

Safe Transport of Spica Casted Children in Passenger Vehicles is Possible: A Frontal Crash Test Analysis of Child Restraint Systems Using Spica Casted Crash Test Dummies

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Purpose: There is a paucity of data defining safe transport protocols for children treated with hip spica casting. No current restraint device has been tested using casted anthropomorphic test devices (ATDs). Our goal was to evaluate current restraint options in simulated frontal crash testing using a casted pediatric ATD.

Methods: Using an ATD simulating a 3-year-old child, dynamic crash sled tests simulating a frontal crash were performed in accordance with Federal Motor Vehicle Safety Standards 213 (FMVSS 213). Sensors within the ATD recorded: HIC₃₆ (Head Injury Criterion score; predictive of skull fracture), neck injury assessment

(Nij), chest compression, chest acceleration, and pelvic injury assessment. Test crash video visual assessment was performed (Figures 1 & 2). The ATD was casted in

Figure 2. Example image of an ATD crash simulation for a supine child restraint system, such as the EZ-On Harness Vest.



Figure 1. Example image of an ATD crash simulation for an upright child restraint system, such as the Merrit Wallenberg, Britax Booster, Diono Radian, and Graco Nautilus systems.



a double-leg spica. Five restraint devices were tested: seat designed for spica-casted children (Merrit seat designed for spica-casted children (Merrit Wallenberg), modified restraint harness (Modified EZ-On-Vest), commercially available booster seat (Britax Parkway SGL Booster), and 2 commercially available forward-facing car seats able to accommodate the casted ATD (Diono Radian R100, Graco Nautilus 65 LX). One test was performed for each restraint system. All tests were performed at 30 MPH on a deceleration sled.

Results: Although the presence of the cast increased many of the injury metrics measured, all 5 seats that were tested passed current FMVSS 213 federal guidelines for the head and chest. However, there were marked differences between the 5 restraint options (Figures 3-5). No single seat performed best in all

metrics. Additionally, visual analysis of the video from the test crash of the EZ-On-Vest demonstrated that the face and upper extremities of the ATD are impacted during the crash. The ATD does not have a way to record injury to the extremities, thus this is not captured in the quantitative data.

Conclusions: Per the FMVSS 213 standard, these results suggest safe transport in the five evaluated restraint systems is possible with the child properly fitted and restrained. However, the Nautilus and Diono were found to have both the lowest HIC36 and chest acceleration values, suggesting casted children may not need specially designed seats. Additionally, review of the video of the EZ-On Vest appears to demonstrate that the vest may expose the casted child to additional facial and extremity injuries compared to systems that allow the child to sit upright.

