A review of the utility of obtaining repeated postoperative radiographs following single-level anterior cervical decompression, fusion, and plate placement

Case report

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Object. Pseudarthrosis and construct failure following single-level anterior cervical discectomy, fusion, and plate placement (ACDFP) rarely occur. Routine postoperative anteroposterior and lateral radiographs may be an inconvenience to patients and expose them to additional and potentially unnecessary radiation. No standard exists to define when patients should obtain radiographs following an ACDFP. The authors hypothesize that routinely obtaining static anteroposterior and lateral radiographs in patients who recently underwent a single-level ACDFP without new axial neck pain or other neurological complaints or symptoms is unwarranted and does not alter the long-term treatment of the patient.

Methods. The authors retrospectively reviewed the charts and radiographs of patients who underwent a single-level ACDFP between January 1, 2000, and December 31, 2005. All patients underwent a single-level ACDFP and had routine cervical radiographs obtained at various intervals after surgery.

Results. Twenty-one patients underwent ACDFP at C5–6, 14 patients underwent surgery at C6–7, 11 patients at C4–5, and 7 patients at C3–4. None of the intraoperative radiographs demonstrated malposition of the graft or instrumentation. Based on subjective reporting by the patients, the vast majority (49 of 53) showed improvement in neck and arm pain, and/or neurological dysfunction following surgery. Overall, 5 patients (9%) demonstrated abnormalities on their postoperative radiographs. No patients were returned to the operating room as a result of postoperative radiographic findings. The sensitivity of plain radiographs in this patient series or the percentage of patients with new symptoms that had an abnormality related to the construct on plain radiography was 50%. The specificity of plain radiographs or the percentage of patients who were asymptomatic and had normal radiographs was 94%. The positive predictive value was 25%; that is, there was a 25% chance that patients with symptoms would have a construct abnormality on postoperative radiographs. The negative predictive value was 98%; that is, 98% of patients without symptoms will have normal radiographs.

Conclusions. Pseudarthrosis and construct failure following single-level ACDFP occur rarely, and patients with new symptoms following surgery are as likely to have normal radiographic findings as they are to have abnormalities identified on their postoperative plain radiographs. Routinely obtaining postoperative radiographs at regular intervals in asymptomatic patients following single-level ACDFP does not appear to be warranted.

Key Words: anterior cervical discectomy • decompression • fusion • plate placement • radiographs

Abbreviations used in this paper: ACDFP = anterior cervical discectomy fusion and plate placement; AP = anteroposterior.
graphs at every routine follow-up visit, even if the patient is asymptomatic and it is too early to evaluate fusion status. Moreover, static AP and lateral radiographs are a poor statistical predictor when determining whether a patient has achieved fusion or whether a patient has a pseudarthrosis. However, the sensitivity of radiography in evaluating fusion may be increased with the addition of flexion/extension radiographs. The authors hypothesize that routinely obtaining static AP and lateral radiographs in patients who recently underwent a single-level ACDFP without new axial neck pain or other neurological complaints or symptoms is unwarranted and does not alter the long-term treatment of the patient.

**Methods**

We retrospectively reviewed the charts and radiographs of patients who underwent a single-level ACDFP between January 1, 2000, and December 31, 2005. Patient inclusion criteria included: 1) undergoing a single-level procedure between C-3 and C-7 with use of an allograft and a ventral semiconstrained cervical plate and 2) having ≥ 6 months of follow-up data. Exclusion criteria included multilevel procedures, use of an autograft, prior spine surgery, history of smoking, or history of chronic neurological disease such as multiple sclerosis. The medical charts as well as hospital and office notes of the patients were reviewed. Data recorded included sex, age, preoperative complaints, levels undergoing operations, frequency of follow-up, and postoperative complaints.

At each time point, it was noted if the patient had plain radiographs obtained and if there were any new complaints. Radiographs were reviewed and abnormalities were documented. We also recorded whether or not the patient underwent any therapeutic intervention based on the results of his or her plain radiographs. In the series presented, the patients had multiple postoperative radiographs to evaluate fusion status and, in some cases, to document the integrity of the construct. In those patients with new symptoms following the index surgery, the radiographs were additionally used to evaluate the status of adjacent spinal levels.

The statistical sensitivity and specificity of the obtained radiographs were calculated as well as the positive and negative predictive values of the variables recorded.

**Results**

A total of 53 patients (28 males and 25 females) was identified. The study population had a mean age of 57.7 years (range 22–89 years). All procedures were performed by 2 surgeons (I.H.K. and T.E.M.) at the same institution. Twenty-one patients underwent anterior cervical discectomy at C5–6, 14 patients underwent surgery at C6–7, 11 patients at C4–5, and 7 patients at C3–4.

