

# COMPARISON OF EURONCAP ASSESSMENTS WITH INJURY CAUSATION IN ACCIDENTS

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## ABSTRACT

In this analysis, body-region injury-risk ratings determined for consumers by EuroNCAP are examined from the perspective of real contemporary accidents. The aim is to compare the real-life experience of various occupants with the objective and subjective conclusions that are presented by EuroNCAP. The accident sample, of several car models, is taken from the Co-operative Crash Injury Study (CCIS), and is comprised of crashes similar to the impact tests. CCIS is the in-depth project that analyses a sample of severe car accidents and provides the foundation of much of the UK's secondary car-safety research programme.

The European New Car Assessment Programme (EuroNCAP) has had a significant influence on the way that cars are designed. Objective measurements from frontal and side impact tests of each vehicle are augmented by assessments based on real-world accident investigation experience.

Using real-world car accidents that are as similar as possible to the EuroNCAP impact tests, detailed accident cases are analysed to determine the injuries to the occupants; the body-region severities; the causes of the injuries; and the global patterns of damage to the vehicle.

## INTRODUCTION

### Aim of this comparison

It is important to find out whether the car safety assessments based on these crash tests really are indicative of the injury risks of motorists involved in real accidents.

The comparison described in this report aims to provide analysis addressing two distinct issues in a comparison of EuroNCAP with injury causation in accidents. Firstly, the comparison assesses overall features of individual models, and relates these to the justification of individual modifiers in frontal impact. Secondly, for side impact, the pattern of injury to the occupants is compared with the relative body region assessments made by EuroNCAP.

There are likely to be few matches of exact impact type, precise impact severity and identical vehicle model in any real-world accident studies. For this reason, this in-depth comparison does not extend to a statistical "validation" of the overall star ratings for particular models relative to each other. Indeed, comparison in this report is limited to the vehicle models that are found in the CCIS database, having suffered impacts similar to those EuroNCAP seeks to address. A recent study into the differences in casualty severities in cars with different EuroNCAP ratings does however address this issue. Lie and Tingvall, (2000) reported that the overall indication of the safety level, provided by EuroNCAP, is a valid prediction – at least when considering the star rating and severe to fatal injuries.

### EuroNCAP and Accident Data

The European New Car Assessment Programme (EuroNCAP) has been operating since 1996. Its purpose is to give consumers objective data on how new vehicles behave under crash conditions. In EuroNCAP's frontal impact test, the vehicle strikes a deformable barrier at 40 percent overlap. This produces vehicle damage which is closely comparable to that suffered in partial overlap car-to-car impacts. The test speed is greater than that used in the legislative test, so as to address a higher severity of accident. Relating the test severity to that of accidents was examined in detail by Wykes et al (1999) and is not considered from this small sample. In the side impact test, a mobile deformable barrier strikes the stationary test vehicle at 90°.

The injury risk, in each of the tested vehicles, is quantified from measurements made by instrumented dummies in the vehicles. In frontal tests, modifiers can augment these measurements. The modifiers are applied as a result of a post-impact inspection by an experienced accident investigator. The main aims of the assessments include relating the information from the test

- to a wider section of the population of occupants than can be represented by a 50<sup>th</sup> percentile male dummy;

- to occupants whose seating position differs slightly from the dummy position, and
- to a range of impacts in which one or more of the parameters that characterise the impact was slightly different from those of the carefully controlled and therefore repeatable specification of the EuroNCAP test.

For the period of EuroNCAP covered by this work, modifiers were applied for the following occurrences:

- Head: Unstable contact with the airbag  
Steering wheel displacement
- Chest: Steering wheel contact  
A-pillar displacement  
Loss of passenger compartment integrity
- Upper Leg: Variable loading  
Localised load
- Lower leg: Brake pedal vertical movement
- Ankle/Foot: Footwell rupture.

The modifiers are being updated to include such things as the head bottoming out on the airbag, and movement of the other pedals.

Individual body region assessments are quoted in EuroNCAP's published results, with a protection level being assigned to each of the body regions.

