Healthcare Innovations
How practice has changed

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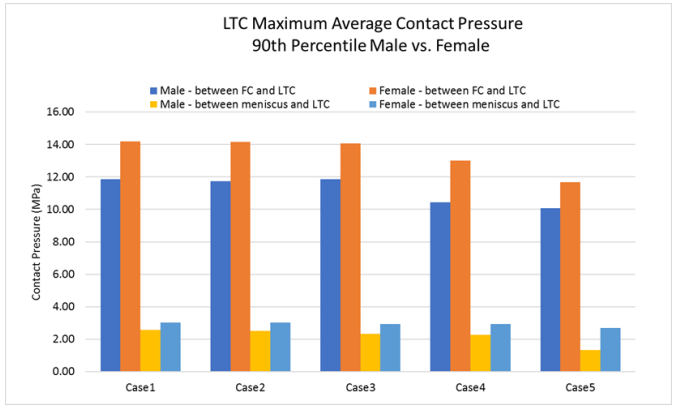
Increased cartilage pressure exposes female athletes to greater risk of osteoarthritis: A dynamic finite element study

Deniz Erbulut[1] , Nick Green[1], Kevin Tetsworth[1] 1. Herston Biofabrication Institute

Purpose: The focal articular cartilage defect is mainly seen in the knee joint of active athletes and remains a significant clinical problem [1,2]. Mechanical overloading causes considerable damage to the collagen network of articular cartilage. Thus, it is necessary to place a high emphasis on the prevention of articular cartilage defects caused mostly by sports activities, as cartilage defects can eventually progress to osteoarthritis (OA). The magnitude of tibial cartilage contact pressure developed in the knee joint during sports activities under subfailure ACL injury loading is currently unknown. We hypothesized that landing during sport activities, implication for subfailure ACL loading, would generate greater contact pressures (CP) at the lateral knee compartment. The objective of this study was to analyze tibiofemoral articular cartilage contact pressure magnitudes in females and males, under clinically relevant noncontact ACL subfailure loadings including knee abduction moment, internal tibial torque, anterior tibial shear forces, and impact during landing.

Methods: Tibiofemoral cartilage contact pressures (TCCP) under clinically relevant anterior cruciate ligament subfailure external loadings were predicted using four dynamic explicit finite element (FE) models (2 males and 2 females) of the knee. Bipedal landing from a jump for five cases of varying magnitudes of external loadings (knee abduction moment, internal tibial torque, and anterior tibial shear) followed by an impact load were simulated. The models were validated against an in vitro study which was conducted by Bates et al. [19]. Impact value of 4158 N which is equivalent of the drop load of half a body weight (bipedal landing) from 30 cm were used. The loadings included knee abduction moment (KAM), anterior tibial shear force (ATS), and internal tibial rotation moment (ITR) and were matched to the corresponding in vivo kinetic measurements previously undertaken.



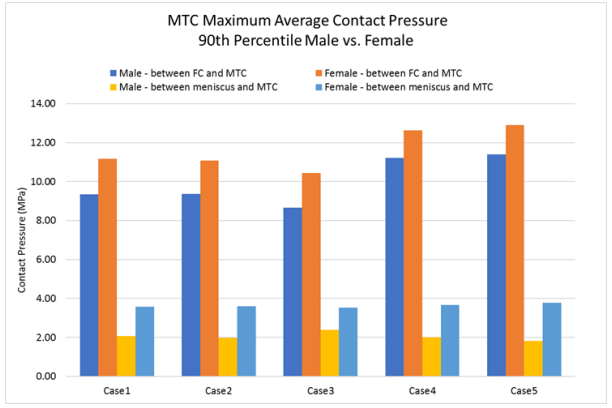


Figure 2: The maximum of average contact pressures (total contact force / total contact area) in lateral compartment for 90th percentile male and female models for Cases 1-5

Results: Lateral TCCP from meniscus (area under meniscus) and from femur (area under femur) increased by up to 94% and %30 respectively when external loads were incorporated with impact load in all the models compared to impact-only case. In addition, FE model predicted higher CP in lateral compartment by up to 37% (11.87 MPa versus 8.67 MPa) and 52% (20.19 MPa versus 13.29 MPa) for 90% and 50% percentile models, respectively. For the same percentile populations, CPs were higher by up to 25% and 82% in smaller size models than larger size.