The patients in this study had postinstrumentsation radiographs obtained intraoperatively and at various time points following surgery. None of the intraoperative radiographs demonstrated malposition of the graft or instrumentation. Fifty patients underwent radiography at 6 weeks, 17 at 3 months, 7 at 6 months, and 36 at 1 year following surgery (Table 1). Based on subjective reporting by the patients, the vast majority (49 of 53) showed improvement in neck and arm pain and/or neurological dysfunction, following surgery.

**Pseudarthrosis**

Two patients in this study demonstrated radiographic evidence of nonunion (a 96% fusion rate). One patient who had undergone a C5–6 ACDFP for left C-6 radiculopathy had radiographic evidence of pseudarthrosis at the surgical level 12 months following surgery (Fig. 1). She had no symptoms and no intervention was taken. A second patient developed new onset of left-hand numbness 3 years after the initial operation. The patient originally underwent a C6–7 ACDFP for left C7 radiculopathy. Anteroposterior and lateral radiographs were interpreted as possibly showing evidence of a nonunion. No further imaging was requested for the patient. The symptoms subsided with physical therapy and an oral steroid taper.

**New Onset Symptoms**

Three patients developed new symptoms. One patient developed worsening lower extremity weakness 11 weeks after her index surgery, which was a C3–4 ACDFP for myelopathy. Cervical AP and lateral radiographs obtained at the time of neurological decline demonstrated a solid construct and good graft placement. The patient underwent a CT myelogram of her cervical spine, which showed continued mild stenosis at the C3–4 level and no evidence of stenosis elsewhere. She was referred to physical therapy. Some improvement was noted in her lower extremity function at 12 months following surgery.

A second patient developed new neck and right-arm pain 5 years after surgery. Cervical AP and lateral radiographs revealed solid fusion of C5–6 and good plate placement (Fig. 2). A CT myelogram was obtained, which demonstrated fusion at C5–6 and spondylitic changes at C6–7 with moderate right-sided C6–7 foraminal stenosis. He was referred to pain management, and 4 months later his symptoms resolved.

The last patient, who underwent a C3–4 ACDFP for myelopathy, had complete relief of symptoms for 5 months, but her gait dysfunction returned. Plain radiographs demonstrated incorporation of the graft at C3–4 and a solid construct. Physical therapy was prescribed. The patient’s symptoms stabilized and she demonstrated mild improvement at her 12-month follow-up.

**TABLE 1**

Summary of follow-up results according to postoperative time points*

<table>
<thead>
<tr>
<th>Follow-Up Variable</th>
<th>6 Wks</th>
<th>3 Mos</th>
<th>6 Mos</th>
<th>12 Mos</th>
<th>&gt;12 Mos</th>
</tr>
</thead>
<tbody>
<tr>
<td>radiographs obtained</td>
<td>50</td>
<td>17</td>
<td>7</td>
<td>36</td>
<td>3</td>
</tr>
<tr>
<td>pseudarthrosis cases</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>new onset symptoms</td>
<td>0</td>
<td>1</td>
<td>1 (af-</td>
<td>1 (af-</td>
<td>1</td>
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<tr>
<td>term 5)</td>
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</table>

* All numbers represent numbers of patients.
Overall, 5 patients (9%) demonstrated abnormalities on their postoperative radiographs. However, 2 of these patients had already demonstrated a fusion and were 3 and 5 years, respectively, past their index operation when new symptoms developed. Therefore, only 2 patients (3.7%) demonstrated radiographic abnormalities (including pseudarthrosis) during the 1st year after surgery. One patient with new complaints was found to have an abnormality on her routine postoperative radiographs, which was a pseudarthrosis. No patient was returned to the operating room as a result of postoperative radiographic findings. Only conservative management was prescribed. Thus, the plain radiographs did not appear to influence the operative therapeutic plan.

The sensitivity of plain radiographs in our series, or the percentage of patients with new symptoms that would show an abnormality related to the construct on plain radiography, was 50%. The specificity of plain radiographs, or the percentage of patients who were asymptomatic and had normal radiographs, was 94%. The positive predictive value of repeated postoperative radiographs in this study was 25%; that is, there was a 25% chance that patients with symptoms would have a construct abnormality on radiographs. The negative predictive value of repeated postoperative radiographs in this study was 98%; that is, 98% of patients without symptoms had normal radiographs. If the 2 patients who showed new symptoms > 1 year after the operation are excluded, the sensitivity decreases to 0%, the specificity becomes 96%, the positive predictive value becomes 0%, and the negative predictive value becomes 98%.