TRL has several sources of data on real-world accidents. Two studies give particularly detailed data on secondary-safety of passenger cars. The Fatal Accident Database contains over 7,000 very severe crashes but, due to the data capture method employed, the most recent accidents in the database took place in 1995. The Co-operative Crash Injury Study (CCIS) database includes around 1500 vehicles per year. Though sampled with a strong bias to fatal and serious outcomes, a considerable proportion of the CCIS database is made up of slight injury cases. The sample size for this work is reduced considerably by the necessary skew towards the newest cars. However, as the accidents are much more recent than those in the Fatal database, there is more likelihood of finding models of cars tested by EuroNCAP. Also, compared with the Fatal database, CCIS contains vastly more detail on the impacts, the vehicle deformation and the injuries sustained.

## Methodology

The CCIS database contains a large number of accidents, but when one specifies exact car model years and variants, and exact impact severities,

impact locations and degrees of overlap, the number of possible cases for review reduces. For example, engine size was allowed to vary slightly from that of the tested car, but Diesel variants were excluded on the basis that the engine would be different both in dimensions and mass. However, for side impacts, more latitude was allowed in engine size, since the engine will have less influence on the crash characteristics in a side impact. Adherence to the number of side doors on the vehicle was maintained to ensure the best correlation.

Cars manufactured prior to or after the model year specified in the EuroNCAP report were also excluded initially, although some older cars were included where necessary, provided it could be determined from photographs that they were the same model as the EuroNCAP car. It is recognised that there are vehicle developments within the production of individual models. Impact direction was allowed to vary by up to one "clock point" either side of that used in EuroNCAP (i.e. 11-o'clock to 1-o'clock for frontal impacts) while impact location was strictly adhered to. In frontal impacts, all degrees of overlap were allowed. In side impacts, impacts to the front or rear wing areas without involving the passenger compartment were excluded. Vehicles with no available impact speed estimates were also excluded.

The impact severity estimates in CCIS are  $\Delta v$  and ETS. The latter is intended for use when the opposing vehicle's details are not known, and gives an estimate of the speed with which the subject vehicle would have to hit a rigid barrier in order to suffer the same amount of damage. Work has been done, using EuroNCAP crashed cars, to obtain the ETS of the tested cars. In each frontal impact case, the calculated ETS value was less than the 64km/h at which the car was crashed, due to the energy absorbed by the barrier. Calculations on the side impact cars gave ETS values of approximately half of the 50km/h closing speed, as expected due to the energy absorption of the barrier. (Wykes et al, 1999).

Injury severity is assessed using the 1990 revision of the Abbreviated Injury Scale (AIS). These assessments are objectively made, based on medical information about the individual injuries.

In total, 75 cases from CCIS were found to have a suitable match with the criteria that identified crashes similar to the EuroNCAP frontal impact test. These had a range of overlaps and severities within the boundaries described, and spanned some 27 different

car models. Twenty further CCIS cases had a suitable vehicle match with the EuroNCAP side impact test, spanning thirteen different models. These had a range of specific characteristics and severities within the boundaries used to select matching cases, and spanned thirteen different car models (Table 1).

**Table 1.**  
**Number of vehicle models in each sample**

Vehicle Model	EuroNCAP Star rating	Frontal impact sample	Side impact sample
Fiat Punto	**	4	1
Ford Fiesta	***	2	3
Nissan Micra	**	2	1
Renault Clio	**	3	0
Rover 100	*	2	0
Vauxhall Corsa	**	6	2
Volkswagen Polo	***	2	0
Audi A4	**	1	1
BMW 3 series	**	1	1
Citroën Xantia	**	1	2
Ford Mondeo	***	8	2
Mercedes C180	**	2	0
Nissan Primera	***	2	0
Peugeot 406	**	3	2
Renault Laguna	***	3	0
Rover 620	**	4	0
Saab 900	**	1	0
Vauxhall Vectra	***	9	2
Volkswagen Passat	***	1	0
Audi A3	****	1	0
Citroën Xsara	***	1	0
Daewoo Lanos	*** flagged	2	0
Fiat Brava	**	1	0
Honda Civic	*** flagged	3	1
Hyundai Accent	** flagged	0	1
Peugeot 306	***	7	1
Renault Megane	****	2	0
Toyota Corolla	***	1	0

## FRONTAL IMPACT COMPARISON

### Steering Wheel Displacement (Related to Head Injury Risk)

Steering wheel movement was frequently observed in the cases studied for this comparison.