Conclusions We showed that subfailure ACL loadings obtained from previously conducted in vivo study led to high pressures on the tibiofemoral cartilage. This knowledge is helpful in enhancing neuromuscular training for athletes to prevent cartilage damage. We can conclude that the decrease in abduction moment, which would be possible with neuromuscular training, may reduce the risk of excessive lateral compartment contact pressure and associated articular cartilage injury during sports activities.

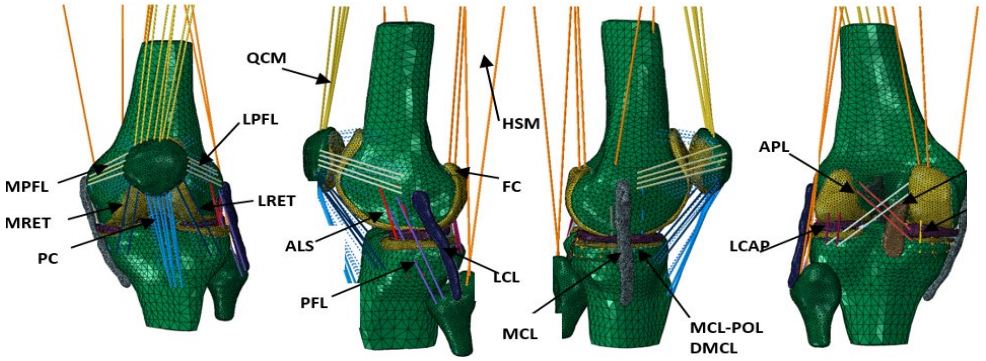
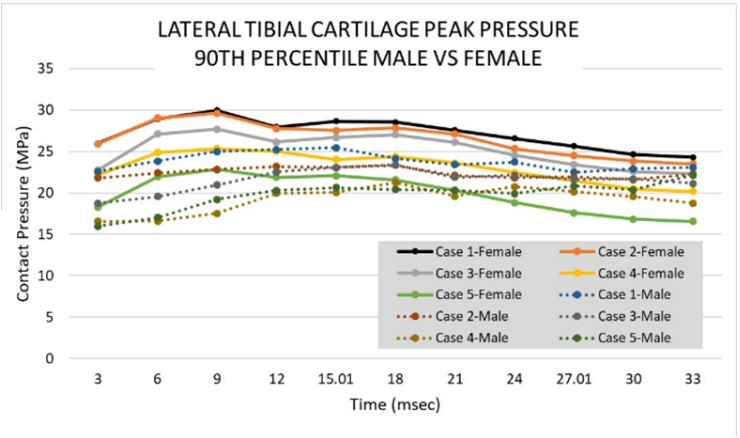


Figure 1: FE models with all the components



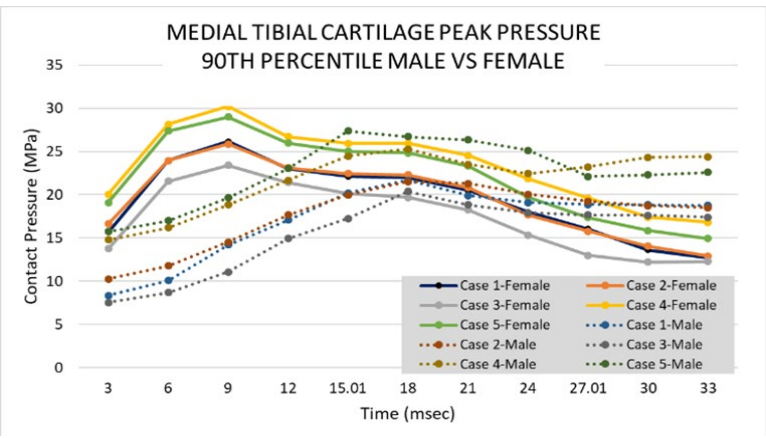


Figure 3: Peak contact pressures for 90th percentile male and female models within the first 33ms after impact for Cases 1-5 (A) Tibial lateral compartment (B) Tibial MC

Scaffold – Fluid Flow (Semi-Closed)

Scaffold – 53.5% porosity, 25mm scaffold size (Scaled) (Open structure)