KNEE AIRBAG EFFECTS ON 5%ILE FEMALE

A. Malczyk, I. Kalliske
Takata-Petri AG, Engineering Center For Automotive Safety Berlin

Keywords: Airbags, Knees, Legs, MADYMO

OBJECTIVES OF THE RESEARCH

Knee airbags are being introduced for enhanced protection in frontal automotive crashes (Aliabadi, 1999, Steiner, 1999). Dynamic in-position tests and static out-of position tests were conducted to assess their influence on biomechanical loading of the lower extremities of a small adult occupant. Furthermore, a numerical simulation model of the knee airbag was established for these scenarios.

METHODOLOGY

In-position performance was compared for a Hybrid III 50%ile male and 5%ile female dummy in sled tests. In addition, static out-of-position tests addressed loading of the lower extremities of the Hybrid III small female to analyse the effect of different knee airbag (KAB) module positions that may occur in different vehicle interior lay-outs. Each configuration was tested twice. Based on these test data a MADYMO model for the KAB was established and validated to conduct a parameter study under in-position and out-of-position conditions.
Sled tests were run with belted 50%ile male and 5%ile female dummy in the driver position in a typical compact car environment exposed to an US-NCAP crash pulse. The standard restraint system was supplemented by a production KAB with a hybrid inflator (160 kPa's of tank pressure in 28.3 liter tank) and a 14 liter silicone-coated cushion without vent holes. Its tubular shape is designed to cover the upper portion of the tibias and knees of a 50%ile male. Both dummy types were equipped with instrumented lower legs and were positioned with the seat according to their respective FMVSS 208 specifications (Federal Register, 2001).
In the static out-of-position tests the 5%ile female dummy was placed with its knees against the lower instrument panel including the KAB module. Seating height was varied to represent three different vertical alignments of the lower leg with the KAB module (Fig. 1). Dummy posture and support by seat and toeboard was maintained. The instrument panel structure was reinforced to facilitate later simulation model validation. While the Hybrid III's lower legs were not designed for direct anterior-posterior contact distribution of the load by the cushion and the use of a flexible, low-weight airbag door allows comparison of the aggressiveness caused by different module mounting positions and airbag characteristics.

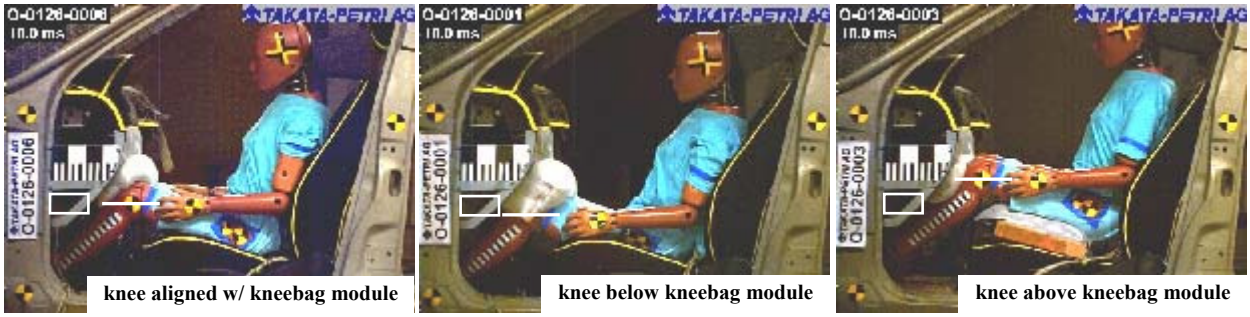

Fig. 1 - Out-of-position test configurations, deployment at 10 ms after KAB activiation

Out-of-position numerical simulation included detailed modeling and validation of the instrument panel area, seat, toeboard in MADYMO 5.4.1 rigid body system and utilized a standard 5%ile female model. The KAB module and door were modeled using MADYMO FE. Loadings and kinematics were validated for the configuration „knee aligned with kneebag module" first but showed good correlation also for the other two positions.

RESULTS AND DISCUSSION

The results were compared with scaled injury limits proposed by Kuppa et al. (2001) assuming a 25% risk of AIS 2+ injury. Since the dummy is not biofidelic for this type of loading occurrence of certain injury types, e.g., to the ligaments, may not be reflected.
Out-of-position tests showed clear differences in peak values depending on the vertical alignment with the KAB module (Fig. 2). The lowest loadings were found with the knee positioned below the KAB because the unfolding cushion inflated partly above the knee. Axial tibia forces were below those obtained in sled tests, Tibia Index values were in a similar range. Apart from measured loading there is a general difference in kinematics between

the in-position case where the legs impact the properly positioned KAB cushion and in an out-of-position scenario where the deployment path of the inflating cushion is obstructed and tends to spread the occupant's legs.

