Child Safety Seat Fatality Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS06002
2000 Toyota Echo
California
December 2005

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. Abstract

The focus of this on site investigation was on a booster safety seat installed in the second row right seat position of a 2000 Toyota Echo. The Toyota Echo was occupied by a 28-year-old female driver and a 5-year-old female who was seated in a booster seat. The booster seat was being used in conjunction with the manual 3-point lap and shoulder belt. The Toyota Echo lost control on an interstate highway and struck the rear of a Dodge Durango with its right side. There was lateral intrusion through the right rear door. The Dodge Durango was pushed into a third vehicle. The driver of the Toyota Echo did not report any injuries. The 5-year-old sustained a C1 fracture/dislocation with complete transection of the spinal cord, subarachnoid hemorrhage, a fractured mandible, and multiple contusions, abrasions and lacerations. She was transported by ambulance to a local hospital where she passed away less than one hour post-crash. The driver of the Durango was not injured.

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Dynamic Science, Inc.
Crash Investigation
Case Number: DS06002

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BACKGROUND

Description

The focus of this on site investigation was on a booster safety seat installed in the second row right seat position of a 2000 Toyota Echo. The Toyota Echo was occupied by a 28-year-old female driver and a 5-year-old female who was seated in a booster seat. The booster seat was being used in conjunction with the manual 3-point lap and shoulder belt. The Toyota Echo lost control on an interstate highway and struck the rear of a Dodge Durango with its right side. The driver of the Toyota Echo did not report any injuries. The 5-year-old sustained head injuries. She was transported by ambulance to a local hospital where she passed away approximately one hour after the crash. The driver of the Durango was not injured.

Figure 1. Right side, 2000 Toyota Echo

This case was identified by DSI from an on-line news article and was forwarded to NHTSA. DSI was notified on January 4, 2006 with instructions to locate both the case vehicle and the child seat. The newspaper article alluded to the fact that the child seat may have come loose during the collision. The investigating officer was interviewed the same day as the case notification. At that time, DSI was informed that the vehicle and the child seat had already been released to the driver; the officer did not know their location. He did indicate that photographs of the low backed booster seat had been taken during their investigation, and provided crash and occupant information. The child seat and vehicle were later located at a tow facility. DSI obtained cooperation to inspect the vehicle on January 9, 2006. The vehicle and child seat inspections took place on January 11, 2006.

SUMMARY

Crash Site

This three vehicle crash occurred in December 2005 at 0656 hours. The crash occurred in the northbound lanes of an interstate highway. The northbound highway was configured with four northbound lanes (lane 4 from right was a car pool lane). The highway was bordered on the right by a solid white line, an asphalt shoulder and a concrete sound wall. The highway was bordered on the left by a solid yellow line, an asphalt shoulder, and a New Jersey style concrete barrier. The temperature

Figure 2. Lane 2, northbound freeway

was 6 degrees C (43 degrees F). Visibility was 8 km (5 miles). The asphalt roadway was dry and the speed limit was 105 km/h (65 mph).

Pre-Crash

The 2000 Toyota Echo was traveling north at a police estimated speed of 113 km/h (70 mph) in the car pool lane. The Echo was occupied by a 28-year-old female driver and 5-year-old female who was seated in a booster seat that was installed in the second row right seat position. The booster seat was being used in conjunction with a manual 3-point lap and shoulder belt. The first other vehicle was a 2001 Dodge Durango. The make/model of the second other vehicle is not known. The Dodge Durango and the second other vehicle were either stopped or had slowed considerably. Both vehicles were in the second lane from the left. The Dodge Durango was behind the second other vehicle. A non-contact vehicle was in front of the Toyota Echo. This vehicle stopped while making a lane change from the car pool lane to the adjacent lane. The rear of this vehicle was still in the car pool lane. The driver of the Echo steered to the left onto the shoulder to avoid this vehicle. The driver lost control of her vehicle. She steered sharply to the right back onto the roadway. She steered once again, this time to the left, and the vehicle began a counterclockwise rotation.

