SUMMARY
Aim: The aim of following study is to simulate different types of loading on cervical vertebra and to identify if mechanical stress concentration in utmost positions corresponds with osteophytes localization find in clinical practice. The objective of our investigation is to develop a theoretical model that may elucidate clinical observation regarding the predilection site of bone remodeling. We will focus our attention on the physiological changes inside the cervical vertebral body.
Methods: Real 3D-geometry of the fourth cervical vertebra had been made by commercially available system ATOS II. It is high-resolution measuring system using principles of optical triangulation. Such flexible optical measuring machine projects fringe patterns on the surface of selected object and the pattern is observed with two cameras. 3D coordinates for each camera pixel were calculated with high precision and a polygon mesh of the object's surface was further generated.
ANSYS program has been used in the next step to calculate strains and stresses in each finite element of the virtual vertebra. Applied forces used in the experiment were of physiological magnitude and direction and mechanical stress distribution inside the vertebra has been calculated. Mechanical loading in neutral position has been characterized by distribution of 80% of mechanical stress to the vertebral body and 10% to each of zygoapophyseal joint. Hyperlordotic position loading had been defined by 60% force transfer by vertebral body end-plate and 20% by each of the small joint while that of kyphotic position by 90% load to the vertebral body end-plate and 5% simultaneously to each facet.
Results: Mechanical stress distribution calculated in neutral position model correlates well with bone mineral distribution of healthy vertebra and the correlation verifies the model itself. The virtual mechanical loading of the vertebra in kyphotic position concentrates the deformation stress into the uncinate processi and into the dorsal apophyseal rim of the vertebral body. Simulation of hyperlordosis mechanical loading on the other hand shifts the region of maximum deformation area into the articulation process of the Z-joint. All the localizations are known areas of osteophyte formation in degenerated cervical vertebra.
Conclusion: Theoretical model developed during the study corresponded well with behavior of human spine in terms of osteodegenerative changes site predilection described in clinical practice. Mathematical simulation of mechanical stress distribution in preoperative planning may lead to the optimization of postoperative anatomical relation between adjacent vertebras. Such implementation to our surgical practice may further reduce the incidence of degenerative changes in adjacent motion segments of the cervical spine and possibly also lead to better subjective and clinical results after cervical spine reconstruction.
KEY WORDS
cervical vertebra - bone remodeling - kyphosis - lordosis - spondylosis - osteophyte