

# **A Preliminary Investigation on Soft Tissue Neck Injuries from Side Impact**

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## **Abstract**

Typically low severity neck injuries (whiplash injuries) have been associated with front and rear impacts. These injuries are classified as low severity injuries and are given the lowest rating on the Abbreviated Injury Scale of (AIS) 1. In spite of its low severity rating, these injuries can be disabling and life altering. More recently, the literature has highlighted the need to investigate low severity neck injuries from side impacts because they can occur frequently enough to be of concern. Research in this area has been limited as the anatomical site of soft tissue neck injury and the mechanism of injury are still unknown.

In this study, real world side impact accidents have been taken from the Monash University Accident Research Centre Database. These accidents have been examined to provide an introduction into low severity neck injuries. The results show that there is a common angle of impact that results in neck injury from side impacts. Occupant age and head contact with the interior of the vehicle were also identified as factors affecting injury. As these results may help identify typical side impacts that produce injury, computer models can now be created to investigate the mechanics of this injury.

## **Introduction**

Soft tissue neck (whiplash) injuries are classified as low severity injuries and are given the lowest rating on the Abbreviated Injury Scale (AIS) of 1 [1]. In spite of their low severity rating, these injuries can be disabling and life altering. Soft tissue injuries often occur as a result of inertial forces acting on the head as a result of an automobile accident, although the exact mechanism of injury has yet to be established. There is limited material available about this injury from side impacts, in spite of it occurring frequently enough to be of concern. With so much still unknown about soft tissue neck injuries, it is difficult for car designers to modify their vehicles to prevent injury.

Literature shows that certain factors such as age, gender and impact type appear to predispose particular occupants to soft tissue neck injury [2]. This study investigates real world side impacts from the Monash University Accident Database and examines these factors. This research is to provide an introduction into and address the absence of literature regarding low severity (AIS 1) neck injuries from side impacts.

## **Literature Review**

The literature shows that a number of factors, appear to increase an individual's likelihood of experiencing a soft tissue neck injury [2]. These factors include both impact and human factors. Impact factors are type of impact and occurrence of head contact within the vehicle. Some human factors identified in the literature are gender and age.

## **Impact Factors**

### **Type of Impact:**

Low severity neck injury has been reported to occur at all impact types, Figure 1 shows the proportion of neck injuries in the Volkswagen Accident Database [2]. Low severity neck injuries are reported to occur most frequently in frontal impacts (38%). Rear and side impacts produce a similar number of AIS 1 neck injuries (16% and 12%). The literature also shows that impact type influences the severity of soft tissue neck injury as rear impacts generally produce neck injuries that take longer to heal. [3]

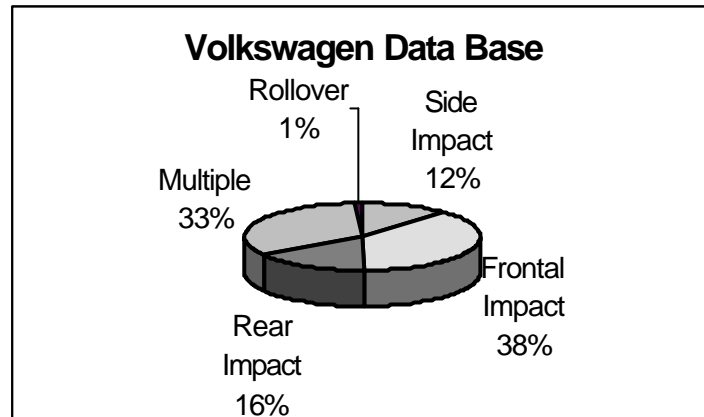


Figure 1: Volkswagen Accident Database, showing the distribution of low severity neck injury and impact type.

#### Head Contact:

It has been reported with low severity neck injuries there is generally no head contact within the interior of the vehicle [4].

#### Human Factors

##### Gender:

Gender has been reported as one of the most important human factors influencing soft tissue neck injury. The data in the Volkswagen database shows that females experience fewer accidents than males. In spite of this, females are reported to experience twice as many soft tissue neck injuries as men [2].

##### Age:

It has been reported that there may be an increasing rate of soft tissue neck injuries with an increase in occupant age. Literature shows that children and adolescents experience much less soft tissue neck injury than adults. Those younger than 17 years were reported to have the lowest rate of soft tissue neck injury [2]. Women between the ages of 18 and 32 are shown to experience the most soft tissue neck injuries. This suggests that physical changes in the structure of the neck with age may predispose someone to neck injury.

