LATERAL BENDING MOMENT THRESHOLD OF THE KNEE JOINT – EFFECTS OF ACTIVE MUSCLES

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1. Research Question / Objective (limit 500 characters with spaces)

Bending moment threshold of knee joint (KBM) in dynamic lateral-medial valgus loading has been estimated using cadaver tests (Kajzer et al. (1999), Kerrigan et al. (2003) and Bose et al. (2004)). Thus, effects of active muscles have not been studied so far. Furthermore, KBM computed by Kajzer et al. is almost three times the values reported in other two studies. Thus, objectives in the present study are to determine KBM for passive loading conditions and then to study the effect of active muscles on it.

2. Material and Methods (limit 1000 characters with spaces)

Simulations have been performed for Kajzer's bending test and Kerrigan's 4-point bending test conditions using passive version of PMALE (Soni et al. 2008). A horizontal section plane has been defined through the knee joint to compute KBM in these simulations. Additionally, in the simulation of Kajzer's test, reaction forces have been recorded at two femur support locations which are then used to calculate KBM using the "correct" and the "incorrect" formulas as suggested by Konosu et al. (2005).

Further, to estimate active muscle effects, full scale car-pedestrian impact simulations have been performed using PMALE (having 42 active muscles in each leg) and front structures of a car FE model. Here, PMALE is configured as standing freely on a rigid ground in a gravity field. Car front is propelled with a speed of 25 kmph towards PMALE in lateral direction. Two sets of simulations, viz, 1) with deactivated muscles 2) with activated muscles (including reflex action) for an unaware pedestrian have been performed. Knee bending moments for different levels of muscle activation are compared.

3. Results (limit 1000 characters with spaces)

It is observed that in the simulation of Kajzer's test, values of KBM calculated using the knee section (115 Nm) and the "correct" formula (92 Nm) are fairly close whereas, it is significantly higher when calculated using the "incorrect" formula (326 Nm). In the simulation of Kerrigan's test, knee bending moment estimated by the model (135 Nm) is in the range of bending moment values (115 – 155 Nm) obtained in the tests. Furthermore, it is observed that with activated muscles (135 Nm) knee bending moment has increased by approximately 1.4 times as compared to deactivated muscles (96 Nm).

4. Conclusions (limit 1000 characters with spaces)

Following conclusions can be drawn from the present study

1) It is observed that KBM calculated using the "incorrect" formula (326 Nm) is close to the value reported by Kajzer et al. (1999) (388 Nm). On the other hand, KBM calculated using the "correct" formula (92 Nm) is close to the KBM computed through the section defined at knee joint (115 Nm) as well as to the results of cadaver test done at UVA. This confirms the observation by Konosu et al that the bending moment calculations of Kajzer et al. were at fault.
2) Muscle activation has a significant contribution to the knee bending limit. Muscle contraction can increase the bending moment threshold of the knee joint by as much as 40%.

5. What does the paper offer that is new in the field? (500)

The current study investigates the effect of active muscle forces on lateral bending stiffness of the knee joint in dynamic lateral-medial valgus loading using explicit simulations.

References

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