3-D FEA of Fracture Tolerance of the Patella to Oblique versus Direct Impacts on the Knee at Various Orientations

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Keywords: “Patella”; “Fracture Tolerance”; “Q-angle”; “Impact Angle”; “Knee Injury”

Abstract

In recent years, the total number of deaths in automobile accidents has declined probably due to mandatory seatbelt use and airbag technology. Yet the frequency of knee injuries in automobile accidents is stagnant and constitutes 10% of all injuries in frontal crashes resulting in $21.5 billion in annual medical costs. As a method of prevention of serious injury, applications that involve impacts to the knee should be designed such that they consider the fracture tolerance of the patella with respect to the knee orientation as well as impact angle.

To this end, this research studies how the knee abduction angle and impact line of action on the patella affects the fracture tolerance of the patella. This study also takes into account the changing area of support on the retropatellar surface provided by the articulating distal femur due to adduction or abduction of the knee.

The FEM used in this study was developed from MRI’s taken from a 2003 Stapp Car Crash Conference study by Meyer and Haut in which a similar study was conducted using experiments. The resulting model was then meshed and subjected to impacts at various angles in various knee positions including the angles and positions used in the study by Meyer and Haut for the purpose of validating the model.

In general, this research shows that reduction of fracture tolerance in the patella occurs in all angles of impact as the knee becomes more adducted. Additionally, it is also shown that fracture tolerance of the patella becomes reduced in all knee positions as the angle of impact on the patella becomes more medial.