Crash

The right side of the Toyota Echo struck the left rear of the Dodge Durango. The missing vehicle routine of the WinSmash program computed a total delta V of 29.0 km/h (18.0 mph). The longitudinal and lateral components were -5.0 km/h (-3.1 mph) and -28.6 km/h (-17.7 mph), respectively. The Dodge Durango was forced forward and struck the rear of the second other vehicle. The Toyota rotated in a clockwise direction post-impact and came to rest generally facing north in the car pool lane. The Dodge Durango and the second other vehicle both came to rest in their original lanes of travel.

Post Crash

The driver of the case vehicle exited her vehicle under her own power. She entered the vehicle through the left rear door and removed the child's lap and shoulder belt. The child occupant was unconscious at this point. Two off-duty members of different fire departments stopped at the scene of the crash and tried to revive the child using cardiopulmonary resuscitation. She sustained a C1 fracture/dislocation with complete transection of the spinal cord, subarachnoid hemorrhage, a fractured mandible, and multiple contusions, abrasions and lacerations. She was transported by ambulance to a local hospital. She arrived at 0722 hours. She was pronounced dead at 0748 hours, less than an hour after the crash.

The Toyota Echo and Dodge Durango were towed from the scene due to damage. The status of the second other vehicle is not known.

VEHICLE DATA - 2000 Toyota Echo

The 2000 Toyota Echo four-door sedan was identified by the Vehicle Identification Number (VIN): JTDBT1236Y0xxxxxx. The vehicle's odometer could not be read because there was no key available. The Toyota Echo was a four-door sedan equipped with a 1.5 liter, four-cylinder engine, a four-speed automatic transmission, front wheel drive, front disc/rear drum brakes, and power steering.

The Echo was configured with Firestone FR440 P175/65R14 tires on the front and Bridgestone Potenza RE900 P175/65R14 tires on the rear. The manufacturer recommended cold tire pressure was 241 kPa (35psi). The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	207 kPa (30 psi)	6 mm (7/32 in)	None	None
LR	200 kPa (29 psi)	6 mm (7/32 in)	None	None
RR	193 kPa (28 psi)	5 mm (6/32 in)	None	None
RF	193 kPa (28 psi)	5 mm (6/32 in)	None	None

The seating in the 2000 Toyota Echo was configured with fabric covered front bucket seats with adjustable head restraints and a rear bench seat with a folding back. The outboard seat positions for the rear seat were configured with adjustable head restraints. The driver's seat was adjusted to the rear most track position. The driver's seat back was at a 70 degree angle, the seat bottom was at a 12 degree angle. The second row right seat back was at a 70 degree angle, the seat bottom was at a 15 degree angle.

VEHICLE DAMAGE

Exterior Damage - 2000 Toyota Echo

Damage Description:	Moderate right side damage as a result of the impact with the Dodge Durango. The direct damage began 47.0 cm (18.5 in) rear of the front axle and extended 216.0 cm (85.0 in) rearward along the right side. Both right side doors were deformed and jammed shut. The right rear door was pried open at some point. The combined direct and induced damage began 41.0 cm (16.1 in) rear of the front axle and extended 226.0 cm (88.9 in) rearward. The right B pillar and right roof rail were deformed laterally. Both right side windows had disintegrated. The windshield was fractured from impact forces and the backlight glazing had disintegrated.	
CDC:	03RZAW3	
Delta V:	Total	29.0 km/h (18.0 mph)
	Longitudinal	-5.0 km/h (-3.1 mph)
	Latitudinal	-28.6 km/h (-17.7 mph)
	Energy	26,513 joules (19,555 ft-lbs)

Six crush measurements were documented at the mid door level as follows: C1 = 0.0 cm (0.0 in), C2 = 0.0 cm (0.0 in), C3 = 15.0 cm (5.9 in), C4 = 25.0 cm (9.8 in), C5 = 17.0 cm (6.7 in), C6 = 0.0 cm (0.0 in). The C3 measurement was taken at a projected point.

Figure 3. Right side damage

Interior Damage - 2000 Toyota Echo

The 2000 Toyota Echo sustained moderate interior damage due to intrusion, occupant contacts and extrication efforts. The right side doors, B pillar, right roof rail, C pillar and sill sustained lateral intrusion.

