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STUDY ON PATHOGENIC MECHANISM OF IDIOPATHIC SCOLIOSIS

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The cause of idiopathic scoliosis is still unknown. The features of idiopathic scoliosis comprise spinal irregularity with lateral curvatures together with rotation without any marked abnormality of the vertebrae or associated musculoskeletal condition. Since almost all cases of the disorder appear during adolescence, growth has been recognized as a key factor for pathogenesis of idiopathic scoliosis. With respect to the pathogenesis of idiopathic scoliosis, a large number of hypotheses and physical models have been presented. From the point of view in mechanics, we can classify these concepts into two types: that growth itself is asymmetrical; or that buckling is induced by symmetrical growth of the vertebral bodies, which we call the buckling hypothesis[1].

For the buckling hypothesis, Dickson et al.[2] presented an important observation on flattening of the thoracic spine during growth spurt. Based on his hypothesis, the authors analysed the buckling phenomenon induced by the growth of vertebral bodies using finite-element models of spine by the linear buckling theory. However, in case using a program based on the nonlinear buckling theory, clear buckling modes similar to the clinical modes could not be obtained[3]. After this investigation, we reanalysed the linear buckling modes using another commercial program. Then, we found that there is a program by which any buckling phenomenon is not obtained. From the dependency of programs, we had the doubt whether the buckling phenomenon exists or not. In the present paper, returning to the starting point, we confirmed the existence of the buckling phenomenon using rather simple models, and made clear the region in which the phenomena occur.

Three finite-element models are used in the present study. Model 1 is shown in Figure 1. Model 2 is a curved rectangular column, and Model 3 is a straight rectangular column with holes like foramina in the vertebrae. All of the models have the same height $h = 500$ [mm] and depth $d = 50$ [mm]. Front width w_F, back width w_B and depth of growth domain g are chosen as variables. We assume that only the bottom plane corresponding

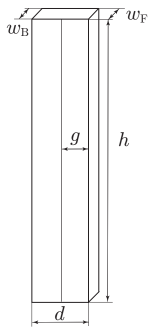

Figure 1: Model 1

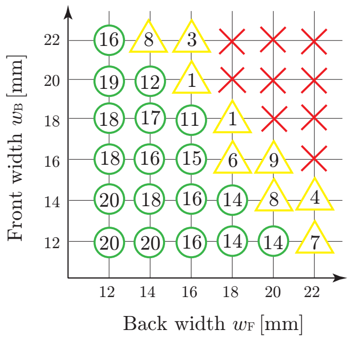

Figure 2: Number of buckling modes for Model 1 at $g = 10$ [mm]

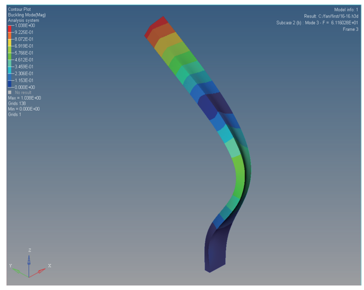

Figure 3: 2nd Buckling mode shape for Model 1 at $g = 10$ [mm]

to the sacrum is fixed as the base position of deformation. The growth of the vertebral bodies is modeled by the thermal expansion in thermal elastic problem.

Figure 2 shows the results of the numbers of the buckling modes in w_F-w_B space for Model 1. Figure 3 shows an example of the buckling modes. From those results, $(w_F, w_B) = (16, 16)$ [mm]^2 can be considered as the parameters in order that the buckling modes occur stably. From the results of the numbers of the buckling modes, it is confirmed that there are boundaries between the domain in which bucklings occur and the domain in which no buckling occurs. Moreover, that the area of the domain in which bucklings occur for Model 1 is larger than that for Model 2 supports Dickson's hypothesis, namely flattening increases possibility causing a buckling phenomenon. That the area in which bucklings occur for Model 3 is larger than that for Mode 1 means that the structure of spine which has holes in vertebrae causes buckling phenomenon more easily.

Based on the results, we confirmed the existence of the buckling phenomena, and made clear the region of geometrical parameters in which the buckling occur. These results support the hypothesis of Dickson.

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