

Lumbar pedicle screw pseudoarthrosis salvage technique with moldable, bioabsorbable, calcium phosphate–based putty: illustrative case

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BACKGROUND Pseudoarthrosis is a complication of spinal fixation. Risk factors include infection, larger constructs, significant medical comorbidities, and diabetes. The authors present a case report of dilated pedicle screw pseudoarthrosis salvaged with moldable, settable calcium phosphate–based putty.

OBSERVATIONS The patient presented with back pain and radiculopathy in the setting of poorly controlled diabetes. He was taken to the operating room for laminectomy and fusion complicated by postoperative infection requiring incision and drainage. He returned to the clinic 6 months later with pseudoarthrosis of the L4 screws and adjacent segment degeneration. He was taken for revision with extension of fusion. The L4 tracts were significantly dilated. A moldable, bioabsorbable polymer-based putty containing calcium phosphate was used to augment the dilated tract after decortication back to bleeding bone, allowing good purchase of screws. The patient did well postoperatively.

LESSONS There are several salvage options for clinically significant pseudoarthrosis after spinal fixation, including anterior or lateral constructs, extension, and revision of fusion. The authors were able to obtain good screw purchase with dilated screw tracts after addition of moldable, bioabsorbable polymer-based putty containing calcium phosphate. It appears that this may represent an effective salvage strategy for dilated pseudoarthropathy in select settings to support extension of fusion.

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KEYWORDS spine surgery; spinal fusion; spine instrumentation; spine pseudoarthrosis; pseudoarthrosis salvage

Pseudoarthrosis is a potential complication of pedicle screw fixation of the spine.^{1,2} Rates of pseudoarthrosis increase with certain factors, including smoking, diabetes, and infection.^{2–5} Postoperative infection is a potential complication of any surgery, especially those that include the implantation of hardware.^{5,6} Risk factors that increase the likelihood of postoperative infection include diabetes, chronic opioid use, prolonged length of stay, and chronic medical illness.^{6,7}

Salvage strategies for significant pseudoarthrosis include revision with extension of fusion, anterior or lateral interbody fusions,^{8–12} or even the implantation of custom, oversized screws if the eroded screw tracts are significantly larger than available screws.⁶ We present a case of postoperative infection and subsequent widely dilated pseudoarthrosis with adjacent segment degeneration. Montage, a moldable, settable (hardening), calcium phosphate (CaP)–based (hydroxyapatite [HA] and β -tricalcium

phosphate [β -TCP]) bone putty was used to support screw purchase as an additional salvage technique, allowing good purchase of 10.5-mm screws in screw tracts that were dilated to over 13 mm.

Illustrative Case

A 52-year-old male presented with severe back pain with right greater than left radiculopathy in the setting of poorly controlled diabetes because of recently finishing a course of steroids for coronavirus disease (COVID-19) pneumonia (hemoglobin [Hgb] A1C 8.4%, glucose levels regularly in the high 200s–300s [mg/dL] during his admission). Magnetic resonance imaging showed degenerative disc disease and facet arthropathy, worse on the right and worse at L4–5 and L5–S1, with moderate canal stenosis and bilateral right greater than left compression of the exiting S1 nerve root (Fig. 1).

ABBREVIATIONS β -TCP = β -tricalcium phosphate; CaP = calcium phosphate; CT = computed tomography; HA = hydroxyapatite; Hgb = hemoglobin; TLIF = transforaminal lumbar interbody fusion.

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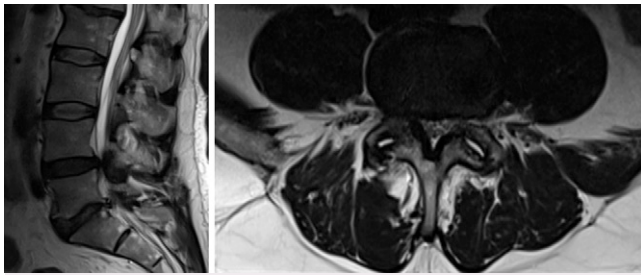


FIG. 1. Presenting sagittal (left) and axial (right) T2-weighted magnetic resonance imaging sequences at the level of L4–5.

Because of his poorly controlled diabetes, conservative management with outpatient follow-up was planned, but the patient returned to the clinic 14 days later with worsening symptoms and was taken to the operating room for L4 to S1 laminectomies, bilateral foraminotomies, and an L5–S1 transforaminal lumbar interbody fusion (TLIF), with L4–S1 pedicle screw/rod fixation (Fig. 2). The patient did well postoperatively with resolution of his preoperative symptoms. Unfortunately, the patient returned on postoperative day 14 with drainage from his incision and was taken to the operating room the following day for wound exploration. Gross purulence was noted intraoperatively. Wound cultures grew *Klebsiella (Enterobacter) aerogenes*. The patient was discharged to home on an extended course of intravenous cefepime with eventual resolution of back pain. The incision was noted to be well healed at his follow-up visits.