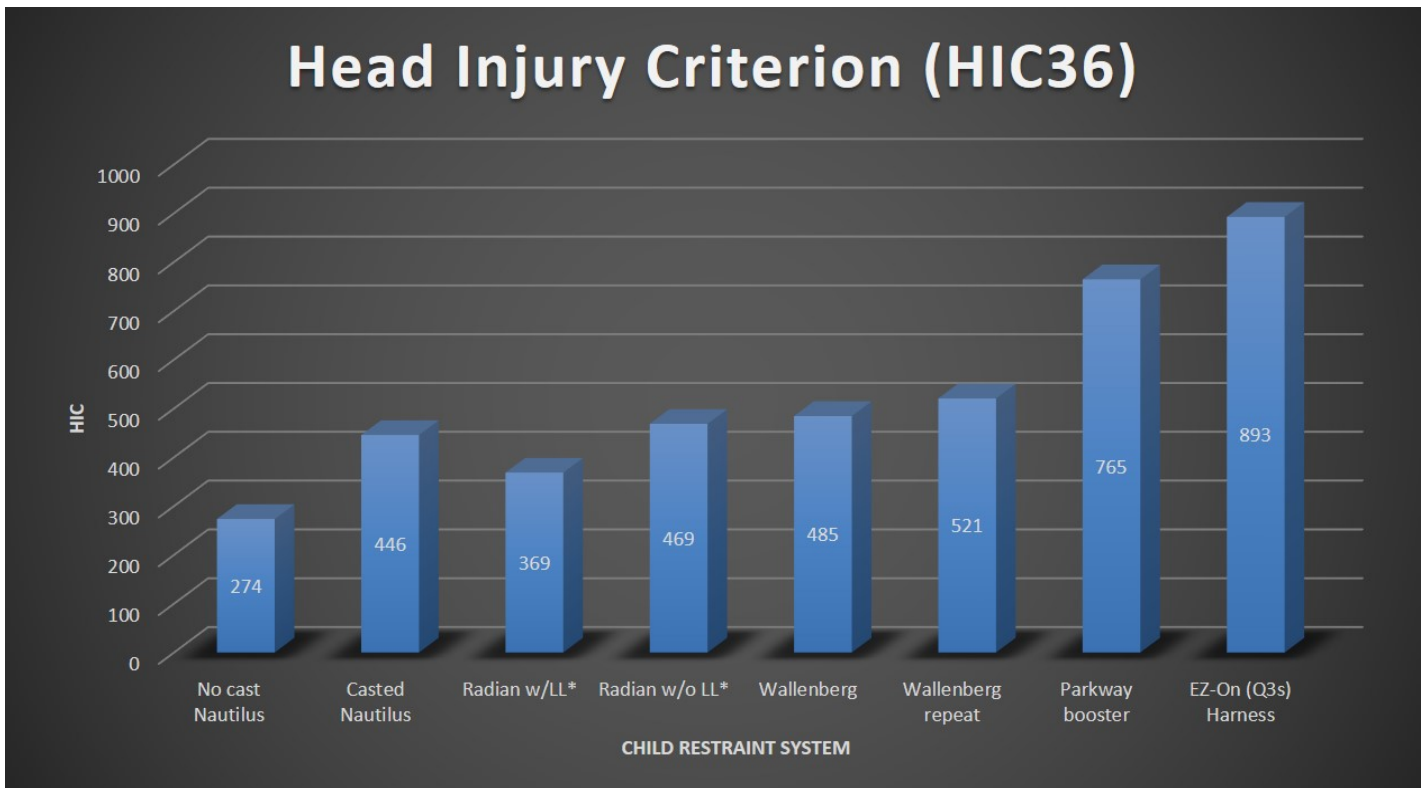
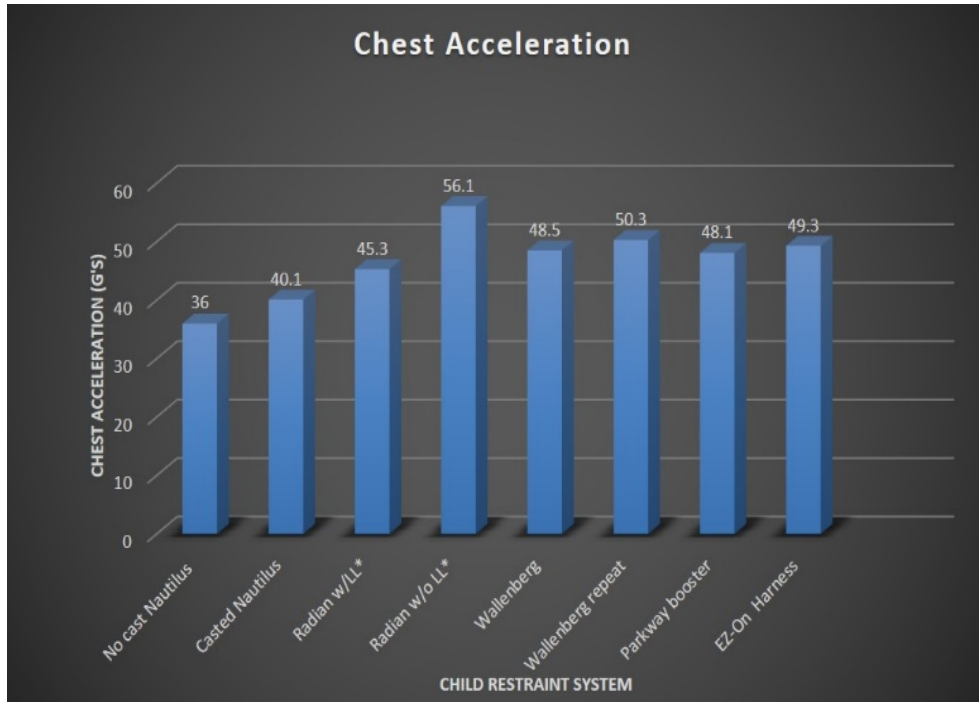


