Imaging of Lumbar Spine Fusion

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KEYWORDS

• Lumbar spine fusion • Arthrodesis • Imaging • Complications

KEY POINTS

- An awareness of the preoperative imaging, the surgical technique and history, and the set of clinical problems and imaging findings most likely to occur at specific postoperative time intervals will greatly improve the accuracy and value of imaging in reports patients with lumbar fusion.
- Fusion surgeries can be categorized into anterior, lateral, and posterior approaches, each with advantages and disadvantages.
- Outcomes studies have not demonstrated a specific benefit of one type over another.
- Surgical exploration is the gold standard for definitive fusion assessment. Thin-section computed tomography with multiplanar reconstruction is the most sensitive and specific imaging modality to detect pseudarthrosis.

INTRODUCTION

Lumbar spinal fusion, or arthrodesis, has been performed since 1911 when it was originally described by Drs Fred Albee and Russell Hibbs, who were the first to use autologous bone graft for spinal stabilization.[1,2] As shown in **Figs. 1** and **2**, decorticated, bleeding cortical surfaces are surgically created and osseous substrates are implanted in the disc space (interbody) or adjacent to the facet joints in a space termed the posterolateral gutter as the necessary components for successful fusion or bone healing. The process creates a physiologic environment favorable for bone formation, which is intended to limit motion of the treated spinal segment.[3]

Fusion surgeries are performed to prevent motion of a single or multiple spinal segments, to alleviate pain or prevent neurologic compromise (**Box 1**). Reviews and prospective randomized trials have demonstrated improved patient outcomes when successful fusion operations have been performed.[4–7] Immediate stabilization improves the chance of successful arthrodesis.[8] Before instrumentation was popularized, this was achieved with bracing or bed rest.[9] Multilevel fusions were soon recognized as producing lower success rates for solid fusion and increased rates of pseudarthrosis. Instrumented fusion was designed to address this lower success rate with multilevel procedures. Over time, instrumented fusion was shown to provide effective immediate immobilization of the fused segment, theoretically increasing the likelihood of successful fusion for single-level procedures as had been shown for multilevel procedures. Implants, however, do not take the place of physiologic bony fusion, and are not designed to provide segmental immobility beyond the period during which true osseous fusion forms.[10] Current practice favors the combination of decorticated, bleeding osseous surfaces

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Fig. 1. Bone substrate. Immediate postoperative coronal CT scan with morselized bone fragments (*arrows*).

and implanted substrate with spinal instrumentation, to provide early internal stabilization and thus allow for eventual complete osseous fusion, as shown in **Fig. 3**.

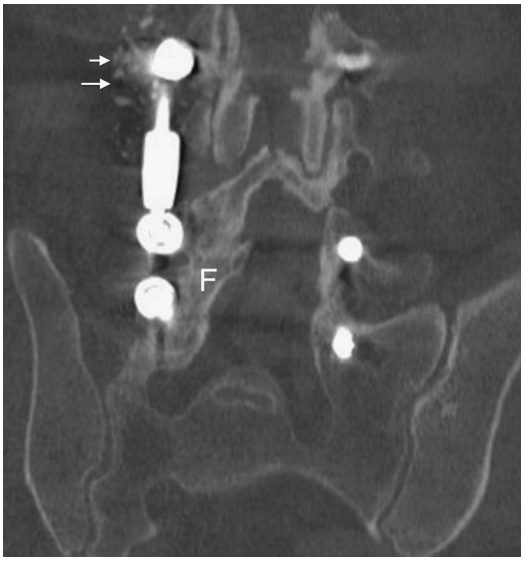

Fig. 2. Comparison of fusion with substrate. Recent postoperative CT coronal scan shows bone-graft material from a revision surgery (*arrows*). Compare with solidly fused graft from prior surgery (F).

Box 1
Instability

Segmental instability: Loss of motion stiffness such that force application to the motion segment produces greater displacement than would be seen in normal structures, resulting in a painful condition that has the potential for progressive deformity and neurologic damage.[11]

INDICATIONS

Spine-related pain complaints are common and have several potential causes (**Box 2**). The decision to operate on the spine to relieve pain is deferred until more conservative treatment methods fail to provide a therapeutic benefit. The broadest indications for elective spinal arthrodesis are pain or instability that threatens neurologic function.

Scoliosis correction is a broad category that is not necessarily a fusion, and is beyond the scope of this article. Instability at the level of the disc and facet joints results in a cascade of degeneration leading to chronic low back pain and anatomic derangement. Disc removal and segmental arthrodesis have been used to address this problem. There are also acute clinical scenarios, such as those caused by acute spinal cord compression resulting in myelopathy, nerve root compression resulting in severe extremity pain and weakness, or cauda equina syndrome, which often necessitate immediate surgical intervention.

PRIMARY VERSUS SECONDARY FUSION

Primary fusion surgeries are performed on the group of patients thought to be suffering from low back pain who have segmental instability, but do not have demonstrable focal neural compression or spinal deformity. In this group of patients the rates of interbody fusion have dramatically increased, although the evidence to support which approach is best remains unclear.[12–15] The general surgical approaches for fusion are described in **Box 3**.

Secondary instrumented fusions result from surgeries designed primarily to accomplish decompression of the thecal sac or nerve roots. When posterolateral fusion is not possible, or instability is likely, instrumented fusion is added to the decompression. When the decompression limits available posterior elements that serve as posterolateral fusion surface area, instrumented posterior fusion or interbody fusions are