The Volkswagen Polo steering wheel moved only in the more severe of the two cases studied, but upwards by the same amount as that in the EuroNCAP tested car. In the BMW 3 series, EuroNCAP noted steering wheel movement as an important feature and displacement was observed in a case-study impact of considerably lower severity. Similarly, the Citroën Xantia from CCIS demonstrated displacement of the steering wheel at a much lower impact severity. The direction and amount of displacement differed from the test results, but residual displacement highlighted by EuroNCAP is evident in the real crash. Figure 1 shows the movement of the Xantia's steering wheel.



**Figure 1. Xantia steering wheel, showing inboard and upward movement.**

The Nissan Micra EuroNCAP test revealed steering wheel intrusion of 60mm. In the two case studies, there was no movement in the less severe but low overlap case, and just 30mm (upwards) in the more severe case. The latter had an overlap similar to the test, but it was to the passenger side of the car. Conversely, the EuroNCAP findings were absent in some of the cases. Undoubtedly this is in part due to the relatively low severity of many of the impacts. The four Rover 600 cases studied were all much less severe than the test (approximately half the ETS, or one quarter the energy absorbed) and only one suffered any significant compartment damage. For the Fiat Puntos, three cases of the four had full overlap, and all four were of low severity. This produced steering column movement in only one of the Puntos. Even the highly rated Renault Megane suffered some steering wheel intrusion in the test, but in each of the case studies the overlap was full and all such movement was controlled.

One of the two Ford Fiesta case studies was of severity approaching that of the EuroNCAP test. Here, the steering wheel did not move, possibly because the impact overlap was fully distributed

across the car. In the other Fiesta study an 88 percent overlap occurred in a low severity impact and again the steering wheel movement seen in EuroNCAP was absent. The EuroNCAP Peugeot 406 suffered 140mm of rearward steering wheel movement, however the larger overlap and (in two of the three case studies) bias to the passenger side of the car resulted in the absence of such movement. Eight of the nine Vauxhall Vectra case studies also showed a lack of the steering wheel movement seen in the EuroNCAP test – all were relatively mild impacts with the exception of one catastrophic case. That case had a higher ETS and lower overlap, causing gross steering wheel intrusion involving the chest and abdomen rather than the head.

#### **Steering Wheel Contact (Related to Chest Injury Risk)**

The most severely impacted Vauxhall Vectra led to an injurious contact of the driver's chest and abdomen with the steering wheel. This driver suffered AIS4 injuries to the chest. These were a tear of the thoracic aorta, bilateral haemothorax and multiple contusions to both lungs. Although seat belt loading will have been significant for this occupant, contact with the steering wheel was clearly severe. EuroNCAP does not rate the abdomen in frontal impacts, and the steering wheel is unlikely to make injurious contact with the abdomen of a restrained driver except in a case such as this rare one.



**Figure 2. Damage to Vectra steering wheel rim, due to loading from contact with driver's chest.**

In another fatal crash, one of the six Vauxhall Corsas, the vehicle suffered an impact of approximately the same severity as the EuroNCAP test but with a larger overlap. This resulted in considerable intrusion of, and occupant contact with, the steering wheel and fascia. The impact was with an HGV, but both of the Corsa's longitudinals became involved, crumpling and bending to absorb energy.

Chest contact with the steering wheel, caused by bottoming out through the deployed airbag, resulted in multiple bilateral rib fractures, and AIS2 abdominal injuries. The driver was a 54 year old 92kg male, and though his belt use cannot be confirmed it is likely to have been used as the rescue services cut the belt webbing to extricate the driver. EuroNCAP found significant intrusion of the steering wheel and fascia in the Corsa's frontal test, which is evident in this impact, and downrated the chest protection rating accordingly.

#### **Compartment Intrusion: A-Pillar Displacement and Fascia Intrusion (Related to Chest Injury Risk)**

Intrusion of the fascia to some extent was present a large proportion of the EuroNCAP tests for the models studied here. Notable exceptions were the Volkswagen Polo, Vauxhall Vectra, Audi A3 and Renault Megane. Apart from the one catastrophically damaged Vectra, fascia intrusion was not observed as a problem for the drivers of the cars in this list and there was little or no intrusion of the fascia that was considered hazardous to the chest. The Polo and Megane impacts were of lower severity and higher overlap than the EuroNCAP test, and no conclusion can be drawn as to how well the fascia would be controlled in a more severe impact. The Audi A3 did suffer 210 to 260mm of intrusion of the driver's fascia, however this was a severe impact in which there was only 27 percent overlap with the other car.



