Analysis of post-crash motorcycle helmet components in Klang Valley, Malaysia

Roszalina Ramli[1,2], Jennifer Oxley[1], Peter Hillard[1], Ahmad Farhan Sadullah[3], Roderick McClure[1]
[1]Monash Injury Research Institute, Monash University, Sunway & Clayton Campus
[2]Dept of Oral & Maxillofacial Surgery, Universiti Kebangsaan Malaysia Medical Centre
[3]Faculty of Civil Engineering, Universiti Sains Malaysia

Introduction

Malaysia has the highest death rate per 100,000 populations in South East Asia due to road traffic crash. Motorcycle crash contributed 58% of the total fatalities in the country. Helmet wearing rate was shown to be 90% among the riders and 70% with the pillions. Despite high helmet wearing rate, statistics of death due to head injury continues to increase.

Aim

The aim of this study was to investigate the association between helmet component characteristics with head and brain injuries among motorcyclists in Klang Valley, Malaysia.

Methods

145 crash-involved helmets were examined at Standards and Industrial Research Institute of Malaysia (SIRIM) laboratories.

Examination involved:
- •basic characteristics
- •physical characteristics- thickness and material of the outer shell, thickness and density of the inner liner and type of the retention system
- •damage or crash marks: on the outer shell, inner liner and retention system.

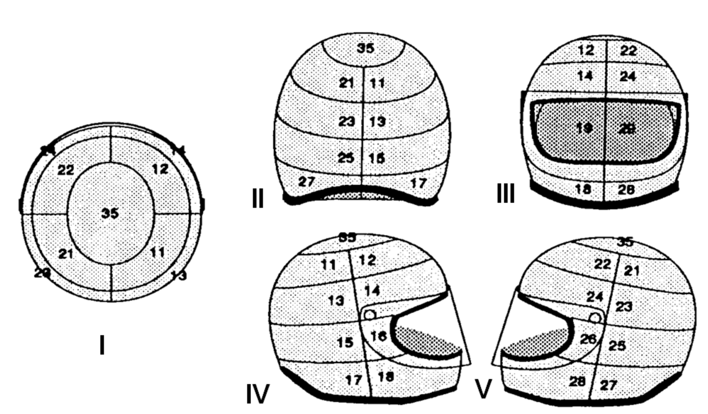

Figure 1: Segment locations for damage description (helmet) (Otte et al, 1999)

Results

Descriptive results

Of the 145 helmets, 86.2% were half-head helmets, 4.8% open-face, 5.5% tropical and 3.4% full-face helmets. Majority of the helmets (89.7%) were size 60 (large). Age of the helmets ranged from a few hours after purchase to 20 years old (mean of 2.23 years). Mean weight for a tropical helmet was 0.72 kg, an open face, 1.09 kg, a half head, 1.24 kg and a full-face helmet, 1.62 kg.

The tropical helmet was shown with the thinnest outer shell. Majority of the helmets were made of acrylonitrile butadiene styrene (ABS) (91.0%). All the selected ABS helmets showed evidence of degradation except for one helmet. All inner liners were made of the expanded polystyrene (EPS). The lowest mean density was shown in the tropical helmets (23.31 g/l) while the highest in the full-face helmets (33.88 g/l). Majority of fastener (retentive system) were the quick release type (67.6%)

Fourier Transform Infrared (FTIR) Spectroscopy

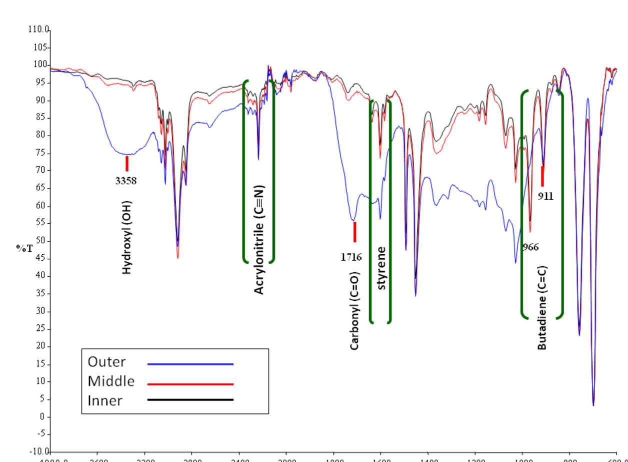

Figure 2: FTIR spectrum of ABS helmet shows evidence of degradation with the presence of OH and C=O group.

Scanning electron microscopy

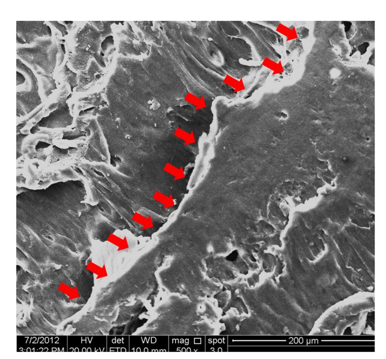

Figure 3

Figure 3: Micro-fracture in the ABS helmet

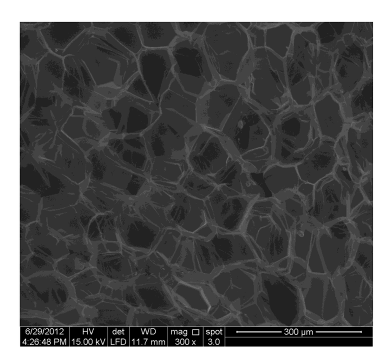

Figure 4

Figure 4: 'Normal-looking' EPS cells after impact

Damage marks and type of head injury sustained by the users

Figure 5: Patterns of damage seen on two half-head helmets. Both users sustained DAI .

Association of helmet components with head, brain and facial injuries

The association of 1) helmet type, 2) helmet weight, 3) material of the outer shell, 4) outer shell thickness, 5) outer shell degradation 6) outer shell damage, 7) inner liner thickness, 8) density, 9) inner liner damage, 10) type of retentive system and 11) damage of the retentive system with head and brain injuries were evaluated using the Pearson chi-square test and Fisher's exact test. None of these associations revealed significant p-values.

Discussion

The biomechanics component comprised 1/3 of the total research.
The main studies – a case series and a case control showed that principal determinant of head and brain injuries was the helmet fastening and helmet fixation status (AOR 2.36 to 11.15 with $p<0.05$).
The limitation of this aspect of study was the sample size. Degradation of the outer shell material was carried out only to 29 helmets due to high cost. Malaysian motorcyclists have a peculiar habit of keeping their helmets directly under the sun (and rain), for at least 6 hours a day and this could accelerate the process of degradation. A non-UV stabilised ABS was shown to have its impact strength falls to approximately 30% of the original value after 1500 hours of UV exposure (Zahn, 1997). Based on clinical evidence, we believe that the function of an inner liner is also affected after prolonged exposure to sunlight and rain but we were unable to prove this theory in the laboratory.
Although all the helmet components tested as the above revealed non-significant results, further research is needed in the area of 1) degradation of the outer shell to show the weakening effect 2) performance of the prolonged environmentally exposed inner liner 3) retention system design as from the other two studies (case control and case series) poor attitude was shown to be associated with the Double-D fastener.

Conclusion

The current properties of the helmet components did not show significant effect with head and brain injuries, however further study is needed in the area of outer shell, inner liner and retention system design.