The patient returned to the clinic approximately 6 months later with the return of back pain and new right lower extremity radiculopathy. His incision was well healed, and his Hgb A1C was down to 7.5%. On further outpatient work-up, the patient was found to have significant pseudoarthrosis of the L4 screws (Fig. 3) with degeneration of the L3–4 disc space and new kyphotic deformity.

After failed attempts at conservative management and clearance of his infection, the patient was taken back to the operating room for elective L3 laminectomy, extension of fusion to L3, and TLIFs at L3–4 and L4–5. During the operation, the L4 screw sites were noted to be significantly dilated with a diameter of over 13 mm. The largest

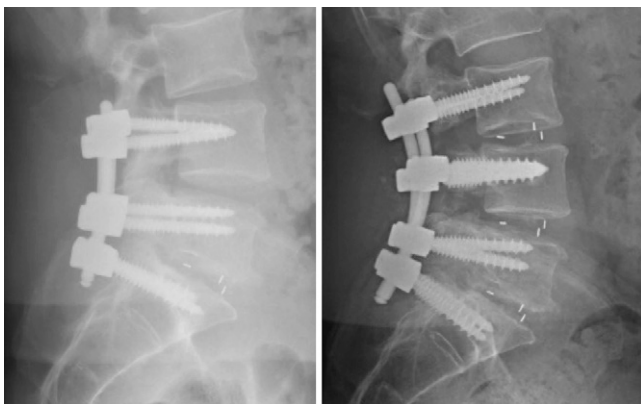


FIG. 2. Left: Postoperative radiograph showing the original construct from L4 to S1 with an L5–S1 transforaminal interbody device. Right: Postoperative radiograph of the revision construct with the fusion extended to L3 and with transforaminal interbody devices placed at L3–4 and L4–5.

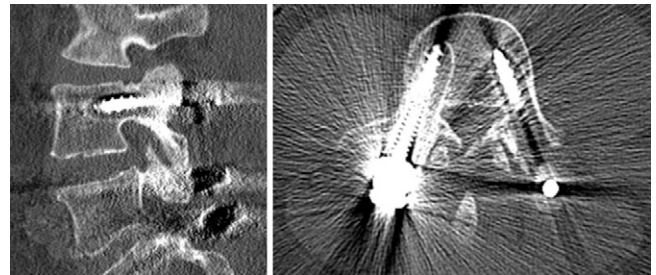


FIG. 3. Postoperative sagittal (left) and axial (right) CT scans obtained approximately 11 months after the patient's initial fusion, showing significant pseudoarthrosis and haloing of the L4 screws bilaterally.

screw readily available in an appropriate length was 10.5 mm. A moldable, settable (hardening), hardening bone putty containing CaP (Montage, Abyrx) was used as a salvage strategy. The screw tracts were explored with a ball-tipped probe to confirm no defects outside of the vertebral body or through the pedicle wall, and an intraoperative O-arm computed tomography (CT) scan was obtained for bony evaluation and navigation. The dilated tracts were then debrided with curettes and decorticated with a high-speed drill. The Montage putty was mixed per the manufacturer's instructions and was then shaped into a cylinder slightly smaller than the prepared approximately 13- to 14-mm screw sites. The putty was placed into the screw sites, and screws were placed through the putty under navigation to confirm their trajectory. Excellent purchase of a 10.5 × 45-mm screw on the left and a 10.5 × 50-mm screw on the right at that level was obtained. Slight extrusion of the product was noted during screw placement, but the excessive material was easily removed with a curette and suction before further setting. After confirming stability of the above screws, the rest of the fixation was performed. Postoperatively, upright radiographs (Fig. 2) and a CT scan of the lumbar spine (Fig. 4) were obtained and showed no hardware complication and a stable-appearing construct. The patient did well postoperatively with no further return of his symptoms and excellent wound healing. He was seen 6 months postoperatively and was doing well with no complaints. CT of the lumbar spine showed good bony healing around the previously pseudoarthrosed screws (Fig. 5).

Discussion

Observations

This case demonstrates the combined complications of postoperative infection, likely associated with poorly controlled diabetes, and subsequent



FIG. 4. Postoperative sagittal (left) and axial (right) CT scans obtained at the L4 level, showing placement of the 10.5-mm screws in the approximately 13-mm dilated, augmented, screw tracts.

