

WHAT MALIBU MEANS FOR ROLLOVER ROOF CRUSH CASES

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What is Malibu?

Since the early 1970s, General Motors has taken the position that roof crush does not cause occupant head and neck injuries in rollovers. In 1975, General Motors research engineer, Dr. Edward Moffatt, presented a paper to the American Association of Automotive Medicine in which he presented this position as a scientific theory. He said that since an occupant's head is in contact with the roof when the roof hits the ground, the subsequent collapse of the roof cannot exacerbate the forces imposed on the head and neck by the occupant's diving toward the ground, and the torso's momentum augmentation from that dive.

In 1983 and 1987, GM conducted two series of rollover tests using 1983 Chevrolet Malibu sedans according to the procedures spelled out in FMVSS 208. In those tests, a vehicle with Hybrid III dummies in the front outboard seating positions is projected laterally from a dolly moving at 33 mph. They rolled at least 3 complete rolls in each test. The first series used unrestrained dummies. In four of the cars, GM installed a roll cage to prevent roof crush. The remaining four tests were conducted using standard Malibus. The second series was similar except that the dummies were all restrained.

GM engineers wrote papers on each of these series in which they claimed that the tests proved Moffatt's theory. Unfortunately, the papers were seriously flawed by the selection of an unrealistically conservative injury criterion for neck injury and by outright misinterpretation of the evidence. Fortunately, we have been able to obtain sufficient Malibu data and film from to permit a more scientific analysis of the results. This data does not support the Moffatt theory. Rather, it provides a basis for a plaintiff's case that roof crush *is* specifically responsible for rollover head and neck injuries.

The Malibu Head Strikes

In the first Malibu series, the dummies sustained numerous head impacts with forces between 2,000 and 6,000 N, measured at the top of the dummy's solid rubber neck. Since the dummies were all unbelted in this series, they were mostly out of position by the time the roof crushed in the second or third roll.

The number and distribution of impacts within the 2,000 to 6,000 N range were approximately the same among the cars with and without roll cages. Only two impacts were sufficiently severe to injure a human head or neck. Both were in the cars with unreinforced roofs and both coincided with major collapse of the vehicle's roof. [Show video of 4L4 and 1L3.]

In the second Malibu test series all dummies were safety belted. The belts held them in their seating positions, so that their heads were positioned near the roof rail where they were more likely to receive blows from the collapsing and buckling roofs of these cars. The four head impacts in which the force on the neck exceeded 7,000 N were again all in cars without roll cage reinforcements. They ranged from 7,500 to 13,300 N.

[Show video of 3L2, 3L3, 4L2, and 7L4.]

In the first three of these impacts, the mechanism of injury producing intrusion was lateral roof collapse. The roof is forced sharply to one side and down by friction with the ground because the roof is moving laterally with respect to the ground when it strikes the ground. The speed of the intruding roof is several times the speed with which the dummy is dropping vertically toward the ground. The degree of neck compression is obvious from these films. Showing a jury how stiff an actual dummy neck is makes it clear how much force is required to depress the neck to this degree.

In the last case, the head is forced into the neck by the roof's inward buckling as it rolls over the ground. Again, the speed of the roof intrusion relative to the dummy is greater than the speed at which the dummy is dropping to the ground.

We can tell that the Moffatt theory does not hold because of the timing of the peak neck forces which lag roof touchdown by 5 to 55 ms the time of roof impact. [Show graph of neck injuries versus time.]

The dummy does not suffer injury producing forces if the roof does not collapse. [Show the video of 2L1.] The quite regular, low force motion of the head when the roof does not collapse is shown in this diagram [show my diagram showing the vehicle at 1/8 roll instances].

The key to effective use of the Malibu tests is to convince the jury that (1) rollovers are essentially low force events despite the drama of a rollover and the superficial damage that it does, (2) that the human body can survive the forces of a rollover if they are not amplified by a collapsing or buckling roof, and (3) FMVSS 216 does not ensure an adequately strong roof and that most cars and light trucks on the American roads have woefully weak roofs that cannot withstand even the modest forces of a rollover without failing in a most catastrophic manner.

One need only consider what happens in racing crashes where the driver is protected by a roll cage, a 5 point safety belt, and a helmet. [Show video of racing pickup roll.] A production car could provide these protections with a stronger roof, a well-designed safety belt, and the interior padding now required by regulation.

Furthermore, tests conducted by Don Friedman and his son Keith show that if the roof does not collapse, a belted human can easily withstand a drop of up to 3

feet. The safety belts absorb much of the impact force, and the head and neck can withstand the remaining force without injury or even significant discomfort. [Show video of Friedman drop tests.] For courts that require demonstration of alternative designs or technical feasibility, the evidence from racing and these drop tests is very useful.