**Figure 3. Audi A3 showing fascia intrusion in a low overlap impact.**



The driver of the Audi was a 35 year old male of 1.80m stature and 89kg mass. Restrained by seat belt and airbag, he suffered only AIS1 injuries in this impact. Along with strain injury to the cervical and lower thoracic spinal regions, he had a right shoulder abrasion from the seat belt, and a laceration to the tongue from biting it at some stage in the impact. There were no injuries to the driver's chest, and the evidence for loading of the upper body is limited to the shoulder abrasion which was undoubtedly caused by the restraint system.

#### **Lack of Compartment Integrity: Facia Rail Detachment (Related to Chest Injury Risk)**

For the models that are studied in this report, EuroNCAP reported compartment instability due to door failure or facia detachment in the Fiat Punto, Renault Clio, Rover 100, BMW 316, Citroën Xantia, Ford Mondeo, Rover 620, Saab 900, Fiat Brava and Hyundai Accent. The Citroën Xsara compartment was on the limit of maintaining its integrity.

This failure of the passenger compartment structure is most clearly demonstrated in the two Rover 100 cases. Although both of these impacts were biased to the passenger's side rather than the driver's side, each had an overlap of approximately 65 percent and a severity comparable to the EuroNCAP test. These cases were remarkable in that the injury severity in each Rover was low. The driver of the car in Figure 4 escaped with small lacerations, while her male front seat passenger was uninjured. The Rover's nearside longitudinal was crushed and bent. There was no energy-absorbing crush of the offside longitudinal, which bent inwards. This bending to the nearside was evident in the roof, as the nearside A-pillar translated backwards and pulled the roof down and across towards the nearside. The passenger door buckled, and split apart in a similar pattern of damage as that seen in the EuroNCAP test car's driver's door.



**Figure 4. Rover 100 compartment failure.**



**Figure 5. Rover 100, showing passenger compartment failure.**

The driver of the Rover in Figure 5 also survived with very minor injuries. There was no front seat passenger. This vehicle shows damage very similar to the previous Rover 100 case. Almost all of the Rover's impact energy was absorbed on the passenger side of the car and the offside longitudinal was bent inboard without any crushing.

#### **Variable Loading or Localised Loading through the Knee (Related to Upper Leg Injury Risk)**

The risk of a localised load to the driver's knees, from stiff structures adjacent to or within the facia, is frequently seen in the case studies. EuroNCAP found this to be a significant feature for all of our case study models except the Ford Fiesta, Vauxhall Corsa, VW Polo, Renault Megane, Fiat Brava, Mercedes C180, Saab 900 and Vauxhall Vectra. Only the Polo and Vectra avoided both localised loading and variable loading modifiers for their drivers' legs.

In each of the three Fiat Puntos that had restrained drivers, knee contacts were observed. The three drivers' left knees contacted the facias, with one suffering an AIS1 injury. Minor right knee injury was caused to one of the drivers. The Xantia and five of the eight Mondeos also showed evidence of knee impact with the facia. In the more serious impacts of the Mondeos, the contact results ranged from no knee injury to laceration caused by bracketry behind the facia.

Of the seven Peugeot 306s, one in particular showed several serious injuries. This was a severe impact, and the restraint loading fractured the driver's clavicle. Of note in this context is that the restrained driver suffered a fracture of the right femur from contact with the steering column and its shroud.



**Figure 6. Peugeot 306 steering column & shroud, showing right knee contact area.**

Both of the Nissan Micras in the sample caused AIS1 injuries to their drivers' knees. The first case saw right knee injury from the fascia, and laceration of the left knee from contacting a bracket behind the fascia. (Figure 7) In the second Micra, the right knee suffered a penetrative AIS1 injury from contact with the fascia and the broken steering column cover.