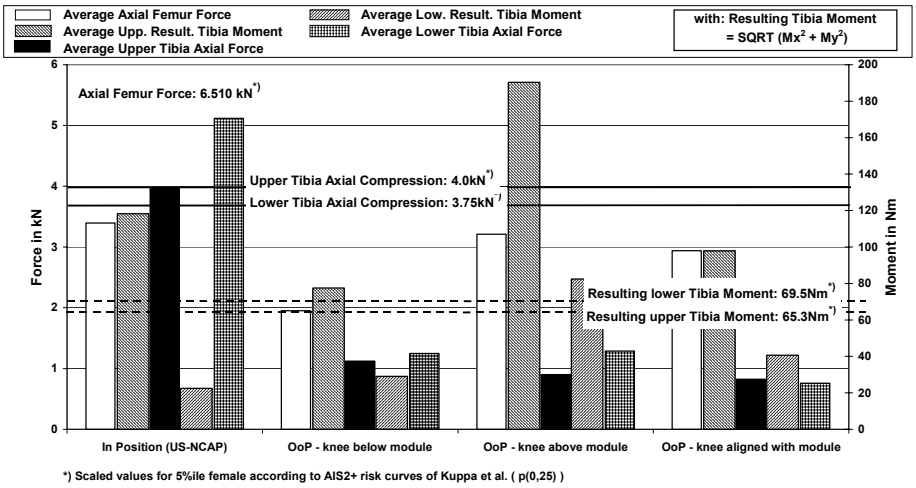

Fig. 2 - Major lower leg loadings in comparison to IARV's for 25% AIS 2+ injury for 5%ile female

The validated simulation model of the KAB was then used for parameter studies that varied inflator onset and maximum tank pressure. These calculations indicate that reduction of inflator onset by 20% would reduce injury values slightly in out-of-position and even improve lower leg loading for the in-position 5%ile (Fig. 3). This may be explained by the fact that the investigated KAB is designed primarily for unbelted occupants.

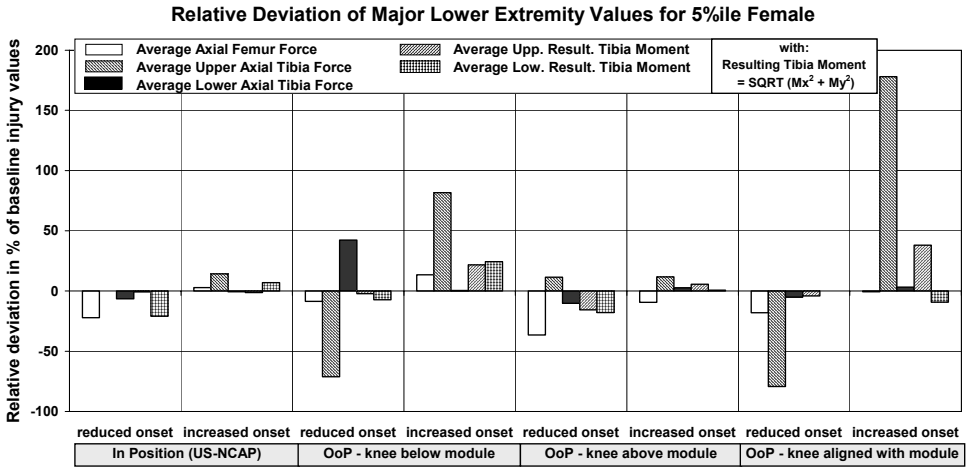

Fig. 3 - Influence of inflator onset variation (+/- 20%) on loading for in-position and out-of-position

CONCLUSIONS

A higher injury risk for the lower extremities can be assumed for small adults due to the influence of knee airbags that are tailored primarily for the restraint of mid-sized occupants. However, the great majority of loading values in static out-of-position tests was not higher than under dynamic in-position conditions. Airbag fold and airbag door tearseam pattern are assumed to play a significant role in out-of-position, too.

REFERENCES

Aliabadi, R. et al., „The Knee Airbag – An Innovative Component for the Control of...", VDI Berichte 1471 Innovativer Kfz-Insassen- und Partnerschutz, VDI Verlag GmbH, 1999, Duesseldorf, pg. 109 – 128

Kuppa, S. et al., „Lower Extremity Injuries And Associated Injury Criteria", ESV Conference 2001, Amsterdam, Paper No. 457

NHTSA (Nat. Highway Traffic Safety Admin.), „Federal Register, Vol. 66, No. 243, 49 CFR 571, Docket No. NHTSA 01-11110, Notice 1", Dec. 18, 2001

Steiner, K. et al., „The Influence of Different Protection Concepts in Regard to the Injury...", VDI Berichte 1471 Innovativer Kfz-Insassen- und Partnerschutz, VDI Verlag GmbH, Duesseldorf, 1999, pg. 129 - 148