The specific passenger compartment intrusions were documented as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
RF	Door	30.0 cm (11.8 in)	Lateral
RF	Sill	3.0 cm (1.2 in)	Lateral
RF	B pillar	17.0 cm (6.7 in)	Lateral
RF	Roof rail	4.0 cm (1.6 in)	Lateral
RR	Door	Unknown, door removed, estimated at 17.0 cm (6.7 in)	Lateral
RR	Sill	5.0 cm (1.9 in)	Lateral
RR	Roof rail	5.0 cm (1.9 in)	Lateral
RR	C pillar	1.0 cm (0.4 in)	Lateral

MANUAL RESTRAINT SYSTEMS - 2000 Toyota Echo

The 2000 Toyota Echo was configured with manual 3-point lap and shoulder belts for each seating position. Both front seat safety belts were equipped with adjustable D-rings that were in the full up position. The driver's safety belt was configured with a sliding latch plate and an Emergency Locking Retractor (ELR). There was evidence of historic usage on the seat belt tang, but no indications of any loading. The remaining safety belts were configured with sliding latch plates and switchable ELR/Automatic Locking Retractors (ALR). The front right seat belt was trapped in the stowed position by the B pillar. The second row left seat belt was not functioning correctly. The retractor mechanism appeared jammed and the belt would only retract a small amount.

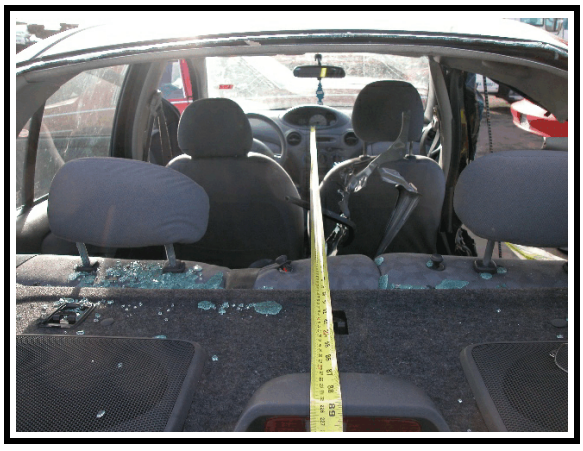


Figure 4. Overview of right side intrusion

Supplemental Restraint System - 2000 Toyota Echo

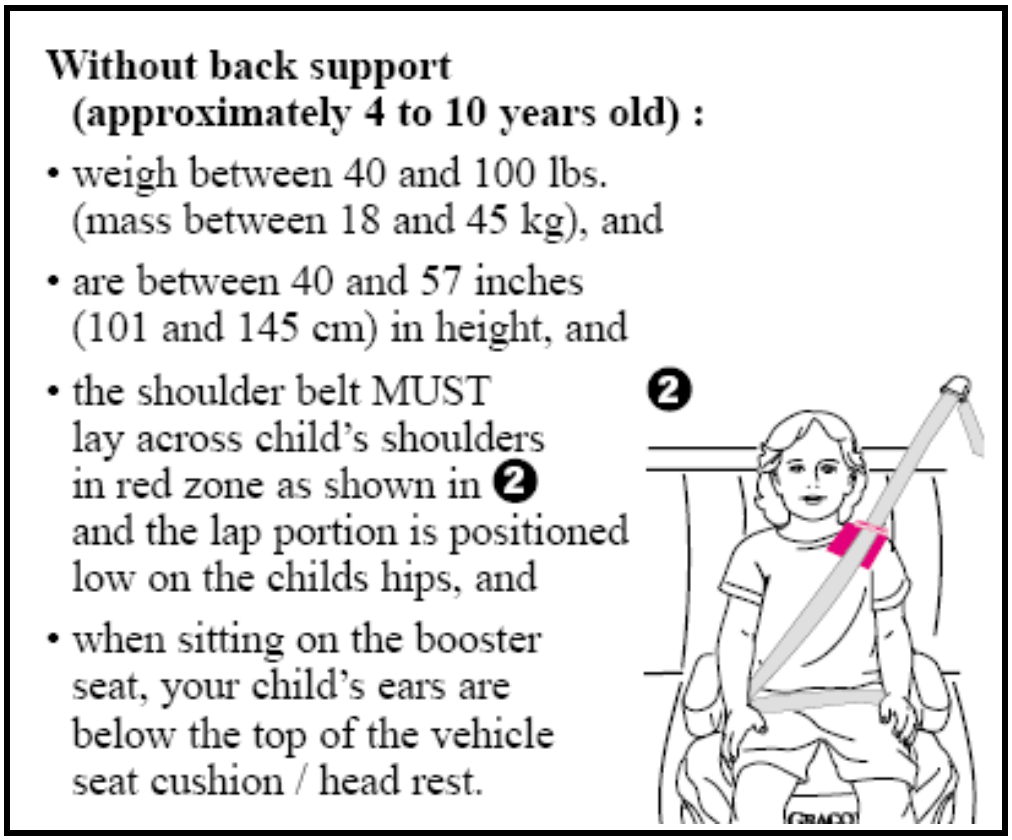
The 2000 Toyota Echo was equipped with frontal air bags. The driver's air bag was mounted in the center of the steering wheel hub. The front right passenger air bag was mounted on top of the right instrument panel. There were no air bag deployments.