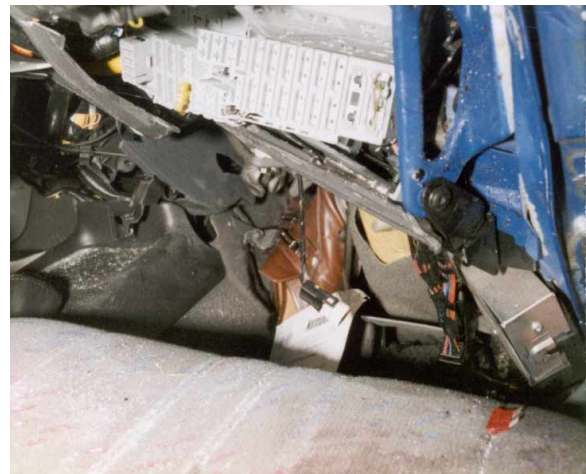
**Figure 7. Nissan Micra, showing disruption of lower fascia.**

Three of the six Corsas showed some knee interaction with the fascia. There was an AIS1 right knee injury to the driver in the first case from contact with the fuse box cover, and bilateral AIS1 knee injuries were suffered by the driver of the second case (the fuse box was again implicated). The fatally injured driver in the third case had an AIS2 fracture in the left knee region from the intruding fascia, with a more serious right knee contact related to fractures of the femur, tibia and fibula. This Corsa (Figure 8 and 9) had severe fascia intrusion in the driver's knee area and, although the impact was with a heavy goods vehicle, both longitudinals were involved so this should not be discounted by regarding it as an under-run case.

This case is consistent with EuroNCAP's assessment of the right femur loading being considerably higher than that of the left femur.



**Figure 8. Vauxhall Corsa showing overall damage.**



**Figure 9. Vauxhall Corsa showing disruption of lower fascia and fuse box.**

The first of the two Polo case studies included an AIS1 puncture wound and abrasion to the right knee of a 31 year old female driver, from contact that dislodged the lower fascia. This impact was not very severe. In the second Polo case, a male driver (of the same age) contacted the lower fascia but did not receive any knee injury. The latter case was a more severe impact, however there is no available information regarding the stature of the two drivers.

EuroNCAP has concerns over the driver's legs in the Audi A3, however in the single A3 in this sample, 260mm intrusion of the fascia at knee level resulted in no knee injury (Figure 3).



### **Brake Pedal Vertical Movement (Related to Lower Leg Injury Risk)**

EuroNCAP did not report vertical pedal movement as a concern for the lower legs of the drivers of any of the models that are studied in this report.

In one of the eight Mondeos, there was a recorded upward pedal movement of 160mm. This is twice the amount of movement set as EuroNCAP's limit. In this case the driver suffered a fracture of the right ankle, which may have been due to loading of the foot by the pedal (had the foot been on that pedal at impact) or possibly by the associated footwell intrusion. Whichever mechanism caused the ankle injury, the vertical movement of the brake pedal in this case did not result in any injury to the proximal portion of the lower leg. Another of the Mondeos highlighted a comminuted fracture of the 44 year old female passenger's heel. Clearly no pedal movement was associated with this, but there was no footwell intrusion here either.



**Figure 10. Ford Mondeo – upward movement of pedals.**

In one of the two Micras, 40mm of vertical pedal movement was recorded, but there was no injury attributed to the vertical motion of the pedal.

### **Footwell Intrusion or Footwell Rupture (Related to Foot and Ankle Injury Risk)**

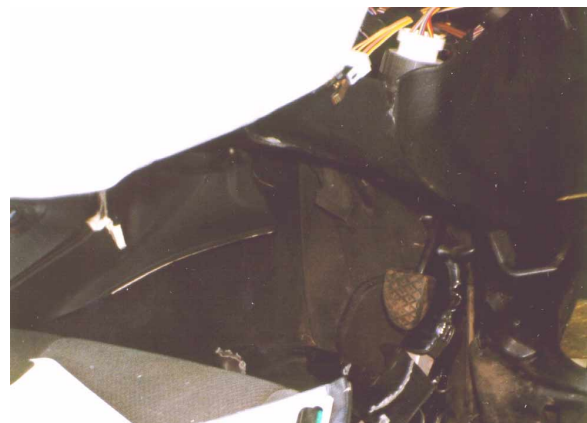
Footwell intrusion was seen in many EuroNCAP cars. Of the cars in the case studies, only the Audi A4, Volkswagen Passat and Daewoo Lanos were considered good by NCAP. However, models such as the Ford Fiesta, Nissan Micra, Rover 100, Vauxhall Corsa, Volkswagen Polo, BMW 316, Citroën Xantia, Ford Mondeo, Mercedes C180 Nissan Primera, Rover 620, Fiat Brava and Honda Civic were rated as having excessive levels of footwell intrusion.