#### **Method**

A sample of 660 accidents was taken from the Monash University Accident Research Centre (MUARC) accident database. All of these vehicles were of similar size, model and mass. Each accident case file consisted of an engineer's report and a medical report. The accident cases for those occupants with a low severity neck injury were examined and compared to the occupants who were also involved in a side impact but received no minor neck injury. The group without neck injury acted as a control group. The results for human factors (occupant age, gender, and injuries received) and impact factors (side and angle of impact) were examined. In some cases, the results for the group with low severity neck injury were presented only, so that this data could be investigated independently. In other cases, the data for the neck injury group was presented against the control group (those with no soft tissue neck injury) so that comparisons could be made.

#### **Results**

Side impacts accounted for 227 (34%) of the 660 accidents investigated. 47 occupants (21%) were reported to have a soft tissue (AIS 1) neck injury from a side impact. For the occupants that do not have a neck injury, 59 occupants (26%) received no injuries from the side impacts. For those injured, 88 occupants (38%) received a maximum AIS 1 injury (with no neck injury), and 19 occupants (8%) received a maximum AIS 2 injury (with no neck injury). Those occupants more seriously injured 6 occupants (3%) received a maximum AIS 3 injury, 3 occupants (1%) received a maximum AIS 4 injury, 4 occupants (2%) received a maximum AIS 5 injury and 1 occupant (<1%) received a maximum AIS 6 injury, none of these occupants received a neck injury. Those with a MAIS 3-6 have been grouped together as MAIS 3+. This data for occupant injury severity has been presented in figure 2. The term MAIS is the maximum injury received as graded by the Abbreviated Injury Scale.

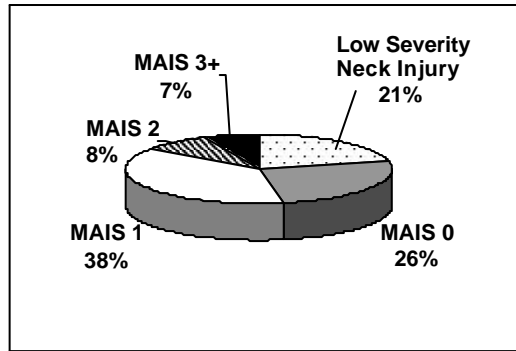


Figure 2: Proportion of Side Impacts from MUARC Database.

**Gender**

Of the 227 occupants that were involved in a side impact, 60% were males and 40% were females. 20% of the males, 22% of females and involved in a side impact received a soft tissue injury.

**Age**

Only occupants over the age of 17 were included in the study. This was so conclusions could be drawn for adult occupants only and to reduce the variation in physical characteristics of height and weight. The average age of occupants is shown in table 1.

Table 1: Average age of Occupants in Lower Severity Impacts

	Male (yrs.)	Female (yrs.)
Soft Tissue Neck Injury	39	38
MAIS 0	40	42
MAIS 1	38	41
MAIS 2	35	41
MAIS 3+	47	34

The results for average age show a range of 34 and 47 years. The results show that there is little variation in age between the genders in the low severity side impacts < MAIS 2. However, differences can be seen when dividing up the group of occupants with low severity neck injury. Figure 3 shows these occupants divided by age group and gender. It is shown that more males with a soft tissue neck injury are aged between 47 and 57 years old when comparing to all other age groups. Females reporting a soft tissue neck injury were most likely to be between 17-26 or 37-46 years old.

