**Introduction:** Osteogenesis imperfecta (OI) is a heritable bone fragility disorder characterized by skeletal deformities. A prevalence of 1 in 5,000 to 1 in 10,000 has been suggested [1]. It affects an estimated 20,000 to 50,000 people in the United States [2]. OI is clinically classified into several forms. Type I is the mildest and most common form. Patients with type I are community ambulators but are susceptible to bone fracture and muscle weakness [2]. Type II (lethal) is the most severe form of the disease. Type III is the most severe form of OI compatible with life. Persons with OI type III often experience about 100 prepubescent fractures. Type IV falls between types I and III in terms of severity. Patients exhibit mild to severe bone fragility, moderately deforming bones and variable short stature [1]. More recently types V, VI and VII have been described from children previously classified with type IV. Underlying genetic defects remain to be defined. Treatment strategies in OI are generally personalized based on motor function, functional needs and fracture risk. However, fracture risk is difficult to evaluate and is very clinician dependent. The goal of this project is to create a patient-specific model of an OI type I femur for fracture risk assessment using finite element analysis (FEA), kinetic gait data and bone material property data gathered from nanoindentation tests.

**Materials and Methods:** The fracture prediction models are created and analyzed in ABAQUS/CAE (SIMULIA, Providence, RI) using tetrahedral elements. The femur model originated from the standard femur, which was available through the International Society of Biomechanics (ISB) website [3]. The standard femur is altered through nodal manipulation to match a specific OI type I subject’s right femur morphology based on a coronal plane X-ray. OI bone material properties are input as an isotropic linear elastic solid. Young’s modulus is 19 GPa and Poisson’s ratio is 0.3 based on nanoindentation testing of children and young adults with OI [4]. Loading conditions are based on gait kinetics and muscle loading data [5]. A model is created for the maximum loading during each of the seven phases of the gait cycle (Perry) for three clinical gait trials. Moments and forces from the gait trials are applied at the femoral head and condyles. Muscle forces are applied based on activation during each gait phase with force values calculated as a percentage of body weight [5]. The attachment points are based on standard anatomy. The muscle force lines of action are based on attachment to adjoining skeletal structures and limb position from the gait analysis kinematics. The model is analyzed for maximum von Mises stress, which is compared to the fracture criteria of 140 MPa.

**Results:** The quantitative results of the fracture risk assessment model include maximum von Mises stress. The stress results are graphically displayed in Figure 1.

**Discussion:** The model analysis indicates that the specific OI type I subject is not at risk for femoral fracture during normal gait. This is consistent with the subject’s clinical history of no femoral fractures. It shows the highest risk of fracture during normal gait occurs at mid stance (MSt), which is consistent with loading levels seen in clinical motion analysis. The benefit of this initial model is the development of a repeatable methodology for creating a patient-specific FEA model to assess femoral fracture risk. A patient-specific model with material properties from nanoindentation and applied loading based on physiologic conditions and gait analysis offers an improved method for assessing fracture risk in OI. Improved fracture prediction in turn may allow more effective clinical intervention including activity modification and assistive device recommendations. Ultimately, the proposed FEA model could offer a more reliable tool to enhance the clinician’s ability to more effectively treat OI.

**References:**

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