EXPERIMENTAL MODEL OF HUMAN SPINE DURING LOADING

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INTRODUCTION

This work has been based in a model having in mind the human vertebrae and its instrumentalisation with electrical strain gauges, with the objective of evaluating the transmission and the nature of efforts developed in the lumbar-sacral hinge, in flexion, extension and axial rotation. The electrical strain gauge consists in a very light electric wire collocated in a support which is welded with a surface from which we know the state of deformation. As a method of experimental tension analysis, the electrical strain gauge allows the measurement of the tension or deformation states that occur on the bodies´ surface.
Beyond this biomechanical component we mention some difficulties we can find not only in the modelling and in the placement of the strain gauges, but also in the solutions found in each specific case. For this study, which involves engineering and medicine areas, the experimental analysis of tensions gives tools which, associated to the building of laboratories models, can contribute to remove some empiricism which still subsists in the answer given by the human body to the efforts in which it is submitted.

METHODS

In our study we prepared a set formed by the lumbar spine and sacrum removed from a dead body an we have to release all the bone structure and the intervertebral discs of the surrounding tissues.
The main objective was to know in the model the level of tensions and its main directions in «pars interarticularis» where usually can find classified fractures like fatigue fractures (spondilolisis). Unfortunately we don't know the elasticity modulus of the bones in study; that's why we only found the extension levels on the nearest points of the critical areas of the «pars interarticularis» being the main parameter the variation of the angle formed between each vertebrae and the contiguous ones.
This kind of study has serious modelling problems in order to get a general behaviour of the whole not completely deprived of characteristics. One of the most serious problems is related to the function of the intervertebral discs, which due to the drying of the hydrophilic tissue, loose flexibility. It was necessary to substitute it by similar material with height elastic characteristics. The gluing of the vertebrae's was made with contact glue that proved to have a good adhesion.
The muscle and ligament forces on the anterior and posterior portions were simulated using rubber strings with 3 mm of diameter. These strings were fixed vertebrae to vertebrae by means of little metallic hooks kept them tensioned using a tying mechanism, allowing the individual movement of each vertebrae or the global movement of the set. The articulate capsules were involved by silicon rubber confining the sliding of articulate surfaces and increasing the repetition of movements.

As we used a true lumbar spine, it was necessary to make special cleaning operations. It was made a supplementary cleaning of spots of grease and a drying in a stove of the 5th lumbar vertebrae with the objective of improving the adherence of the base of the strain gauges. We uniformed the surface and we eliminated the bone porosity in the gluing zone by interposition of a small quantity of glue to the base of the cianoacrilate kind M.Bond 200 MM. After this procedure we verified a sensible stabilisation in off-set. Them we used singular strain gauges ref. EA-06-050 SB-120, positioned in each of the «pars interarticularis» L5-S1 and rosettes of strain gauges ref. EA-06-062 RB-120, with the objective of showing as better as possible the state of deformation. We made several demanding of anterior flexion, backward extension and axial rotation, trying to establish the relation, in the a model conditions, between the state of deformation and the rotation of the 5th lumbar vertebrae in what concerns the sacrum. We also tried to know the direction of the main extensions. To determine the rotation angle, it was made the photographic superposition form the rest position.

RESULTS

Comparing a certain amount of X-rays in several positions of anterior flexion and backward extension we observed the model behaviour and its capacity of simulating the reality. This comparison showed that simulation is not the perfect, however we concluded that the backward extension demanded to the model, which seamed very exigent, were significantly shorter than the ones obtained by X-ray in an healthy individual in normal strain.

We noticed a deviation in the model behaviour, mainly in the rotation of the 5th lumbar vertebrae in relation to the sacrum.

CONCLUSION

There were some difficulties on the application of the electric strain gauge to the model formed by human bones that were overcome by the used of adequate technics.

In fact, the intervertebral discs don't present the same flexibility, however it was used in the model the same material and measure to simulate them. This will allow in future works, adequate the mechanical function of the model, choosing different measures and materials to simulate the intervertebral discs.

The developed model wasn't especially adequate to describe the anterior flexion movement having been significant the dispersion found in the extensions in what concerns to the rotation angle. The backward extension movement has shown little dispersion with the extensions which developed in a linear manner in the rotation L5-sacrum.

The axial rotation movement showed more high extensions because of the incompatibilty of the movements in the transversal plane in the articulate apophysis of the lumbar vertebrae.

The direction of the maximum main deformation for the maximum rotation noticed on the tests of anterior flexion and backward extension might justify the fracture in the zone of the «pars interarticularis». The application of the electrical strain gauge and the obtained results can justify the model validity in terms of scientific investigation for specific cases of human movement.

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