Child Safety Seat

A Graco Backless TurboBooster booster car seat was positioned in the right rear seat of the Toyota Echo. The model number was 8491RGB. The seat was manufactured on April 13, 2003.

The Graco Backless TurboBooster youth booster car seat is to be used forward-facing only. An excerpt from the user's manual outlined the recommended use of the CSS as follows:

Figure 5. Top, Graco booster seat



Without back support (approximately 4 to 10 years old) :

- weigh between 40 and 100 lbs. (mass between 18 and 45 kg), and
- are between 40 and 57 inches (101 and 145 cm) in height, and
- the shoulder belt MUST lay across child's shoulders in red zone as shown in ❷ and the lap portion is positioned low on the childs hips, and
- when sitting on the booster seat, your child's ears are below the top of the vehicle seat cushion / head rest.

The CSS was used in a front-facing orientation. The child was placed in the seat and the lap and shoulder belt was placed around the child. The seat was equipped with adjustable arm rests that were at the upper most position.

The booster seat sustained moderate damage as a result of the crash. The upper part of the right side arm rest was dislodged. The forward aspect of the seat bottom was abraded from contact to the intruding right rear door.

Figure 7. Front, Graco booster seat

Figure 8. Right side, Graco booster seat

Figure 9. Close up of abrasion to seat base

VEHICLE DATA - 2001 Dodge Durango

Description:	2001 Dodge Durango sport utility vehicle	
VIN:	Unknown	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Per the police report: Moderate left rear damage consisting of, but not limited to, the following: left rear passenger door dented, and bent forward, left rear quarter panel at left rear taillight crushed inward, left rear rim scratched, front bumper center to left side dented and scratched, right front bumper dented away from grille, and left side front bumper pushed into the left front tire. Human body tissue and blood found on the rear cargo door.	
CDC:	Unknown	
Delta V (Impact 1):	Total	13.0 km/h (8.1 mph)
	Longitudinal	12.8 km/h (8.0 mph)
	Latitudinal	2.3 km/h (1.4 mph)
	Energy	17,829 joules (13,150 ft/lbs)

Figure 10. Exemplar photo, 2001 Dodge Durango

VEHICLE DATA - Unknown third vehicle

Description:	Unknown make/model	
VIN:	Unknown	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Per the police report, minor rear end damage consisting of, but not limited to, the following: rear bumper dented and scratched, rear trunk dented, and right rear taillight broken.	
CDC:	Unknown	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

OCCUPANT DEMOGRAPHICS - 2000 Toyota Echo

	Driver	Occupant 2
Age/Sex:	28/Female	5/Female
Seated Position:	Front left	Second row, right
Seat Type:	Fabric covered bucket seat, seat adjusted to rear most track position	Fabric covered bench seat with a folding back
Height:	Unknown	117 cm (46 in)
Weight:	Unknown	27 kg (60 lbs)
Occupation:	Unknown	NA
Pre-existing Medical Condition:	None noted	None
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Unknown	NA
Body Posture:	Presumably, normal and upright	Presumably, normal and upright
Hand Position:	Unknown	Unknown
Foot Position:	Right foot presumed to be on brake	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt used with booster seat
Air bag:	Steering wheel mounted front air bag, did not deploy	None

OCCUPANT INJURIES -2000 Toyota Echo

Driver: No reported injuries.

