

Influence of angle on failure of growth rods in H3S2 construct

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Scoliosis is an abnormal three-dimensional deformation of the vertebral column with an angle larger than 10° in the frontal plane. This deformation can appear at any time during life, but it is particularly problematic during childhood growth period. Depending on the amplitude of the deformation, different treatments are applied. Arthrodesis consists in merging vertebrae together; however, for children this can have a negative impact on the development of other organs. Children can be immobilized using braces. However, if the brace does not provide a significant result and if the child still has an important growth potential, surgery is unavoidable.

Surgery consists in inserting one or two growth rods along the column to straighten it. The so-called H3S2 setup "3 hooks 2 screws", which uses one long cylindrical beam, has been studied in this work. Since children keep growing and the column tries to return to its initial deformed configuration, varying stresses are constantly induced in the rods. In 36 percent of treatments, the rod fails inside the body weeks or months after surgery [Yang2011]. The failure mechanism is usually due to a fatigue cracking process. During the surgery, the surgeon bends the rod to fit the natural shape of the patient spine. This bending process as well as the marking of the material due to contact during bending are believed to affect the fatigue resistance of the rod.

The aim of this research is to characterize and model the failure mechanisms in the rods by means of mechanical tests and numerical simulations. The decrease of rods lifetime due to the bending process is investigated by carrying static and fatigue tests as well as finite element simulations on pre-bent or as-received specimens. Rods made of pure titanium, titanium alloy TiAl6V4 and cobalt-chromium alloy, which are typically used in surgery, were selected. Particular attention is put on the development of internal stress, on the fatigue life, on failure mechanisms, on Bauschinger effect and on the strain hardening capacity in order to generate a quantitative understanding of the problem. These results provide guidelines towards selecting more adapted procedures and materials.

Keywords: Growth rods — H3S2 — Rod contour — Rod failure — Fatigue life — Internal stresses — Strain hardening

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