ANTERIOR cervical discectomy and fusion is an efficacious procedure used to treat a variety of cervical spinal disorders, including spondylosis, myelopathy, herniated discs, trauma, and degenerative disc disease. Pseudarthrosis, or failure of fusion, may be the most common complication of spinal fusion procedures. The incidence of pseudarthrosis following anterior cervical fusion increases with the number of levels fused. It is important to note that although the full clinical implications of pseudarthrosis are somewhat controversial, its significant role in postoperative morbidity is well documented.

Various surgical procedures have been proposed for the revision of symptomatic pseudarthrosis following anterior cervical fusion. Whether the anterior or the posterior approach is more efficacious remains undecided. Although there has been no prospective, randomized series to evaluate this issue, several studies have advocated posterior repair using spinous process wiring with or without autogenous onlay grafts.

We report a series of 19 consecutive patients with symptomatic pseudarthrosis following anterior cervical fusion who were treated with anterior revision surgery using allograft interbody fusion and plating.
Clinical Material and Methods

Inclusion Criteria

We conducted a detailed review of the medical records of 19 consecutive patients undergoing anterior revision of anterior cervical pseudarthrosis with allograft interbody fusion and plating during a 3-year period between January 1992 and January 1995 at North Carolina Baptist Hospital/Bowman Gray School of Medicine. The diagnosis of pseudarthrosis was based on both clinical and radiographic criteria. The clinical criteria included intractable neck pain with or without recurrence of radicular symptoms. Radiographically, pseudarthrosis was diagnosed if dynamic radiographs revealed gross instability at the previous fusion site. In the absence of frank instability, pseudarthrosis was diagnosed if plain radiographs failed to show obliteration of the disc space by bone trabeculation and graft remodeling, and if single-photon emission computerized tomography (SPECT) revealed focal uptake or if there was evidence of instrument failure.

Patient Population

The 10 women and nine men studied ranged in age from 25 to 72 years (mean age 49.1 years). Nine (47.4%) were smokers. Six (31.6%) had applied for workers’ compensation or were involved in litigation. All had complained of intractable neck pain and a recurrence of the radicular symptoms that they had experienced prior to their latest fusion. Radiculopathy was defined as pain, paresthesia, or muscle weakness in a pattern corresponding to a nerve root distribution. Two patients also showed signs of myelopathy on physical examination.

All 19 patients had previously undergone anterior discectomy via the Smith–Robinson procedure. Previously, arthrodesis had been attempted with banked allograft bone in nine patients and with autogenous iliac crest grafts in six patients. The remaining four patients had undergone disc excision without grafting.

The initial evaluation consisted of a medical history and physical examination as well as plain radiographs, including cervical flexion and extension studies. If patients did not improve with vigorous nonsurgical therapy, they were further evaluated with magnetic resonance imaging or CT myelography. Additionally, eight patients were evaluated with SPECT.

Pseudarthrosis was revised at a single level in 11 patients, at two levels in six patients, and at three levels in two patients. The average interval from initial anterior cervical fusion to pseudarthrosis revision was 20 months (range 3–48 months). The most commonly involved level was C5–6 (12 cases) followed by C4–5 (eight cases) and C6–7 (seven cases). The graft material consisted of cadaveric iliac crest allograft. The anterior plating systems used were the Cervical Spine Locking Plate (10 patients) and the Trapezial Osteosynthetic Plate (nine patients).

Postoperative follow-up review consisted of obtaining medical history and physical evaluation as well as lateral flexion–extension radiographs. The final clinical evaluation was performed by a physician other than the primary surgeon.

The clinical outcomes were graded for functional and economic status using a modification of the scale developed by Prolo, et al. (Table 1). The sum of these responses for each patient can range from 10 (a perfect result) to 2 (an incapacitated state). For our purposes, these summations of clinical results were categorized as excellent (9–10), good (7–8), fair (5–6), and poor (2–4).

Final radiographs were evaluated by an independent radiologist using the following criteria (adapted from Brown, et al.) to document fusion: 1) obliteration of the disc space by bone trabeculae; 2) dissolution of the endplates of involved vertebral bodies; and 3) evidence of graft remodeling.

Surgical Technique

The existing anterior scar was resected and the failed fusion was approached via the previous incision by dissection in a plane medial to the carotid sheath and lateral to the esophagus. The location of the failed fusion was confirmed with intraoperative fluoroscopy. Distraction pins were placed in the vertebral bodies superior and inferior to the pseudarthrosis. Residual graft, scar, and fibrous tissues were excised using curettes and a high-speed drill. The interbody graft was fashioned from cadaveric iliac crest allograft and impacted into the interspace. An anterior or cervical plate (uni- or bicortical) was positioned so that it spanned the level(s) where the new graft(s) was placed. Intraoperative fluoroscopy was used to assure optimum plate/screw placement. The patient was asked to wear a Philadelphia cervical collar for 1 month postoperatively.