Figure 3. Head Injury Criterion (HIC₃₆) results for crash simulation. The FMVSS 213 limit value is 1000. LL = load limiter device provided by manufacturer for use with the child restraint system. Wallenberg repeat test performed to verify repeatability of crash test scenario. No cast simulation performed as a control.



Significance: Parents should not assume a restraint system is automatically appropriate for use with their child. While there were differences in the performances of the tested restraint systems, each child is unique, and a trained healthcare provider should be consulted to ensure the child is properly restrained.

Figure 4. Chest Acceleration results for crash simulation (g's). The FMVSS 213 limit is 60 g's.

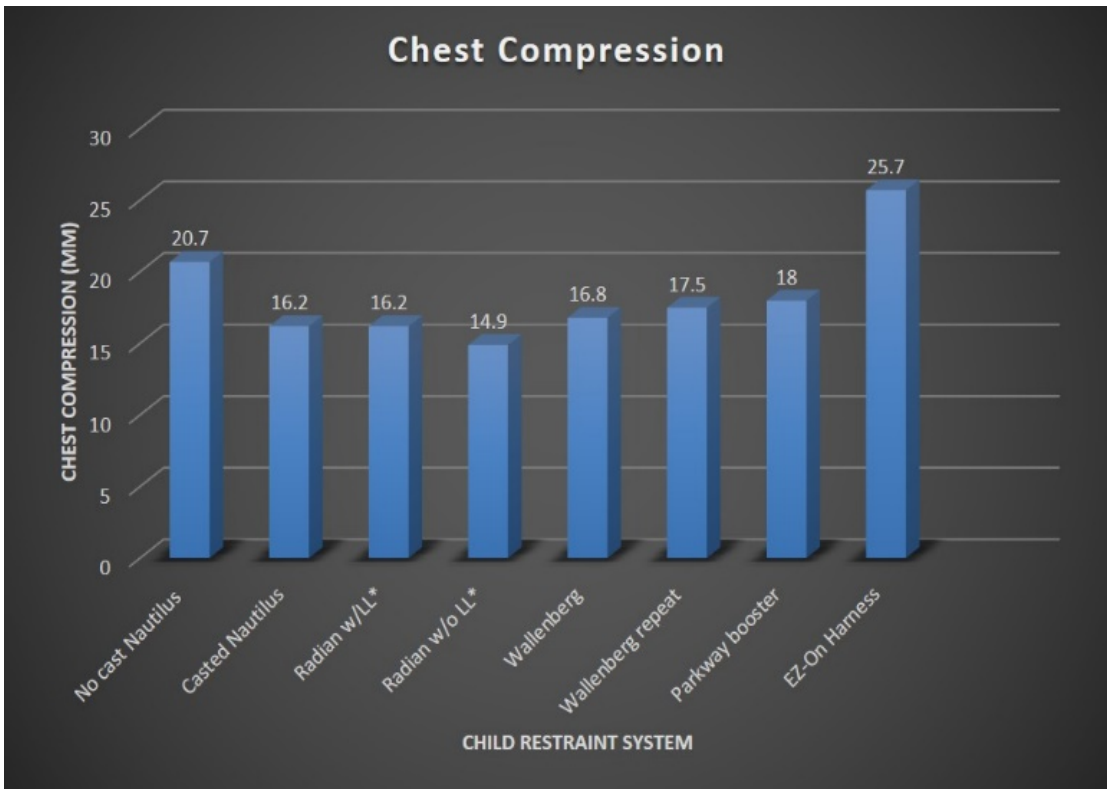


Figure 5. Chest Compression results for crash simulation (mm).