# SIDE IMPACT PROTECTION AND BELT POSITIONING BOOSTERS FOR CHILDREN

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## INTRODUCTION

BELT POSITIONING BOOSTERS (BPBS) are often described as the optimal form of restraint for children aged between 4 and 8 years. The primary objective of this type of restraint is to 'boost' the height and geometry of a seated child to improve the compatibility between a young child and a three-point seat belt designed for the adult population. Improved belt fit allows a child within this age range to benefit from the protection provided by three-point seat belts in frontal impacts. However, the inadequacy of the three-point seat belt in providing optimal protection in side impacts has long been established. It therefore follows that belt positioning boosters that simply aim to achieve a better seat belt fit will not provide any great improvement in the level of protection provided to children in side impact compared to three point belt systems alone. The effectiveness of BPBs that have high backs and "side-wings", and therefore have the potential to help protect the head of children in side impacts, has not been established.

The aims of this study were to evaluate the effectiveness of BPBs in side impact, and to determine the scope for improving their performance by incorporating improved anchorage systems. As part of this evaluation, the need for inclusion of side impact testing in regulatory and consumer test programs was assessed.

## METHOD

Two of the most commonly used high back booster seats in Australia, a convertible blow molded plastic booster (BS #1) and a molded polystyrene booster (BS #2) were tested in 90° and 45° side impacts with different anchorage mechanisms. In addition to the conventional anchorage system (which consists of only the three point seat belt to anchor BS#1 and a top tether in addition to the three point seat belt to anchor BS#2), three additional anchorages were tested - a rigid ISOFIX, a semi-rigid system consisting of a continuous loop through the base of the booster (semi-rigid #1) and a semi-rigid system consisting of two flexible straps on the sides of the base of the booster (semi-rigid #2). Top tethers were used in all rigid/semi-rigid configurations. In total, 44 sled tests were conducted on a rebound sled with a simulated change in velocity of approximately 30km/h and a peak deceleration of 15g. Each test was duplicated to ensure consistency in the results. The test rig used incorporated a standardized test seat and a simulated rear door structure.

A Hybrid III 6 year-old-dummy, instrumented with sensors to measure head acceleration, neck forces and moments, was used in all tests. The motion of the dummy and restraint systems was captured using a high speed digital camera at 500 frames per second. Resultant head acceleration, resultant neck force and moment, HIC, and the motion of the dummy and the booster seat, were evaluated.

Figure 1: Contact between the dummy and the side door.

## RESULTS

The side wings of the two booster seats tested were at the height of the lower edge of the jaw of the Hybrid III 6-year-old dummy, not offering any protection to the head of the dummy upon impact as seen in figure 1. The dummy's head impacted the door frame in every test performed at 90°. Figure 1 also shows a contact between the shoulder and the door frame. Also, the shallow side structure of the booster seats offered little resistance to sideways motion, and did not provide protection for the shoulder and the torso. At 90°, all $HIC_{15}$ results were above the new assessment reference value of 700 adopted in the US FMVSS 213, apart from the test using the BS #2 with a rigid attachment (see figure 2 below). The rigid attachment kept the restraint in place, away from the door frame while, in every other test, the booster moved towards the door with the dummy. This reduced the severity of the head impact.

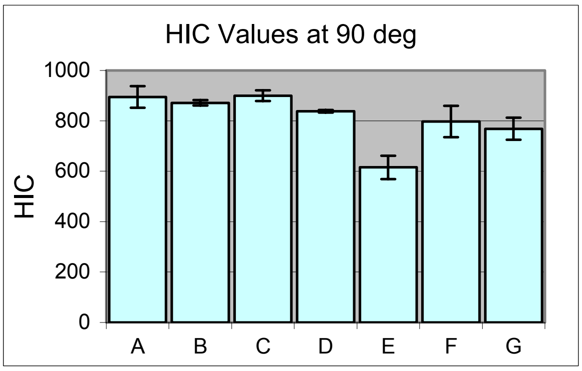


Figure 2: HIC values for different booster seat configurations in 90 degree side impacts.

A: Adult three point seat belt only
B: BS #1 with conventional anchorage
C: BS#2 with conventional anchorage
D: BS#1 with rigid anchorage
E: BS#2 with rigid anchorage
F: BS#2 with semi-rigid anchorage #1
G: BS #2 with semi-rigid anchorage #2

In 45° impact tests, the motion of the dummy and loads on the dummy restrained in a three point seat belt are very similar to the one of the dummy restrained in a booster seat, suggesting the booster plays little role in such impacts. Head impacts were present in about one quarter of the tests but consisted only of a light contact on the upper part of the back of the dummy's head, with low associated HIC values (45-140).

## DISCUSSION

Results from this work indicated that the high back belt positioning boosters tested do not appear to provide greatly improved protection in side impact compared to a three point seat belt alone because of poor head and torso containment. In most of the tests conducted in this program, the dummy was not adequately contained within the booster. This work has also demonstrated that scope does exist for improving the protection provided by belt positioning boosters in side impact through rigidly anchoring the booster seat to the vehicle and improving the geometry of the side wings. However, for this potential to be fully realized, belt positioning booster seats must be able to better contain the dummy (or child) during the impact. It should be noted that, while only commonly used Australian belt positioning boosters were used in this test series, booster seats of these types are also used in other countries.

## CONCLUSIONS

The study has shown that there is a clear need for improved booster seat designs to achieve higher levels of side impact protection for children between 4 and 8 years old and that particular attention should be placed in developing head protection suitable for the entire age range of children using belt positioning boosters. It also showed that the level of protection provided by belt positioning booster seats can be improved through the use of rigid anchorage systems.

These results also demonstrated that more attention should be placed on the performance of boosters in side impact internationally, and that there is a need for inclusion of side impact evaluation in regulatory and consumer test programs.

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