Results

One patient with preexisting coronary artery disease died from myocardial infarction 4 months after surgical revision. His fusion had appeared solid 1 month before his death. Solid osseous fusion was achieved in the remaining 18 patients over all 28 levels (Table 2). The mean follow-up interval was 22.4 months (range 12–42 months).
Anterior cervical pseudarthrosis

The summed economic and functional scores stratified the clinical results as follows: excellent and good, six and nine patients, respectively (83.3%); fair and poor, two and one patients, respectively (16.7%).

There were no intraoperative complications. Postoperatively, two patients (10.5%) experienced transient hoarseness, which was secondary in one to a superficial hematoma; both cases had resolved by 1 month postsurgery. No patient required repeat operation or blood transfusion. The average hospital stay was 3.3 days (range 2–6 days).

Discussion

As is the case in the surgical management of uncomplicated cervical spondylitic disease,16,22,25 the optimum approach for surgical revision of cervical pseudarthrosis remains controversial. There have been no prospective randomized studies that have directly evaluated anterior versus posterior techniques and both approaches have their proponents. Fuji, et al.20 reported a series of nine patients with anterior cervical pseudarthroses revised with interspinous wiring without bone grafting. These authors recommended this revision for nonunion 6 to 12 months after anterior surgery and a similar approach including bone grafting for nonunion after 12 months, but they reported a nonunion rate of 22%. Farey, et al.,13 retrospectively analyzed 19 consecutive patients with symptomatic anterior pseudarthrosis treated with posterior decompression, interspinous wire stabilization, and autogenous arthrodesis and found that solid fusion occurred in all patients, but bone graft donor site morbidity was present in 15%. Brodsky, et al.5 retrospectively compared anterior versus posterior repair of anterior pseudarthrosis in 34 patients. Successful fusion was accomplished in 76% of patients treated with anterior repair using autografts without plating and in 94% of patients who had a posterior repair with interspinous wiring and onlay autograft fusion. The issue of complications was not addressed in that study. Lowery and associates39 retrospectively compared three methods of anterior cervical pseudarthrosis revision. These authors reported a 94% fusion rate in 17 patients treated with posterior revisions and only a 45% fusion rate in 20 patients who underwent anterior revisions using anterior plating. This series of patients was nonrandomized and the anterior approach was used primarily following a previously failed attempt at fusion with anterior instrumentation. In our series of 19 patients, only one had previously received anterior instrumentation. Additionally, Lowery, et al., reported a high incidence (45%) of hardware failure following their anterior fixation procedure. It is possible that the dismal fusion rate reported by these authors following anterior revision and plating was due, at least in part, to selection bias.

The posterior approach has been advocated as better than anterior revision surgery, because visceral and vascular structures may be placed at increased risk with the anterior procedure because of scarring of the anterior fascial planes.8,29 However, in our series there were no instances of carotid artery or esophageal injury, and complications were limited to transient hoarseness.

Various materials have been used for the interbody graft in anterior cervical fusions. The most commonly used grafts are autogenous iliac crest and varied cadaveric allografts.15 The use of allograft bone eliminates donor site morbidity and decreases operating time, blood loss, and patient discomfort. Various authors have reported donor site complication rates as high as 29% with the use of autogenous grafts.22–27 These complications consist primarily of hematoma/seroma, superficial or deep infection, and chronic pain, but more serious donor site complications have been reported, including vascular compromise, osteomyelitis, fracture of the ilium, bowel perforation, and thigh pain.2,27

The literature is somewhat ambiguous when comparing the clinical results for allografts and autografts in spinal fusions. Some authors report significantly superior results when using autografts, whereas others report equal efficacy with both materials.1,3,11,12,13,24,32,33,38 Brown and colleagues reviewed serial radiographs following anterior cervical fusion over 139 levels in 98 patients and found arthrodesis rates of 97% with autograft and 94% with allograft. Cloward10 reported the results of 187 allografts used in 58 lumbar and cervical fusions and found outcomes comparable to those seen when autografts were used. Rish, et al.,24 found no significant difference in radiographic appearance or clinical response between allo- and autograft materials in 124 anterior cervical fusions. Using fibular allografts, Segal and Harway46 reported a 100% success rate in 25 consecutive patients treated with single-level anterior cervical fusion, and Grossman and colleagues23 reported 92% fusion in 42 patients over 83 segments. Recently, Savolainen and associates38 reviewed a series of 250 patients and found 98% fusion rates in both auto- and allograft without significant differences in clinical outcome. They also reported a 16% donor site complication rate in the autograft group.

