Introduction: Spinal fusion with instrumentation is an essential component in the management of degenerative condition in the spinal motion segment. It is performed to improve initial stability with simplified external fixation for early ambulation. The solid fixation, however, often induces an adjacent segment degeneration (ASD) above or below the fusion. ASD can be described as any abnormal process of disc degeneration, listhesis, instability, and etc. that develops in the motion segment adjacent to a fused segment. Biomechanical changes of the segment due to the fusion, increase intradiscal pressure, increase facet loading, or increase mobility are considered to contribute ASD 4).

To avoid the adverse effects of spinal fusion, various flexible stabilization systems have been developed to stabilize the unstable segment. Flexible stabilization systems were based on the concept to allow spinal motion but to restrict excessive motion. The Graf system was one of the most practiced methods of flexible stabilization. To be stabilized, the bands are pretensioned on application to place the motion segments into lordosis and to lock the facet joints.

Kanayama et al. reported that radiographic evidence of adjacent disc deterioration was observed more frequently in patients with posterolateral fusion group than those with Graf system and concluded that the Graf system decreased risk of ASD compared with PF with instrumentation (5).

The objective of this study was to assess the biomechanical influence that occurred at the adjacent segment by flexible stabilization with Graf system and instrumented spinal fusion.

Materials and Methods: The in vitro experiments were performed with fresh frozen porcine lumbar spines. The lumbar spines were harvested from fifteen mature porcines. Each specimen was dissected into an L3-L6 spinal column consisting of four adjacent vertebral bodies, including posterior elements, and intervertebral discs. The spines were tested intact first, then after bilateral medial facetectomy (MF), augmented by Graf system (Graf), and instrumented spinal fusion, respectively. Medial Facetectomy and the instrumentations were performed at L4.

The spinal columns were tested using a spinal motion tester which was designed to apply displacement to the cranial vertebra to simulate sequential flexion-extension movement of the spine. During testing, axial compressive load of 70N was applied to the column. The actuator generated at speed of 5.0mm/sec with displacement of ±20mm to bend the vertebral column. Three cycles of flexion-extension motion was applied from a neutral position to approximately 8° extension then to 8° flexion. Angular motion and intradiscal pressure of each segment were recorded on the third cycle for each testing state.

To observe the tested results of the segmental motion of each vertebra, three set of markers were mounted on the cranial vertebrae body, L4 vertebra body, and L5. As the motion was applied to the spine, the location of these markers was tracked with a CCD camera. Based on the location of these markers, two-dimensional angular motion at sagittal plane of each segment and whole specimen were calculated. For the measurement of intradiscal pressure, a miniature fiber optic pressure sensor was directed into central region of the nucleus pulposus of each disc from 45 degrees right-anterior approach.

Results: The angular deformity in each segment increased linearly in intact. After MF, the angular deformity in each segment increased similar to intact in both of position. In Graf, although the angular deformity of L4/5 was suppressed until 4 degrees deformation, the deformity gradually increased after 4 degrees deformation and then finally became equal to intact spine. During the change of L4/5 deformation in Graf, the caudal L5/6 segment decreased compared to spinal fusion when the spine was flexed more than 4 degrees.

The range of motion (ROM) was defined as the unilateral angular deformation of the each segment during the spinal column bend from neutral position to 8 degrees flexion and to 8 degrees extension. The ROM at superior adjacent segment (L3/L4) was increased 54% in Graf and 46% in spinal fusion in flexed position, and 30% in the Graf and 75% in spinal fusion in extended position significantly compared with intact. At inferior segment (L5/6), the ROM was increased 18% in spinal fusion in flexion, 117% in Graf, and 74% in spinal fusion in extension significantly. MF remained nearly equal to the intact with no significant differences in distribution of the ROM. The ROM was distributed with significantly greater percentage of the total motion at the adjacent segments (L3/4 and L5/6) in Graf and Spinal fusion than in intact and MF.

The intradiscal pressure in MF remained equal to intact with no significant difference at each segment at neutral position. The intradiscal pressure was significant increased 47% at L4/5 and 33% at L5/6 in Graf, and was significant decreased 46% at L4/5 in spinal fusion. The maximal value of the intradiscal pressure in MF remained equal to intact with no significant difference. The maximal value of the intradiscal pressure was increased 96% at L3/4, 90% at L4/5, and 67% at L5/6 significantly in Graf. In spinal fusion, the maximal value of the intradiscal pressure was significant increased 54% at L3/4 and 67% at L5/6.

Discussion: It is considered that the increased intradiscal pressure, increased facet loading, and increased mobility occur after fusion were implicated in causing ASD. In this study, intradiscal pressure in both instrument were increased and there was no significant between Graf and spinal fusion. These results were not clarified the relation between increased intradiscal pressure and ASD.

The angular deformity at the flexible stabilized segment (L4/5) was suppressed until 4 degrees deformation, the deformity gradually increased after 4 degrees deformation and then finally became equal to intact spine. This increment of the angular deformity in L4/5 reduced the angular deformity of adjacent segments. In spinal fusion, L4/5 was fixed rigidly and the movement which was found at the flexible stabilized segment was not observed in spinal fusion. In this study, it seems reasonable that increment of the angular deformity at the flexible stabilized segment reduced the risk of ASD.

5) Kanayama M, Hashimoto T, et al. (2001) ‘Adjacent-segment morbidity after Graf ligamentoplasty compared with posterolateral lumbar fusion.’, J. Neurosurg., 95, pp.5–10