked Fibula Fusion With Locking Cervical Plate**

This group included 24 patients with single-level cervical spondylotic radiculopathy (Table 1), nine with single-level radiculomyelopathy (Table 2), and four with ACD-iliac crest fusion who experienced graft fracture collapse (Fig. 1). There was one technical error in the single-level group. An upper screw penetrated the endplate and disc in a petite woman, and the screw was left in place because of the very small size of her vertebral bodies. There have been no ill effects from this screw placement. Of the four cases of iliac crest collapse, revision to banked fibula/locking plate fusion dramatically lessened their symptoms of neck pain and/or arm pain. Of 25 patients who were working prior to surgery, 24 returned to work at a mean time of 6 weeks from surgery (range 2–12 weeks, with 25% having returned by 2 weeks) and one did not return to work. There have been no screw-, plate-, or graft-related complications for this group. At 1 year or more of follow up there has been no motion at the fused level on flexion/extension films, no kyphosis, and no banked fibula graft suffered graft collapse.

**Multilevel ACD Fusion With AO Plates**

This group included 24 cervical spondylotic radiculopathy cases (Table 1) and 21 radiculomyelopathy cases (Table 2). There were two complications. The first complication was transient hoarseness that resolved after 3 to 4 weeks. The second complication was seen in an intoxicated man involved in a high-speed motor vehicle accident 6 months after surgery and who presented with neck pain to the emergency room. The x-ray film demonstrated a fractured plate without extrusion. The plate was left in, and at 17-month follow-up examination the patient had minimal neck pain only. Of 24 patients working prior to surgery, 19 returned to work at a mean time from surgery.
Banked fibula and cervical locking plate fusion

**TABLE 1**
Anterior cervical fusions for cervical spondylotic radiculopathy in 48 patients

<table>
<thead>
<tr>
<th>Variables &amp; Outcomes</th>
<th>Single Level</th>
<th>Multilevel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fibula/Plate</td>
<td>Iliac Crest</td>
</tr>
<tr>
<td>mean age (yrs)</td>
<td>44</td>
<td>45</td>
</tr>
<tr>
<td>mean blood loss (ccs)</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>mean hospital time (days)</td>
<td>1.6</td>
<td>4</td>
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<tr>
<td>complete relief of arm pain</td>
<td>20 (83)</td>
<td>35 (73)</td>
</tr>
<tr>
<td>partial relief of arm pain</td>
<td>3 (13)</td>
<td>11 (23)</td>
</tr>
<tr>
<td>arm pain unchanged</td>
<td>1 (4)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>arm strength remained normal</td>
<td>3 (13)</td>
<td>4 (8)</td>
</tr>
<tr>
<td>arm strength improved</td>
<td>20 (83)</td>
<td>42 (88)</td>
</tr>
<tr>
<td>arm strength unchanged</td>
<td>1 (4)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>complete relief of neck pain</td>
<td>18 (75)</td>
<td>26 (54)</td>
</tr>
<tr>
<td>partial relief of neck pain</td>
<td>5 (21)</td>
<td>19 (40)</td>
</tr>
<tr>
<td>neck pain unchanged</td>
<td>1 (4)</td>
<td>3 (6)</td>
</tr>
<tr>
<td>neck pain worse</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>graft-related complications</td>
<td>0</td>
<td>5 (10)</td>
</tr>
</tbody>
</table>

* Numbers in parentheses are percentages.

of 6.5 weeks (range 1–17 weeks), and five never returned to work. At 1 year or more of follow up there has been no motion at the fused level on flexion/extension films, no kyphosis, and no banked fibula graft suffered graft collapse.

**Single-Level Banked Fibula/Anterior Locking Plate Fusion in Combination With Posterior Cervical Spinal Fusion for Trauma**

Six cervical spine trauma patients underwent a combined anterior cervical locking plate fusion and posterior cervical instrumentation. Three suffered a flexion rotatory injury with unilateral locking of a facet combined with a significant disc herniation causing a severe incomplete cord injury. Another three suffered bilateral locked/perched facets combined with a significant disc herniation causing a severe cord injury in two. There were no operative complications or transfusions. Immediately after surgery, the four incomplete spinal cord injuries improved from a C to a D using the American Spinal Cord Injury Association impairment scale. At follow up there has been no motion at the fused level on flexion/extension films, no kyphosis, and no banked fibula graft suffered graft collapse.

