Effects of Anterior Cervical Decompression and Fusion on Adjacent Level Kinematics

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Introduction Degenerative cervical disc disease is usually treated surgically with anterior cervical decompression and fusion (ACDF) as a standard procedure. However, there is uncertainty with respect to the influence of ACDF on adjacent segment degeneration or disease (ASD). The etiology of ASD is unclear and it has not been fully established whether ASD is a consequence of fusion or it represents the natural history of the degenerative cervical process, thus making it a controversial topic [1-3]. There have been several discussions about the possibility of ACDF altering biomechanical conditions at adjacent segments, therefore resulting in increased loading and excessive motion [3,4]. The purpose of this study was to compare the cervical segmental motion before and after ACDF using novel 3D analytical techniques.

Methods Nine patients (2F/7M, mean age: 54.1 years, range 36-77 y.o.) underwent ACDF due to cervical degenerative disc at the same institution. Single-level ACDF was performed on four patients and the remaining five patients underwent two-level ACDF surgery, using cylindrical titanium cage implant(s). Before and after (postoperative period: 12.09 months) surgery, dynamic-CT examinations were conducted in neutral, flexion and extension positions. Subject-based 3D CT models were created for segmental motion analyses (Fig. 1). Six-degrees-of-freedom 3D segmental movements were analyzed using a validated Volume-Merge method (accuracy: 0.1 mm in translation, 0.2° in rotation) [5]. The segmental translation was evaluated by the segmental translations of gravity centers of endplates (Fig. 2). Disc height distribution was measured using a custom-written Visual C++ routine implementing a distance calculation algorithm. The mean translation distance was calculated for each adjacent level (Fig. 2). Differences of segmental motions and mean disc height between before and after surgery at each level were compared by the Wilcoxon signed rank test. Results are presented as mean±SEM.

Figures

Figure 1. Representative subject-based 3D CT computer models in flexion, neutral and extension position. ACDF level: C4/5.

Figure 2. Local coordinate system and gravity center on the endplates of a motion segment used in segmental translation analysis and quantification of its corresponding disc height distribution. Color scale bar is in mm, range: 1 to 4 mm.

Figure 3. Comparison of the pre- and post-operative conditions for motion parameters at the fusion level and the adjacent levels. Left: Angular range of motion (ROM) for the Flexion/Extension motion in degrees. Right: Anterior-Posterior segmental translation in mm. Error bars correspond to the standard error of the mean.

Conclusions The use of a high-accuracy in vivo 3D kinematic analysis method enabled the detection of subtle changes in segmental movement between pre- and post-ACDF conditions. The results of the current study showed increased segmental movements in flexion/extension angles at the adjacent level. These results are consistent with those of some previous studies in the literature [4,6-11]. The magnitude of the increased movement, however, was only 1.74° from full-flexion to full-extension and no increase was found in AP translation. No disc height loss associated with disc degeneration was observed during a 1-year period after ACDF. Longer follow-up studies with larger patient cohorts will be required to investigate whether the increased F/E angle at the adjacent level effectively causes ASD.

References