Zdeblick and Ducker50 compared allograft to autograft in a consecutive series of 87 patients treated with anterior cervical fusions and reported a significantly higher rate of pseudarthrosis in the allograft group (22% vs. 8%), although the clinical results were similar in both groups. Fernyhough and associates18 reviewed 126 consecutive multilevel cervical discectomy and vertebrectomy fusions using allo- and autograft. Although the pseudarthrosis rate was high in both groups, autografts proved more efficacious, with a nonunion rate of 27% compared to 41% for allografts. Recently, Bishop, et al.,3 prospectively compared autografts to allografts in 132 patients undergoing anterior cervical interbody fusion. These authors found higher fusion rates for autografts versus allografts in both single (97% vs. 87%) and multiple (100% vs. 89%) levels, but also reported a 10% donor site complication rate.

The onlay nature of the posterior fusion necessitates autologous bone grafting and its concomitant donor site morbidity. However, posterior wire stabilization with onlay grafting has also been reported to result in consistently higher fusion rates when compared with historical anterior procedures.5,18 This higher rate of arthrodesis is due, at least in part, to the stabilizing effect of the interspinous wiring. In the present study, additional segmental stability was achieved using anterior plating, and all patients demonstrated solid osseous fusion over all levels with the use of allograft interbody fusion. Fifteen patients (83%)
had either excellent or good clinical results. All three of the remaining patients were involved in compensable injury claims. This latter group of patients may have also suffered concomitant soft-tissue damage at the time of their initial injury. This type of complicating injury would have made these patients poor candidates for their initial discectomy, thereby contributing to their less than satisfactory clinical result despite a solid osseous fusion following revision.

Despite its prevalence and documented clinical relevance, pseudarthrosis has received comparatively little direct study. This paucity of empirical investigation is due in part to the inadequacies of currently available diagnostic imaging. Traditionally, the diagnosis of pseudarthrosis has been based on the clinical triad of pain, radiographic evidence of instability, and loss of correction or fixation. A study by Brodsky and associates in 1991 underscored the inherent difficulties in evaluating pseudarthrosis. This group explored and evaluated radiological findings in 175 patients who had undergone lumbar spinal fusion, and the investigators clearly demonstrated the inaccuracy of current radiological assessment methods (plain radiographs, polytomography, bending films, and CT scans) in the diagnosis of spinal fusion. Our patients with recurrent symptoms following anterior cervical fusion were initially evaluated with plain cervical radiographs, including flexion–extension views, and, in some circumstances, with cervical CT or magnetic resonance imaging. If gross instability was noted, the patient was considered a surgical candidate. However, if these studies were not conclusive for a nonunion, the patient was further evaluated with SPECT, a radionuclide technique using a tomographic camera to remove three-dimensional superimposition. The SPECT technique provides both improved image contrast and more complete spatial information in the detection of focal uptake compared to conventional bone scans. Pseudarthrosis appears as a focal area of increased radionuclide uptake within a fusion mass (Fig. 1). All eight patients in the present study who were evaluated with SPECT scanning demonstrated such increased focal uptake, and the diagnosis of pseudarthrosis was subsequently confirmed intraoperatively in all eight (Fig. 2).

To date, although various imaging techniques have been used as potential diagnostic tools in the detection of pseudarthrosis, none has proven to be consistently reliable. The expense and morbidity rate associated with surgical exploration of spinal fusions necessitate the development of more accurate noninvasive diagnostic methods. The SPECT technique has the potential to confirm the diagnosis of pseudarthrosis reliably, but its implementation as a screening tool is currently limited by a paucity of information documenting the natural history of arthrodesis on SPECT images following surgical fusion. We are currently initiating a longitudinal study to document the progression of SPECT imaging following anterior cervical discectomy and fusion.
Anterior cervical pseudarthrosis

There is no empirical evidence to support the dogmatic endorsement of either the anterior or the posterior approach as being more advantageous in the revision of anterior cervical pseudarthrosis. Each approach can be performed with good efficacy and low rates of morbidity, and any claim of superiority would have to be supported by a prospective, randomized study.

Conclusions

Anterior revision of failed cervical fusions using allograft interbody fusion material and anterior plating appears to be a safe and efficacious procedure. The anterior approach avoids a second incision and can allow anterior decompensation in patients with radiculopathy or myelopathy without increased risk to visceral and neural structures. Our use of allograft bone avoided donor site morbidity without adversely affecting fusion rates in this small series in which internal fixation was always used. The use of anterior plating assured rigid internal fixation without increasing surgical complications.

References

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