Comparative Analysis of Cervical Kinematics, Pain and Functional Disability Between Single- and Two-level Anterior Cervical Discectomy and Fusion

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Introduction: Anterior Cervical Decompression and Fusion (ACDF) is one of the most commonly utilized techniques for the treatment of cervical myelopathy or radiculopathy resulting from degenerative disc disease. Despite the generally positive clinical outcome, the development of Adjacent Segment Disease (ASD) due to the over-compensatory motions at the adjacent levels to the fused segment/s have been intensely discussed in the literature. However, the exact etiology of ASD and its relationship with over-compensatory motion remained a subject of much debate due to the lack of correlation between in-vitro biomechanical data and clinical observations. Furthermore, most in-vivo studies have only assessed overall cervical Range of Motion (ROM) using external wearable devices and comparative data on adjacent segments to the fused segments remained limited. The purpose of the present study is therefore to investigate and elucidate the influence of ACDF on the overall cervical ROM and adjacent segment kinematics pre-operatively and at three and six months. Moreover, the impact of the changes in cervical alignment as well as global and segmental ROM on patient’s self-reported pain and functional disability overtime will also be investigated.

Methods: The study population consisted of radiographically confirmed myelopathy or radiculopathy patients that had undergone ACDF at our institution between July 2012 and April 2014. Neutral, full flexion and extension radiographs as well as the clinical outcome measures were collected preoperatively and then again at 3 and 6 months follow up assessments in 42 patients (25 received one-level and 17 with two-level ACDF). The clinical outcomes were assessed with the Pain Visual Analogue Scale (VAS) and the Neck Disability Index (NDI). Radiological measurements included cervical lordotic alignment, global C2-C7 ROM as well as the ROM of the Functional Spinal Unit (FSU) and its adjacent segments (Fig. 1). Statistical comparisons of continuous demographic and preoperative variables between the single- and two-level ACDF groups were analyzed using the Mann-Whitney U-test and Chi-square with the fisher’s exact test was used to compare gender proportion between groups. A mixed-design 2 (surgical type: single- and two-level ACDF) x 3 (time: Preoperative, 3 month and 6 month) ANOVA was carried out to assess the effect of surgery on time related change in cervical spine alignment and ROM, pain VAS, and NDI. A p-value of <0.05 was considered significant. The study was approved by the institutional medical research ethics committee (201201053RIC).

Results: The mean ages of the patients in the single- and two-level groups were 54.7±12.0 and 59.3±10.1 years respectively (p>0.05). No significant differences were found for any of the demographic
and preoperative measures between the two groups (p>0.13). No significant time by surgical type interaction was identified (p>0.44), however, a significant main effect for time (p=0.37) was found for both Pain VAS and NDI. Both groups demonstrated a significant reduction in the Pain VAS during the first 3 months (p=0.001) and maintained from 3 to 6 months (p=0.121). Similarly, the NDI score decreased significantly over the duration of the study period, with most significant reduction also occurring during the first 3 months (p=0.02) (Fig. 2). The preoperative comparison revealed that two-level ACDF group demonstrated significantly reduced lordosis than the single level group (p=0.031). However, mixed design ANOVA did not identify any significant interaction (p=0.722) and main effects (p>0.433) for the measurement of cervical lordosis. Global ROM decreased significantly for both groups at 3 months (p<0.05) and although slightly improved over time, the global ROM remained less than the preoperative ROM at 6 months (p=0.55).

Discussion: To our knowledge, only a limited number of existing studies have used dynamic radiographs to comparatively evaluate the impact of single- and two-level ACDF on global and adjacent segment ROM as well as its association with patient reported pain and functional disability. The results of the current study indicated that global ROM does not significantly exert impact on patient reported pain and functional capacity. It is speculated that the consequence of loss of ROM maybe outweighed by the effect of pain on patient reported functional disability and further highlights the importance of pain management postoperatively. Patients undergone two-level ACDF demonstrated significantly increased superior adjacent segment ROM at 6 months post-operatively but not in those with the single-level ACDF. This is consistent with the normal physiological expectation in which intact adjacent segments will naturally compensate for the motion loss at the fused segment/s and the over-compensatory motions ultimately increases as more levels are fused. It was interesting to note that the over-compensatory motions were only observed in the upper adjacent levels, but not the lower adjacent levels. It is speculated that the physiologically greater available ROM at the lower adjacent levels may have contributed to such finding. A comparable improvement in the global ROM was observed in both groups by 6 months, however, both failed to reach their preoperative values. This is consistent with previous findings of significant reduction of global ROM post-ACDF. The notable limitations of the current study included relatively small sample size and the short follow up period.

Significance: The results highlighted the importance of short-term postoperative pain management and its impact on patient reported outcome. Furthermore, current study identified subtle but significant kinematical differences between single- and two-level ACDF.
Fig. 1. Cervical flexion-extension lateral radiographs obtained after a single-level Anterior Cervical Discectomy and Fusion (ACDF) illustrating: (Left) The range of motion (ROM) of the superior and inferior adjacent segments (θ); (Right) The ROM of the C2-C7 global ROM (α) and Functional Spinal Unit (β). The ROM was defined as the difference between the angles of full flexion and extension.

Fig. 2. Line graphs illustrating the Pain VAS and NDI scores for the single- and two-level ACDF groups preoperatively and then at 3 and 6 months time points.
Fig. 3. Line graphs illustrating the Cervical lordosis, Global Range of Motion (ROM), Functional Spinal Unit (FSU) ROM as well as superior and inferior adjacent segment ROM for the single- and two-level ACDF groups preoperatively and then at 3 and 6 months time points.