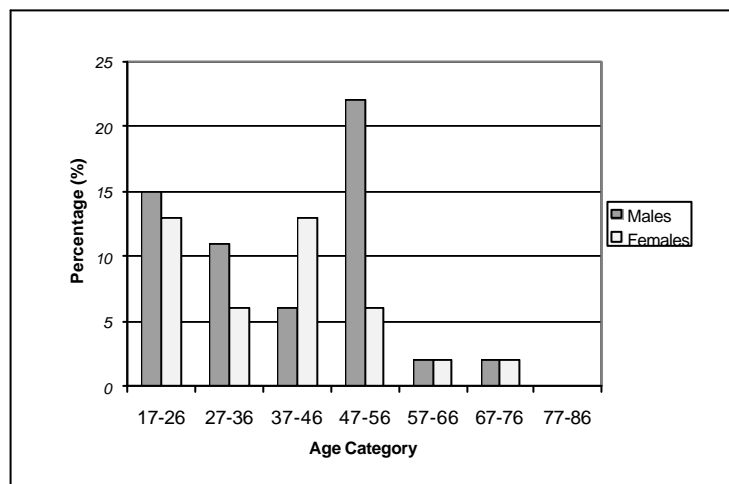


Figure 3: Low Severity Neck Injury Group Age Range

**Side of Impact (All Injury Severity Groups)**

The side of impact for all injury severity groups is presented in figure 4, to examine what influence side of impact has on occupant injury patterns. It is shown that as injury severity increased, more near side impacts were reported (except for those with a MAIS 5). Those with soft tissue injuries were involved in an equal number of near and far side impacts (51% near: 49% far). Those who received no injuries from being involved in a side impact, were mostly involved in far side impacts (73%). Those occupants with no soft tissue neck injury (but had a MAIS 1, MAIS 2, MAIS 3, MAIS 4 and MAIS 6) all had more near side accidents. Occupants with a MAIS 5 injury were the only injury group where more occupants were involved in a far side impact (75%). This may be an affect of the small sample size.

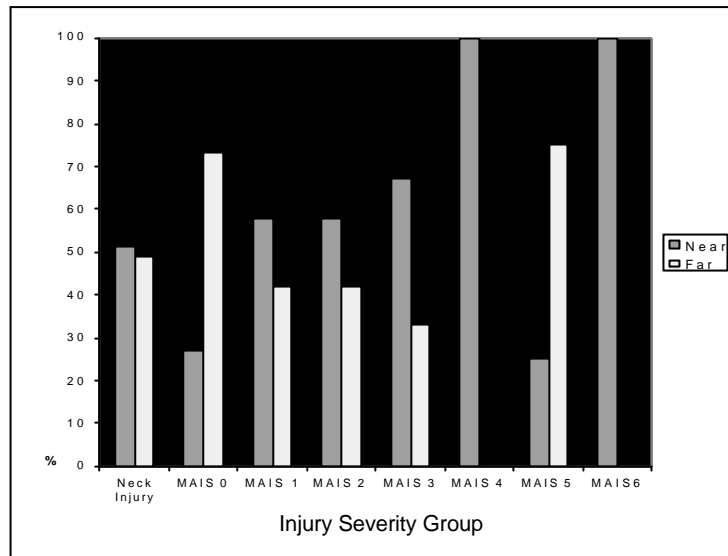


Figure 4: Side of Impact (All Injury Severity Groups)

**Angle of Impact (All severity groups)**

The results for angle of impact for all injury severity groups have been presented in the table 2. Occupants that receive no injuries from a side impact, were more likely to be involved in a 1 o'clock or 11 o'clock impact. As injury severity increased the impact angles were more likely to be a 90 degree (3 o'clock or 9 o'clock) impact. The results show that most side impacts were towards the front of the vehicle or at right angles to the vehicle. No impacts were at angles greater than 90 degrees (6 or 7 o'clock impact). Soft tissue neck injuries also occur at all impact angles except for those greater than 90 degrees. Occupants with an AIS 1 neck injury were more frequently involved in a 10 o'clock or 2 o'clock impact (mirror images of each other). The next most frequent impacts that occupants receive a soft tissue injury were 3 o'clock and 9 o'clock impacts.

Injury Severity	O'Clock (Percentage of Impacts)											
	1	2	3	4	5	6	7	8	9	10	11	12
Neck Injury	6	20	15	2	2	0	0	2	13	24	6	6
MAIS 0	22	10	12	0	0	0	0	2	14	15	17	8
MAIS 1	20	16	16	5	2	0	0	1	8	23	6	3
MAIS 2	5	31	21	0	0	0	0	5	11	11	16	0
MAIS 3+	7	14	36	7	0	0	0	7	29	0	0	0

Table 2: Angle of Impact against Injury Severity (%)

**Delta V (All Impact Severity)**

The average Delta V for all injury severity groups are presented in figure 5. Impacts that resulted in maximum injury had the highest Delta V of 60 km/h. Impacts that produced no injuries had the lowest Delta V of 20 km/h. The Delta V of impacts that caused a low severity neck injury was 26km/h. This value lies between MAIS 1 and MAIS 2.

