



Outcomes of Anterior Spinal Fusion for Degenerative Spinal Disorders

Mila Schumacher*

Department of Orthopaedics, University of Medical Sciences, Iran

Abstract

Anterior spinal fusion (ASF) is a widely utilized surgical technique to treat various degenerative spinal disorders, including degenerative disc disease, spondylolisthesis, and spinal stenosis. By accessing the spine through the anterior approach, the procedure allows for the direct stabilization and fusion of vertebrae, often with the goal of alleviating pain, improving function, and stabilizing the spine. This review evaluates the clinical outcomes of anterior spinal fusion in the treatment of degenerative conditions, focusing on pain relief, functional improvement, complication rates, and long-term results. Recent studies demonstrate that anterior spinal fusion can provide significant pain reduction and improvement in quality of life for patients with degenerative spine diseases, particularly those with discogenic pain or spondylolisthesis. However, the success of the procedure is influenced by several factors, including the age of the patient, the degree of degeneration, the level of fusion, and the presence of comorbidities. In addition to clinical outcomes, this review also highlights the complications associated with anterior spinal fusion, such as vascular injury, pneumothorax, and non-union. While anterior spinal fusion has proven effective for many patients, its use must be carefully considered, especially in cases involving complex degenerative disorders or older patients with multiple comorbid conditions. Long-term studies show that sustained improvements in function and pain relief are possible, but the risk of complications remains a concern. The review concludes that anterior spinal fusion remains an important surgical option for degenerative spinal disorders, though continued refinement of techniques and patient selection criteria is necessary to optimize outcomes.

Keywords: Anterior spinal fusion; Degenerative spinal disorders; Pain relief; Functional improvement; Complications; Spondylolisthesis

Introduction

Anterior spinal fusion (ASF) is a well-established surgical technique primarily used for the treatment of degenerative spinal disorders [1], including conditions such as degenerative disc disease, spondylolisthesis, and spinal stenosis. These disorders often lead to chronic pain, nerve compression, and impaired function [2], which can significantly impact a patient's quality of life. The anterior approach to spinal fusion offers distinct advantages, including direct access to the affected discs or vertebrae, enabling effective decompression, stabilization, and restoration of alignment [3]. The procedure typically involves the removal of damaged intervertebral discs, followed by the placement of a bone graft or cage to facilitate fusion between the vertebrae. Over time, the bone graft heals, resulting in the permanent fusion of the adjacent vertebrae, effectively eliminating motion at the affected segment and reducing pain. Anterior spinal fusion is commonly performed in cases where conservative treatments, such as physical therapy, medications, and injections, have failed to provide adequate relief.

Results and Discussion

Pain relief and functional improvement

Anterior spinal fusion (ASF) has demonstrated significant efficacy in providing pain relief and improving function for patients with degenerative spinal disorders, such as degenerative disc disease, spondylolisthesis, and spinal stenosis [4]. Numerous studies have shown that patients undergoing ASF experience substantial improvements in visual analog scale (VAS) pain scores and Oswestry Disability Index (ODI) scores, which assess functional disability. A study by López et al. (2020) reported that over 80% of patients with degenerative disc disease who underwent ASF experienced a 50% or greater reduction in pain and a significant improvement in functional status at a 2-year follow-up. The improvement in quality of life (QoL) following anterior spinal fusion is largely attributed to the stabilization of the spine,

which alleviates the mechanical stress and nerve compression caused by degenerative changes [5]. In cases of spondylolisthesis, ASF can address the slippage of vertebrae, which often results in nerve root compression and pain. Surgical stabilization also helps restore proper alignment, which, in turn, improves overall spinal biomechanics and reduces the risk of further degeneration at adjacent levels. While short-term improvements in pain relief and function are well-documented, long-term outcomes (5+ years post-surgery) show that many patients continue to experience lasting relief [6]. However, the degree of improvement is often dependent on patient age, preoperative disability, and level of degeneration. Younger patients and those with less advanced degeneration tend to experience more significant and longer-lasting benefits from ASF. In contrast, older patients or those with multiple degenerative levels may report diminished outcomes or require additional treatments post-surgery.

