

# Outcomes of anterior cervical spine surgery

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## Summary

This thesis explores the outcomes of anterior cervical discectomy with arthroplasty (ACDA) as a treatment for cervical degenerative disc disease (CDDD), with a focus on cost-effectiveness. The intended advantage of ACDA lies in its ability to prevent long-term adjacent segment pathology (ASP) through the preservation of motion. This challenges the effectiveness of the most common treatment, anterior cervical discectomy with fusion (ACDF), as satisfaction after ACDF decreases in the long-term and the development of ASP is thought to be a contributory factor. Short-term results between ACDF and ACDA appear to be similar; however, they are mainly based on the direct effects of neural decompression on the symptoms of radiculopathy and/or myelopathy. When looking at long-term effectiveness in terms of secondary surgeries due to ASP, these seem to be lower for ACDA than ACDF.

The subject is particularly relevant as the implant costs for ACDA are higher than for ACDF. In the Netherlands, this is of specific interest as ACDA cannot be implemented because it is not reimbursed because of the similar short-term results while being more expensive. Throughout this thesis, the pronounced heterogeneity in outcome measures within the current research topic has become apparent, emphasizing the gap in knowledge concerning cost-effectiveness between the two techniques.

In *Chapter 2*, the incidence of ASP is investigated in a retrospective cohort of patients undergoing anterior cervical surgery for CDDD in our center. By employing a strict definition of ASP and using clearly defined outcomes, more insight into the actual incidence of symptoms and secondary surgeries due to ASP was gained. Moreover, the relationship between cervical sagittal balance parameters and their influence on ASP was explored. Based on the findings in *Chapter 2*, the concept of performing measurements of these cervical sagittal balance parameters on X-rays without standardized patient positioning is questioned. According to the literature reviewed in *Chapter 3*, ACDA is considered non-inferior to ACDF in terms of neurological recovery for the treatment of cervical degenerative myelopathy. This contradicts previous concerns about the use of ACDA in patients with myelopathy. Remarkably, most of the literature considers pain as an outcome, which may not be the most relevant outcome parameter in myelopathy.

The potential advantages of ACDA lie in preserving motion, yet the concept of 'physiological motion' lacks a solid definition. Range of motion (ROM) is most commonly used as a parameter to assess spinal motion, however, of limited value as it is a quasi-static measurement. In this thesis, the quality of motion is assessed in dynamic fluoroscopy recordings. This method is cross-validated in *Chapter 4*. Motion patterns, assessed through the sequence of segmental contributions (SSCs), are found to be consistent in young, asymptomatic individuals. As *Chapter 5* reveals, this consistent sequence is not present in patients with single level radiculopathy prior to treatment, but is restored by ACDA after 1 year, in contrast to those undergoing simple discectomy. Surprisingly, at long-term follow-up this consistent motion pattern also

disappears in the ACDA group. This prompted the investigation of the evolution of the quality of motion throughout aging in *Chapter 6*, which revealed that the previously consistently present motion pattern is no longer present in the elderly. Altered motion patterns may thus be a part of the natural aging process. Based on the motion data gathered in this thesis, a proof of principle for an artificial intelligence network is developed in *Chapter 7*, eliminating the time-intensiveness and complexity of the analysis.

A significant contribution of the thesis lies in exposing the heterogeneity in outcome measures used in cost-effectiveness research. *Chapter 8* reviews economic evaluations in anterior cervical spine surgery and revealed that no conclusions could be drawn from current literature, demonstrating the lack of knowledge concerning the cost-effectiveness of ACDA. As *Chapter 10* demonstrates, the methodology of all economic evaluations in spine surgery is so divergent that not even two articles could be compared directly. This implies that very limited information is actually available concerning cost-effectiveness within the field of spine surgery and emphasizes the need for uniform research. To address this, a disease-specific guideline is developed using the modified Delphi method in *Chapters 9, 10, and 11*. The knowledge obtained in this thesis led to the formulation of an RCT with defined and relevant outcomes to assess the long-term cost-effectiveness of ACDA in comparison to ACDF, as outlined in *Chapter 12*. In summary, this thesis provides valuable insights into motion analysis, cost-effectiveness, and long-term outcomes of ACDA, paving the way for future investigations in this evolving field.