**Discussion**

Numerous factors contribute to the increasing cost of health care. Some of these factors include the increased cost of implants and obtaining excessive imaging studies by physicians. Routine tests may substantially increase the expense associated with these procedures. Examples include routinely obtaining an echocardiogram and extensive blood tests as part of the preoperative workup of a young fit person who has no medical comorbidities and is < 50 years of age. Obtaining static AP and lateral radiographs has also become routine following anterior cervical surgery. No
standard exists for when these images should be obtained, but it is common practice to obtain them at every follow-up visit. Surgeons often use these images to evaluate hardware integrity, graft placement, and fusion status.

Graft dislodgment and bone graft failure have been reported to occur following anterior cervical fusions, but rarely following single-level ACDFP. Moreover, relevant construct failure as described above is rarely asymptomatic. Patients usually complain of increasing cervical pain, swallowing difficulties, and/or new neurological symptoms. Minor screw dislocation or plate migration may go completely unnoticed by the patient and is rarely managed surgically. In this patient series, no cases of clinically significant construct failure were demonstrated. Four patients developed new complaints in the follow-up period, and when their plain radiographs were reviewed, the radiographs of 3 of the patients demonstrated a stable construct and 1 patient had evidence of a pseudarthrosis. The symptoms developed by the fourth patient were not believed to be associated with a nonunion and further surgery was not recommended. These results are consistent with those in the current literature that support the observation that construct failure is rare after single-level ACDFP. In the investigational device exemption study of a commercially available cervical disc arthroplasty, 265 patients were enrolled in the control arm, which consisted of single-level anterior cervical decompression with allograft and plate fixation. In this series, 8 patients underwent 9 additional procedures following the index ACDFP. Seven procedures (2.6%) were for symptomatic nonunion, 5 (1.9%) were for graft fracture, and 3 (1.1%) for construct migration. These data from a large cohort of patients demonstrate that these adverse events following single-level ACDFP are indeed rare. It is unknown how many of these patients were symptomatic with regard to their radiographic abnormalities.

Pseudarthrosis is a known complication following ACDFP. The incidence of pseudarthrosis varies in the literature, but it was reported to be 2.3% in symptomatic cases in the series presented by Mummaneni and colleagues. The determination of nonunion is somewhat hindered by interpretation of radiographic images. These images are reviewed in the office on routine follow-up visits to determine fusion status, but there are known and accepted limitations of plain radiographs in determining this status. There is often an overestimation of fusion when plain radiographs are compared with CT scans. For determining fusion following ACDFP, it may be more useful to obtain a CT scan at 12 months after surgery, rather than plain radiographs. It should be noted, however, that CT scanning exposes the patient to a larger dose of radiation as compared with radiography and there is an associated increase in cost. Flexion/extension radiographs may also be useful when assessing the fusion status of the operated level.

As discussed previously, construct failure following single-level ACDFP is rare but when it does occur, patients are usually symptomatic. This is also true for pseudarthrosis following single-level ACDFP with the use of an allograft. Standard AP and lateral radiographs have a somewhat poor predictive value in the determination of fusion status, and CT scans are more reliable in this regard. It appears that the added value of routine radiographic imaging in the asymptomatic patient following single-level ACDFP is minimal. The cost of these radiographs varies depending on the institution. At our institution, the cost of a cross-table lateral radiograph, including professional fees, is ~$770. Over a 12-month period, this cost may total $3080.
Radiographs after single-level anterior cervical decompression

We propose that these extensive postoperative radiographs may be unnecessary and that the overall cost of these procedures can be reduced without compromising patient care. The authors have proposed a simple algorithm for the use of imaging following single-level ACDFP (Fig. 3).

There are situations in which radiographs are appropriate in asymptomatic patients. These situations are often special circumstances. A full list is beyond the scope of this paper. One example would include an athlete’s return to competition; in these patients, a solid construct is required and should be documented. Patients in certain jobs may also require the same imaging. In these patients, even when they are asymptomatic, radiographs are extremely useful.

This study is limited by its small sample size and retrospective nature. Perhaps with a larger study cohort, more abnormalities may have been identified and this might have made the rationale for postoperative radiographs more apparent. Moreover, these data represent the practices of a single institution. The practices of many institutions and surgeons would also strengthen the conclusions of the paper. The results cannot be applied to multilevel ACDFP because nonunions and construct failure may be more common with these procedures. Routine postoperative radiographs may be more valuable in this patient population.

Conclusions

Pseudarthrosis and construct failure following single-level ACDFP occur rarely, and patients with new symptoms following surgery are as likely to have normal radiographic findings as they are to have abnormalities identified on their postoperative plain radiographs. Routinely obtaining postoperative radiographs at regular intervals in asymptomatic patients following single-level ACDFP does not appear to be warranted. Fusion status is often difficult to determine with static radiographs, but the addition of flexion/extension films may aid in the determination of this status. Computed tomography scanning, even with an increased cost and radiation exposure to the patient, may be needed in those indeterminate cases.

References


Accepted May 6, 2008.
Sources of support: none reported.
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