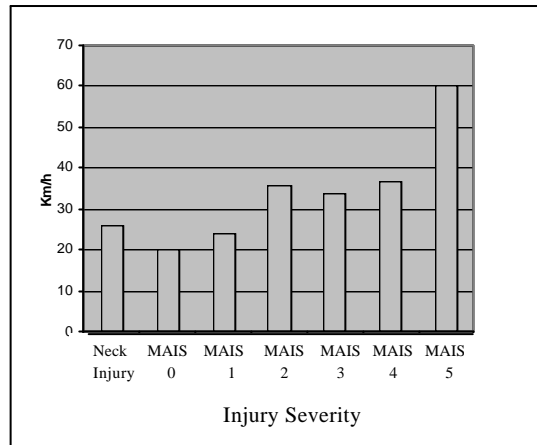


Figure 5: Delta V(Km/h) for all Injury Severity Groups

### Other Injuries

The other injuries received by the group with a soft tissue neck injury were collated compared to investigate any injury patterns in side impacts. It was found that occupants with a low severity neck injury received no other injury greater than an AIS 2. Twenty-one per cent of occupants received only a low severity neck injury. Most occupants (64%) received a low severity neck injury with at least one other injury of MAIS 1. Only 15% of occupants received a more severe injury of an MAIS 2 with their soft tissue neck injury. This with the delta V data suggests that impacts that result in soft tissue neck injury were of relatively low severity impacts as the other injuries received with soft tissue neck injury are minor.

### Head Injuries (All Injury Severity Groups)

Head Injuries for all occupants involved in a side impact are presented in figure 7.

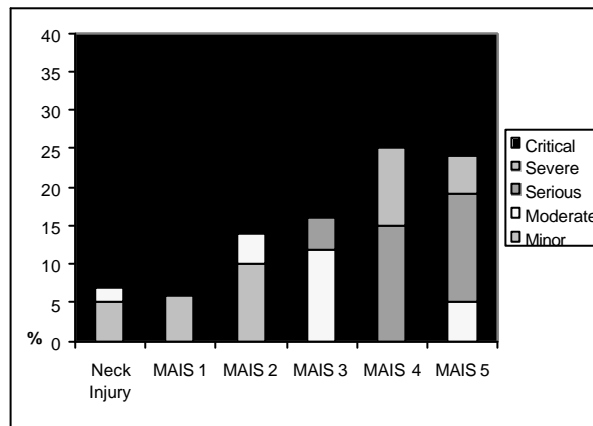


Figure 7: Head Injuries (All Severity Groups)

It is shown that as maximum injury increased head injuries increased both in number and in severity. Occupants reporting soft tissue neck injury and occupants with only a maximum injury of AIS 1 received the lowest number of head injuries. The group reporting maximum injuries of AIS 5 received the most number of head injuries and more injuries rated from serious to critical.

### Discussion

The side of impact, angle of impact and delta V showed that there was typical profile of side impacts of each severity. Side impacts that resulted in serious injuries (> MAIS 3) were more likely to be near side impacts at an angle of approximately 90 degrees (either a 3 o'clock or 9 o'clock), with a high Delta V. Occupants who received no injury from a side impact accident were most likely to be in a far side impact with small impact angles (1 o'clock). Impacts that led to soft tissue neck injuries were equally divided between near and far side

impact. They were more likely to be 2 o'clock and 10 o'clock impacts. The average Delta V for impacts resulting in neck injury is 26 km/h.

The results show that occupant gender alone was not a contributing factor to soft tissue neck injuries from side impacts. Although there was relationship between age and gender of those occupants receiving a soft tissue neck injury. Young females and middle aged males and females were more likely to be injured.

It was shown that no occupant with a soft neck injury received any other injuries more severe than an MAIS 2. Of these injuries head injuries accounted for a very few this suggests that there was little head contact in these impacts. When comparing the side impacts that did not result in neck injury, it was seen that head injuries occurred more often in the most severe impacts.

### **Future Directions**

#### **Age and Gender**

The results suggest the need to investigate the aging and gender effects on the human neck to further understand why certain age groups are reporting more low severity neck injuries in side impacts. The results showed that younger females and older males experienced more soft tissue neck injury in side impacts.

#### **Restraints**

Drawing conclusions regarding the effectiveness of seat belts and head restraints is not possible at this early stage of research. More understanding is required to understand the effectiveness of restraint systems under both 90 degree and oblique impact angles in side impacts. This future research will lead to modifications being made to reduce occupant injury.

#### **Impact Severity**

The impact data shows that side impacts resulting in soft tissue neck injuries have distinctive characteristics. These neck injuries appear to occur more at a particular angle of impact 90 degrees and less and at a low Delta V. Work could be undertaken to improve the crash worthiness of vehicles in these conditions.

### **References**

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