**Nonplated ACD Fusions Using Autologous Iliac Crest**

The single-level autologous iliac crest fusion group included 48 patients with cervical spondylotic radiculopathy (Table 1) and 19 with myelopathy (Table 2). The mean time for return to work for these two groups was 10 weeks. The multilevel autologous iliac crest fusion group included 15 patients with cervical spondylotic radiculopathy (Table 1) and 18 with myelopathy (Table 2). The mean time for return to work for these two groups was 13 weeks. Table 3 provides a list of the graft-related complications for the 100 autologous iliac crest fusions.

**Statistical Analysis**

Banked fibula/anterior locking plate as compared to iliac crest fusion significantly lessened graft-related complications after ACD fusion (p < 0.001). There was a significantly greater chance of iliac crest grafts losing height over the passage of time as compared to banked fibula (p < 0.05). The banked fibula locking plate fusion significantly shortened both the hospital time, by 2 to 3 days (p < 0.05), and the time until return to work, by 5 weeks (p < 0.05). There was no difference in neurological outcome when comparing autologous iliac crest fusion to banked fibula/locking plate fusion. Analyses were by the chi-square test.

**Discussion**

This report does not attempt to address the controversy of fusion versus no fusion following ACD. Gross instability or kyphosis is rare after ACD and osteophytectomy alone. The theory behind graft placement after ACD is to maintain or improve interspace height and to achieve arthrodesis, thus eliminating pathological motion that can lead to osteophyte formation. An ideal graft con-

**TABLE 2**
Anterior cervical fusions for cervical spondylotic radiculomyelopathy in 30 patients

<table>
<thead>
<tr>
<th>Variables &amp; Outcomes</th>
<th>Single Level</th>
<th>Multilevel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fibula/Plate</td>
<td>Iliac Crest</td>
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<tr>
<td>mean age (yrs)</td>
<td>55</td>
<td>55</td>
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<tr>
<td>mean blood loss (ccs)</td>
<td>100</td>
<td>300</td>
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<td>mean hospital time (days)</td>
<td>1.8</td>
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<td>arm strength remained normal</td>
<td>1 (11)</td>
<td>2 (10)</td>
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<td>arm strength improved</td>
<td>8 (89)</td>
<td>13 (68)</td>
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<tr>
<td>arm strength unchanged</td>
<td>0</td>
<td>3 (16)</td>
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<tr>
<td>arm strength worse</td>
<td>0</td>
<td>1 (6)</td>
</tr>
<tr>
<td>gait remained normal</td>
<td>0</td>
<td>3 (16)</td>
</tr>
<tr>
<td>gait improved at least one</td>
<td>8 (89)</td>
<td>14 (74)</td>
</tr>
<tr>
<td>Nurick grade†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gait unchanged</td>
<td>1 (11)</td>
<td>2 (10)</td>
</tr>
<tr>
<td>graft-related complications</td>
<td>0</td>
<td>3 (16)</td>
</tr>
</tbody>
</table>

* Numbers in parentheses are percentages.
† Measured according to the Nurick scale. (Nurick S: The pathogenesis of the spinal cord disorder associated with cervical spondylosis. Brain 95:87–100, 1972.)

**TABLE 3**
Graft-related complications for autologous iliac crest fusions

periooperative (30-day) complications: nine of 100
four graft extrusions reoperated
three iliac crest donor site wound infections with chronic pain
two transfusions
delayed complications: six of 100
one painful pseudoarthrosis
one delayed graft osteomyelitis
two delayed graft fracture collapses with angulation reoperated
two >50% loss of graft height with chronic neck pain, refused surgery
struct according to the above theory will always fuse without collapse and with the fewest attendant complications.