The case study Audi A4 suffered 80mm of footwell intrusion on the passenger side (to which the overlap was biased) but no injury was caused to the passenger as a result of this. Similarly there were no injuries below the knees of the driver of the case study Passat. There was no intrusion of the footwell, and the 34 year old male driver's only serious injury was a fractured sternum from belt loading. He was close to median stature and mass, at 1.78m and 79kg.



**Figure 11. Volkswagen Passat footwell, showing no intrusion.**

In the BMW 3-series case study a fracture of the driver's left medial malleolus (AIS2) was caused by entrapment of the ankle between disrupted pedals, however upward motion of these was not evident. There was also an AIS3 comminuted intra-articular spiral fracture of the lower left tibia.



**Figure 12. BMW 318i footwell with disrupted pedals.**

## SIDE IMPACT COMPARISON

### Head Injury in Side Impacts

From recent British, Swedish and German accident data it has been concluded that in car-to-car side impacts the thorax and head are the body regions (of struck side occupants) that are most frequently injured at the AIS3+ level (Wykes et al, 1999). The frequency of injury at this severity was slightly lower for the head than for the thorax, however these two body regions were clearly ahead of the abdomen in the frequency with which they were observed. The sample used in this analysis is not sufficiently large to confirm this result statistically, however of the twenty vehicles four yielded a head injury more severe than the corresponding thorax injury. Contact with an external object was implicated in both of the cases of head injury at or above the AIS3 severity level.

Almost all of the models tested in EuroNCAP side impacts were found to provide “Good” protection for the head. The exceptions were the Citroën Xantia (“Poor”) and the Hyundai Accent (“Adequate”) in which the dummy head contacted the B-Pillar of the car, resulting in an increased risk of serious head injury. In a real-world crash, the trajectory of the driver’s head will depend on the direction of impact, and the initial position of the head within the vehicle. Should the head be partially ejected through the side window, it could then come into contact with the striking object.

One of the three Fiesta case studies illustrates a pattern of injuries that is a clear example of serious injury having occurred to both the head and the thorax. In this case, which was of similar severity to the test, the driver suffered a head impact directly with the impacting vehicle. There was no evidence that her head hit the B-pillar, but her head did make violent contact with the headlamp area of the intruding car, causing a fracture of the base of her skull and partial transection of the brain stem. Figure 13 shows the Fiesta.



**Figure 13. Side impacted Fiesta, in which the driver suffered an AIS6 head injury.**

This mechanism of head injury is patently not confined to this one model, nor does its occurrence in this case indicate that any particular model’s safety rating relative to its peers is flawed. It would clearly be unsupportable to suggest that this evidence relates to any one model in particular. Rather, it applies to all cases in which the head exits the perimeter of the vehicle.

Based on the conclusions of wider analysis, this is a valuable case to illustrate that prevention of contact with the B-pillar is not sufficient to afford protection to the head in this type of impact.

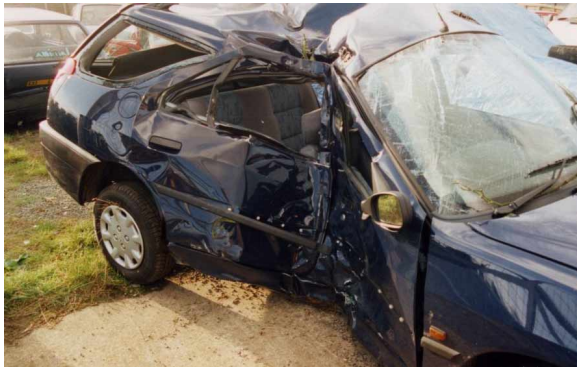
### **EuroNCAP Assessments of Side Impact Injury Risks**

The Peugeot 306 case study provided a clear endorsement of EuroNCAP’s ratings of the different body regions. There was good agreement between the relative severities of each body region in the test and the real-world crash, despite some differences in the type of side impact.

In this impact, the Peugeot struck a tree, but this was directly on the B-Pillar area, and was a severe impact. Although leaving a maximum crush of 730mm, the impact was not aligned such that the driver’s head was brought into direct contact with an intruding object. This separates this case from the issues described in the previous section and allows comparison of the overall distribution of injury to the struck side occupant. The driver of this car was killed, but the pelvis and head were uninjured in the impact. The injury to the aorta is indicative of a very high thoracic acceleration. However, even without this injury to the main artery of the body, the thorax showed severe injury to the lungs and serious rib cage injury.



