

PROPOSAL FOR CORRIGENDUM TO PROPOSAL TO DEVELOP AMENDMENTS TO
GLOBAL TECHNICAL REGULATION NO. 9 (PEDESTRIAN SAFETY)
(ECE/TRANS/WP.29/GRSP/2009/21)

Note: The text reproduced below was prepared by the expert from Japan in order to propose a corrigendum to proposal to develop amendments to global technical regulation No. 9 (ECE/TRANS/WP.29/GRSP/2009/21) to eliminate the anterior/posterior cruciate ligament elongations from the performance requirements and state in the preamble that these injury assessment reference values shall be monitored. The modifications to the proposed amendments to global technical regulation No. 9 (ECE/TRANS/WP.29/GRSP/2009/21) are marked in bold or strikethrough characters.

A. PROPOSAL

Paragraph 111., amend to read:

"111. With regard to knee shearing limits, the informal group selected a limit of 6 mm for the EEVC WG 17 pedestrian lower legform impactor, based on the analysis of PMHS by EEVC WG17 and WG10 that showed that a 6 mm shear displacement corresponds to a 4 kN shear force. The 4 kN shear force in the TRL device approximates the 3 kN average peak shearing force acting at the knee joint level that was found associated in the PMHS tests with diaphysis/metaphysis failure. **However, a more recent forensic study investigating detailed injury distribution in pedestrian victims showed that isolated anterior cruciate ligament (ACL) failure was seen in only 2.6 % (4 out of 155) of all victims sustaining knee injuries, and that most of the knee injuries in lateral impact involved valgus bending mechanism. In addition, 3-point lateral bending tests of the knee joint applying a combination of shear force and bending moment resulted in no isolated ACL failure. Although pure shear tests of the knee joint showed isolated ACL failure, all the knees sustained unrealistic bone fractures due to contact between femoral condyle and tibial eminence, and only 2 data out of 3 tests performed in the study can be used for determining an injury threshold. Considering all these recent findings, for the FlexPLI, it is premature to mandate anterior/posterior cruciate ligament elongation requirements. These injury assessment reference values shall be monitored, in preparation for future potential application of the requirements, with a tentative reference value of 13 mm determined from currently available data, subject to further considerations with more biomechanical data.** ~~As for the FlexPLI, a limit of anterior cruciate ligament (ACL) elongation and a limit of posterior cruciate ligament (PCL) elongation at the knee are both set as [(1) 13 mm only for monitoring purposes or nothing because the percentage of isolated ACL/PCL damage in car-pedestrian accidents is very small (3 per cent). Besides only two biomechanical data are available for the ACL/PCL threshold values (JAMA and ACEA opinion), or (2) 13 mm as mandatory threshold value because the current gr 9 sets shearing displacement requirement for the EEVC WG17 pedestrian legform impactor and because of existing though limited biomechanical data (BASt opinion)].~~"

Paragraph 113., amend to read:

"113. ...at the following limits:

For EEVC WG 17 pedestrian lower legform impactor

Maximum lateral knee bending angle $\leq 19.0^\circ$;

Maximum lateral knee shearing displacement ≤ 6.0 mm;

Maximum lateral tibia acceleration $\leq 170g$.

For FlexPLI

Maximum MCL elongation $\leq [22]$ mm;

Maximum Tibia bending moment $\leq [340]$ Nm;

~~Maximum ACL and PCL elongation $\leq [13$ mm only for monitoring purposes or nothing or mandatory].-~~"

Paragraph 5.1.1.2., amend to read:

"5.1.1.2. When tested in accordance with paragraph 7.1.2., the maximum dynamic medial collateral ligament elongation at the knee shall not exceed [22] mm, and the dynamic bending moments at the tibia shall not exceed [340] Nm. ~~[The maximum dynamic anterior cruciate ligament and posterior cruciate ligament elongation shall be monitored with a reference value of 13 mm or nothing or mandatory with a reference value of 13 mm].~~ [In addition, the manufacturer may nominate bumper test widths up to a maximum of 264 mm in total where the tibia bending moment of the FlexPLI shall not exceed TBD Nm]."

B. JUSTIFICATION

Teresinski et al. (2001) investigated detailed injury distribution in 357 fatal pedestrian victims using a forensic approach. They found that isolated anterior cruciate ligament (ACL) failure was seen in only 2.6 % (4 out of 155) of all victims sustaining knee injuries. They also investigated statistical significance of correlation between loading directions and injury mechanisms and found that most of the knee injuries in lateral impact involved valgus bending mechanism. In addition, Figure 8 in the paper clearly illustrates the sequence of knee ligament failure in valgus bending, with initial MCL failure followed by ACL failure and then failure of the posterior cruciate ligament (PCL).

Bose et al. (2004) performed 3-point lateral bending tests of the knee joint to apply a combination of shear force and bending moment to the knee joint, based on the findings from Teresinski et al. that showed that this loading mechanism is most likely to happen in real world car-pedestrian crashes. They performed 8 tests by varying the ratio of applied bending moment to shear force. No ligamentous damage was seen in 1 case, and the medial collateral ligament (MCL) failed in the rest of 7 cases. Failure of the ACL was seen in 1 case accompanied by MCL failure, resulting in no isolated ACL failure.

Bhalla et al. (2003) performed pure shear tests of the knee joint. They performed 3 tests and one of them was a repeated test that cannot be used for determining injury thresholds. Isolated ACL failure was seen in all of the 3 tests, and all the knees also sustained osteo-chondral fractures due to contact between the inside surface of the femoral condyle and the tibial eminence, which are not seen in real world car-pedestrian crashes. The estimated shear displacements at ACL failure from the 2 tests (single test to failure) were 17.8 mm and 12.7 mm. It should be noted that there is

a consensus among biomechanics researchers that at least 10 data points are required for injury probability functions not to be statistically insignificant, meaning that an injury probability function cannot be developed using the above-mentioned only 2 data in an appropriate manner. Taking these findings from recent forensic and biomechanical studies into consideration, Japan proposes to eliminate ACL/PCL elongation thresholds from the performance requirements and state in the preamble that these injury assessment reference values shall be monitored. More information relevant to this justification can be found in a supplemental informal document (GRSP-46-xx).

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