Second row right occupant: Injuries obtained from autopsy report.

Injury	OIC Code	Injury Mechanism	Confidence Level
Complete transection, spinal cord, with C-1 fracture and dislocation	640272.6,6	Impact forces	Probable
Fracture, mandible, left side	250600.1,2	Other vehicle	Probable
Subarachnoid hemorrhage	140466.3,6	Impact forces	Probable
Laceration, scalp, bilateral	190604.2,3	Other vehicle	Probable
Abrasion, left zygomatic area	290202.1,2	Other vehicle	Possible
Laceration, minor, right upper lip	290602.1,8	Other vehicle	Probable
Laceration, minor, chin	290602.1,8	Other vehicle	Probable
Multiple abrasions, chin	290202.1,8	Other vehicle	Probable
Multiple lacerations, zygomas, bilateral	290602.1,7	Other vehicle	Possible
Laceration, minor, mandible, right side	290602.1,8	Other vehicle	Probable
Multiple abrasions, chin	290202.1,8	Other vehicle	Probable
Laceration, minor, upper neck	390602.1,5	Unknown	Unknown
Abrasion, neck, right side	390202.1,1	Belt webbing	Possible
Contusion, neck, right side	390402.1,1	Belt webbing	Possible
Contusion, right upper arm	790402.1,1	Door panel	Certain
Contusion, right elbow	790402.1,1	Door panel	Possible
Multiple abrasions, right hand/digits	790202.1,1	Door panel	Possible
Contusion, left elbow	790402.1,2	Booster seat	Possible

Abrasion, left forearm	790202.1,2	Booster seat	Possible
Multiple abrasions, right thigh	890202.1,1	Door panel	Possible
Multiple contusions, right thigh	890402.1,1	Door hardware	Possible
Multiple abrasions, right lower leg	890202.1,1	Door panel	Possible
Multiple contusions, right lower leg	890402.1,1	Door panel	Possible
Abrasion, left lower leg	890202.1,2	Unknown	Unknown
Contusion, left lower leg	890402.1,2	Unknown	Unknown
Abrasion, lower abdomen	590202.1,8	Seat belt webbing	Probable
Abrasions, abdomen, right side	590202.1,1	Seat belt webbing	Possible

OCCUPANT KINEMATICS - 2000 Toyota Echo

Driver kinematics

The 28-year-old female driver was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt. The seat was adjusted to the rear most track position. The driver's seat back was at a 70 degree angle, the seat bottom was at a 12 degree angle. According to police accounts, she was actively steering and braking. The driver was pitched first to the right and then to the left. As she lost control of the vehicle, and the vehicle began a counterclockwise rotation, the driver began pitching to the right. At impact, the driver initiated a lateral and slightly forward trajectory to the right. There were no indications that the driver contacted any interior structures. The driver was not injured. She was able to exit the vehicle under her own ability.

Figure 11. Driver seated position

Second row right occupant kinematics

The 5-year-old female second row right occupant was seated in what is believed to be an upright posture. She was seated in a backless booster seat and was using the manual 3-point lap and shoulder belt. The second row right seat back was at a 70 degree angle, the seat bottom was at a 15 degree angle. According to police accounts, the driver was actively steering and braking. The child was pitched first to the right and then to the left. As the driver lost control of the vehicle, and the vehicle began a counterclockwise rotation, the child began pitching to the right. At impact, the child initiated a lateral and slightly forward trajectory to the right. Intrusion of the right rear door caused scuffing damage to the booster seat base and a portion of the right arm rest was broken away. The child contacted the door panel and door hardware with her right side, causing multiple contusions and abrasions to the upper arm and to the right leg. The child sustained abrasions to the right side of the neck and lower abdomen from the seat belt webbing. As the Dodge Durango intruded into the vehicle, the child's head came into contact with the rear cargo area of the Durango, causing multiple facial contusions and abrasions as well as a mandible fracture. The lateral movement of the child's head to the right during the intrusion likely caused the C1 fracture and dislocation with a complete transection of the spinal cord.

Figure 12. Booster seat belted into right rear seat position

Attachment 1. Scene Diagram