**Autologous Iliac Crest Versus Cadaveric Iliac Crest**

The autograft versus allograft comparison must be specific and not generalized. Brown, et al., reported a 28% rate of collapse with cadaveric freeze-dried iliac crest as compared to 14% for autologous iliac crest. The extrusion rate in that study was 13% for cadaveric as compared to 4% for autologous iliac crest. Other reports have documented this as well (R Bishop, et al., unpublished data and S Shapiro, et al., unpublished data). Thus cadaveric freeze-dried iliac crest graft is inferior to autologous iliac crest for fusion following ACD.

**Autologous Iliac Crest Versus Cadaveric Fibula**

Hanley, et al., reported that cadaveric freeze-dried fibula does not collapse like iliac crest. We saw no patient with collapse of the graft. Reports of series using cadaveric fibula for spinal fusions have documented a reduction in operative time by 35 minutes on average and a reduction in blood loss of 330 ml. These same reports also documented a reduction in hospitalization time by 50% (from 4.7 to 2.3 days; p < 0.05). The harvesting of iliac crest is the dominant source of blood loss during an ACD fusion. The use of banked fibula eliminated any risk of transfusion in our experience. Hospitalization for the banked fibula group was short, with 27% home by 24 hours and 90% home by 48 hours.

Donor site complications do occur after autologous iliac crest grafting. Gore, et al., reported a 13% donor site complication rate in anterior cervical fusions with autologous iliac crest. A 1% incidence of donor site complications was reported by Espersen, et al. There is very little literature addressing chronic pain at the donor site, but it does occur as our experience testifies. Cadaveric fibula eliminates donor site complications. However, any allograft introduces the potential for donor to recipient transfer of infectious diseases, especially the human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome. To date, four bone or soft-tissue allograft recipients have been reported to have acquired HIV infection from two donors. A recent report estimated that the risk of obtaining an allograft from an unrecognized HIV-infected donor was approximately one in 1.6 million. Guidelines and regulations concerning bone and soft-tissue allografts under the auspices of the United States Food and Drug Administration should keep the risk near zero.

Determination of fusion versus true anatomical pseudoarthrosis may be difficult despite information from many radiological studies. In addition, there can be an asymptomatic pseudoarthrosis and a symptomatic fusion postoperatively. Reported fusion rates for cadaveric fibula alone range from 80% to 100%, and no significant difference as compared to autologous iliac crest was seen in those reports. Cadaveric freeze-dried fibula locking cervical plate fusion has achieved 100% arthrodesis with no graft extrusion, abnormal motion on flexion or extension films at 1 year, or beyond that, kyphosis or recurrence of radiculopathy in any patient. Initially outlined for long bone fractures, the principles of absolute immobilization plus compression of bone surfaces result in faster bone healing and have been applied successfully to cervical trauma and cervical spondylosis using anterior plate stabilization. There are some animal studies that suggest that the addition of an anterior plate does not increase the union rate. Or purpose for placing the plate was not to increase the rate of bone growth but rather to keep the banked fibula in place so that it can be incorporated over the duration of the patient’s life.

**Locking Cervical Plate**

Anterior cervical plating does not increase the risk of infection. The locking cervical plate avoids posterior cortical penetration, which is desirable in light of a recent report suggesting that posterior cortical penetration does not improve the pull-out strength of Caspar screws in an isolated vertebral body model. We have seen no plate/screw/graft extrusions with the locking anterior cervical plate in ACD banked fibula fusions, which is less than the reported rates with the Caspar system, suggesting that the locking system may help reduce plate/screw/graft extrusion. Cervical internal fixation avoided prolonged external immobilization and allowed earlier return to work. If there is a significant pseudoarthrosis rate despite no motion on flexion/extension, then delayed plate failure could occur in this series.

The plate combined with a banked fibula graft may add to the initial cost of the operation. Only through a critical analysis of surgical cost, hospital cost, complications cost, and the cost of lost wages can an accurate assessment of overall cost/benefit be determined. This should be possible to determine in the near future for this operation.

**Conclusions**

The early results of using banked fibula with the locking cervical plate appear to be in better accordance with the theory behind anterior cervical fusion than autologous iliac crest. We do not advocate this approach for general use. Only with long-term determination of instrumentation–graft construct complication rate can any meaningful statement be made with reference to the use of locking plates in cervical disc disease.

**References**


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*J. Neurosurg.* / Volume 84 / February, 1996
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