# VARIATIONS IN GROWTH PLATE STRESSES AND FLUID PRESSURES DURING THE STANCE PHASE OF NORMAL GAIT

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**Introduction:**

Clinically, malalignment of the knee has been shown to create altered joint contact loads, however, it is not understood how this affects longitudinal bone growth. Previous investigators have addressed this issue by applying static loads in a two-dimensional linear elastic finite element model (2). However, studies have shown that load passing through the knee is highly dependent not only on a static angular deformity, but also on dynamic factors during gait (4). Therefore, the objective of this preliminary study is to investigate the patterns of stress and fluid pressure within the proximal tibia growth plate during a normal gait cycle.

**Methods:**

A 2D plane strain model of the rabbit proximal tibia was generated in HyperMesh pre-processing software (Altair, Inc.) by digitizing tissue outlines in a high-resolution magnetic resonance image. Although growth plate material parameters are poorly understood, our model assumed a transversely isotropic poroelastic material with the transverse modulus 10 times the vertical modulus (1, 3). It was assumed that fluid could flow freely out of the perichondrial region, but bone surfaces were defined as impermeable. All other materials were assumed linear elastic, including the articular cartilage and meniscus, for convenience. Pressure loads were applied to the medial and lateral surfaces with a time history reflecting the stance phase of a walking gait trial. Contact forces were calculated using a mathematical model initially developed by Harrington (4,5). In addition to joint contact forces, the model includes cruciate and collateral ligaments as well as the quadriceps, hamstrings and gastrocnemius muscle groups. The muscle, ligament and joint contact forces are calculated by balancing their actions with the external intersegmental forces and moments obtained using an Optotrack 3020 Motion Analysis System (Northern Digital Inc.) and a force plate (Kistler Inst. Corp.). For this preliminary analysis, a typical human gait trial was selected for analysis and forces were scaled such that contact forces of one BW resulted in a pressure of 1 MPa. All finite element analyses were performed with Abaqus 5.8, (HKS, Inc.)

**Results and Discussion:**

During the normal gait cycle, there are differences in both magnitude and duration of medial vs. lateral joint forces and subsequent growth plate pressures. As expected, during this rapid loading cycle, the fluid pressure supports the majority of the joint loads. Interestingly, the model indicates differences between the time history of joint contact loads and pore pressures, suggesting variations in the distribution of loads between the fluid and solid phases of the growth plate tissue during gait. Regional variations in fluid pressures also suggest significant fluid flow within the growth plate. In addition, a tension-compression non-linearity in growth plate material properties may be more appropriate than transverse isotropy to resist localized vertical tensile stresses in the growth plate. Our ongoing studies investigate altered joint loading in the rabbit knee to study the relationship between mechanical stresses and bone growth. Considering the entire gait cycle in a poroelastic model provides important insight on the time history of this influence and other parameters such as fluid pressure and flow.

**References**:

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