Contact with the B-pillar was the cause of the fracture of the right clavicle. This indicates that the shoulder was impacted by the intruding B-pillar (supported by the tree) but that the head was not impacted in this way. Had it been contacted here, there would have been a very great likelihood of serious head injury.



**Figure 14 Pole-impacted Peugeot 306, in which the injury pattern matched EuroNCAP's side impact assessment.**

## CONCLUSIONS

### Frontal Impact

Using broad selection criteria to find the types of accidents that EuroNCAP sets out to address, this analysis has shown that the crashworthiness features identified in the tests are often seen in real life. Overall, there is good agreement between EuroNCAP's post-test inspection findings and real accidents. The frontal impact Modifiers are justifiable in terms of the evidence seen from these accidents.

Steering wheel movement was present in many of the cases studied, as was predicted by EuroNCAP. However, this movement was often seen to be controlled in frontal impacts that involved a large overlap, but less consistently where the overlap was small. In some cases where the steering wheel did not move, this was due to the impact being less severe than the test.

Chest contact with the steering wheel is relatively rare in the sample. Two fatal cases, in which drivers suffered major trauma to the chest, were studied. These each involved considerable intrusion of the facia and steering column.

Intrusion of the facia, to various extents, was present in a large proportion of the EuroNCAP tests for the vehicle models studied here. Intrusion that was not

predicted by EuroNCAP did occur in one vehicle, however the overlap here was only 27 percent and the impact was severe. In spite of this intrusion, the injuries to the driver's chest were minor.

Compartment instability, often characterised by door failure or facia detachment, was reported by EuroNCAP in tests of several cars. This was seen in the real cases – particularly clearly in two accidents. The damage that is caused to the test vehicles is realistic, when compared with accidents, and an almost identical pattern of residual damage was seen on some models. It was fortunate that the compartment collapse in each of these two Rover 100 models was biased to the passenger side of the vehicle, affording the drivers a lesser injury risk.

The risk of a localised load being applied to the knees of the driver, from stiff structures within the facia, is frequently seen in the case studies. EuroNCAP found this to be a significant feature for all except eight of our case study models (though some of these eight did have a modification for the variable loading). There is clear evidence of this being a problem in these cars. In six case-study examples of one model for which EuroNCAP found no severe localised loading in this area, some knee loading was evident in three. However, it is important to note that this loading caused serious injury in only one of the three case studies, and here the loading was exacerbated by gross facia intrusion.

The knee loading modifier has been updated since these models were rated, and this change is supported by these accident data – confirming that the rating in this area is of greater relevance to the vehicles' performance in accidents. The models for which the case studies highlighted a disparity between the accidents and the EuroNCAP assessments would be likely to have the new localised loading modifier applied.

EuroNCAP did not report vertical movement of the brake pedal as a concern for the lower legs of the drivers of any of the models that are studied in this report. Footwell intrusion was seen in many EuroNCAP cars. Of the cars in the case studies only three were considered good by EuroNCAP. Many models were rated as having excessive levels of footwell intrusion. The case study vehicles exhibited the patterns of intrusion found by EuroNCAP although few injuries resulted from this.

## **Side Impact**

Side impacts show that the EuroNCAP test reflects much of the vehicles' performance with good accuracy. However, these data also confirm head protection as one area of concern that is significant. The existing understanding – that head protection is not adequately addressed if the head exits the vehicle – is reinforced, and this strengthens the case for ensuring that vehicles constrain the movement of the head in side impacts, preventing its excursion beyond the car.

EuroNCAP does not currently apply modifiers for side impact protection. Therefore the discussion presented in this report focuses on the pattern of injuries sustained by the struck side occupant of the vehicles. This analysis does not seek to justify the relative protection afforded by any two models in terms of a statistical analysis, and the small sample size is the principal reason for this.

## **ACKNOWLEDGEMENTS**

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The data were collected by teams from the Birmingham Automotive Safety Centre of the University of Birmingham; the Vehicle Safety Research Centre of the University of Loughborough; and the Vehicle Inspectorate Executive Agency of the DETR.

Further information on CCIS can be found at <http://www.ukccis.com/>

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