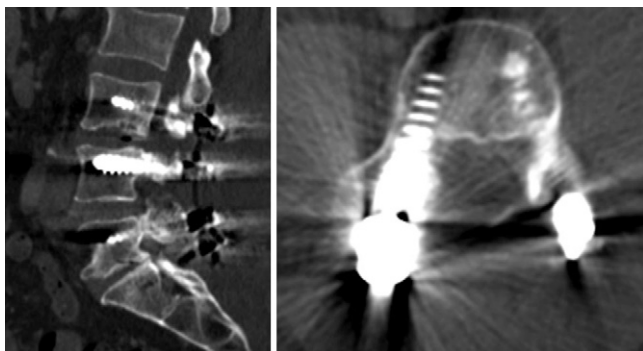


FIG. 5. CT scans obtained 6 months postoperatively showing good bony healing around the L4 screws, given constraints of the metal artifact.

significantly dilated pseudoarthrosis, again likely associated with both diabetes and infection. During revision surgery, no screws were available that were of sufficient size to allow good purchase in the widely dilated screw sites. Options included extending the fixation multiple levels without attempting to instrument the L4 pedicles or the addition of anterior or lateral approaches with significantly longer operating room time or additional surgeries. The option of securing the dilated screw sites with a cement or some other agent was then considered with the hope of obtaining good screw purchase while allowing a smaller construct.

Under ideal circumstances, bone has the ability to regenerate.¹³ In some settings, a graft is used to allow filling of gaps or defects. Several options for graft material exist, including autograft, allograft, or synthetic substances. Autograft possesses many desirable features for bone growth, but harvest morbidity is common. Allograft is a viable and commonly used substitute but lacks some of the efficacy of autograft due to lack of growth factors.^{14,15} There are multiple options for synthetic products when neither of the above is available or desirable, depending on the circumstances.

Bone consists primarily of collagen and CaP. Native CaP is bioactive. HA is a synthetic CaP ceramic similar to the CaP found in human bone.^{13,16} When used as bone graft, HA remodels very slowly, depending on its preparation, making it less than ideal for fast bone growth.¹³ β -TCP is a chemically similar synthetic CaP.^{13,14} When used as a bone graft, it has osteoconductive properties and is much more resorbable.^{14,16,17} These features combine to make it one of the most potent known synthetic bone graft substitutes.^{16–18} When combined, HA and β -TCP are referred to as biphasic CaPs and become an excellent option for bone grafting.¹³ As mentioned, β -TCP is readily absorbed by human cells, primary osteoclasts but also macrophages and multinucleated giant cells, leading to rapid dissolution, and HA is readily osteoconductive.^{13,17} As the β -TCP is resorbed and dissolved, it even gives off calcium ions that are used in local bone formation.¹⁷ In one animal series, it was shown that biphasic CaPs also improved the purchase of titanium implants.¹⁹ The size and shape of these synthetic CaP particles are readily controllable during synthesis, making them ideal for a variety of bone graft substitute modalities to include moldable putties.¹⁷ Their use as bone graft materials also appear to be well tolerated with minimal to no reported complications or adverse effects.^{14,16}

Montage is a moldable, settable (hardening), resorbable hemostatic putty that contains both HA and β -TCP. It was designed as a settable (hardening) hemostatic bone putty that resorbs and remodels into bone and contains osteoconductive CaP. It consists of two putties that are hand mixed and shaped as required. The device exhibits up to 10%

expansion as it cures. It is widely used across multiple surgical specialties, with several clinical publications demonstrating efficacy,^{14,16,17,20} however, no literature exists to date on its use in spine surgery, especially in the setting of dilated pseudoarthrosis salvage. On the basis of its design, function, and characteristics, it appears to represent an excellent option for this use. In the case described here, the use of Montage putty allowed excellent screw purchase with screws that were at least 3 mm smaller than the dilated tracts. This capability increased the level of comfort with revising L4 screws, and the extension of fusion to only one level above the dilated pseudoarthrosis became more reasonable, saving the patient the morbidity of either longer or more extensive surgery or of additional surgery from other approaches. There were no immediate complications in this case.

Lessons

Montage settable resorbable hemostatic bone putty appears to represent a useful tool in the salvage of widely dilated pseudoarthrosis in pedicle screw fixation. Further series are warranted to establish effectiveness and evaluate for any possible long-term complications, but it is hoped that the presentation of this technique in the literature can help disseminate this as a potential option for the salvage of pseudoarthrosis and that further interest will allow the collection of more data in the future to confirm the success of this strategy.

This presentation consists of only one case, and certainly further study on this technique is warranted. The process described here can potentially provide an additional tool to the armamentarium of the spine surgeon dealing with pseudoarthrosis. More cases and further follow-up will be necessary to determine the long-term effects and efficacy of this strategy.

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Disclosures

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

Conception and design: Esplin, Elhamdani, Jeong, Pace. Acquisition of data: Esplin, Elhamdani. Analysis and interpretation of data: Esplin, Rogowski. Drafting the article: Esplin, Jeong, Moran. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Esplin. Administrative/technical/material support: Pace. Study supervision: Pace.

Supplemental Information

Previous Presentations

This case was presented as a poster at the 2022 Annual Scientific Meeting of the Pennsylvania Neurosurgical Society, Hershey, Pennsylvania, July 22–23, 2022.

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