Complications and risks

Although anterior spinal fusion has a high success rate, it is not without its complications [7]. Vascular injury, particularly to the iliac vessels or aorta, is one of the most significant risks due to the anterior approach, which places the surgeon in close proximity to these structures. A study by Zhao et al. (2021) found that vascular complications occurred in approximately 2% of anterior fusion procedures, though the rate has been reduced with improved surgical

*Corresponding author: Mila Schumacher, Department of Orthopaedics, University of Medical Sciences, Iran, E-mail: mila.s@schuma.com

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techniques and better preoperative planning. Other complications include pneumothorax, especially in cervical and thoracic surgeries, and nerve damage, though these are relatively rare. Non-union, or failure of the vertebrae to fuse properly, is another risk that can result in persistent pain and the need for additional surgery [8]. The incidence of non-union in anterior spinal fusion is generally low, with studies reporting rates between 3% and 10%. The likelihood of non-union increases with factors such as smoking, poor bone quality, and inadequate grafting techniques. Adjacent segment degeneration is another potential concern with ASF. Although the fusion of the affected vertebral segments can relieve symptoms in the short term, the altered mechanics of the spine may lead to accelerated degeneration at adjacent levels over time. This is a particular concern in younger patients, who may require additional interventions as they age. The development of motion-preserving techniques, such as anterior lumbar interbody fusion (ALIF) with the use of artificial discs or dynamic stabilization systems, aims to address this concern by preserving some level of motion at the treated segments.

Success factors and patient selection

The success of anterior spinal fusion is highly influenced by patient selection and the degree of degeneration. Young, healthy patients with mild to moderate degeneration of the spine tend to experience the best outcomes, with significant improvements in both pain relief and functional status. Older patients or those with severe degeneration, multiple levels of involvement, or significant comorbidities (such as osteoporosis or diabetes) may face higher risks of complications, slower recovery, and less favorable outcomes. Additionally, smoking has been identified as a major risk factor for delayed healing and non-union, making smoking cessation a critical part of preoperative counseling. The choice of surgical technique also plays a crucial role in outcomes. Advances in surgical tools, navigation systems, and minimally invasive techniques have contributed to improved precision, reduced complication rates, and faster recovery times [9]. The decision between using an anterior approach versus a posterior approach often depends on the location of the pathology, the patient's anatomy, and surgeon experience. For certain degenerative conditions, such as cervical disc disease, anterior cervical discectomy and fusion (ACDF) may be preferred, while anterior lumbar interbody fusion (ALIF) is commonly used for lumbar disc disease and spondylolisthesis.

Long-term outlook

Long-term follow-up studies indicate that anterior spinal fusion can provide sustained pain relief and functional improvement for a significant portion of patients. However, the benefits may diminish over time, particularly in patients with advanced degeneration or adjacent segment degeneration. Although the fusion effectively stabilizes the spine and prevents further displacement, it does not restore motion, and some patients may experience limitations in spinal flexibility [10]. Recent developments in motion-preserving technologies, such as artificial discs and dynamic stabilization devices, may help reduce the risk of adjacent segment disease and provide more durable outcomes for younger or more active patients. Furthermore, the ongoing

development of biologic therapies, such as bone morphogenetic proteins (BMPs) and growth factors, holds promise for enhancing the fusion process and improving postoperative healing.

Conclusion

Anterior spinal fusion is an effective surgical option for patients with degenerative spinal disorders, providing substantial pain relief and functional improvement. While the procedure is generally safe and successful, complications such as vascular injury, pneumothorax, and non-union highlight the need for careful patient selection and technical expertise. The long-term outcomes are generally favorable for younger patients with mild to moderate degeneration, but the risk of adjacent segment degeneration and other complications necessitates continued monitoring and possibly additional interventions. With advancements in surgical techniques and motion-preserving technologies, the outcomes of anterior spinal fusion are likely to improve, offering more durable solutions for patients suffering from degenerative spinal disorders.

Acknowledgement

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Conflict of Interest

None

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