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ON-SITE CHILD AIR BAG-RELATED FATALITY INVESTIGATION

CASE NUMBER - IN01-015
LOCATION - TEXAS
VEHICLE - 2001 FORD F150 XLT
CRASH DATE - May, 2001

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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. <i>Abstract</i> This report covers an on-site investigation of an air bag deployment crash that involved a 2001 Ford F150 XLT pickup truck (case vehicle) and a 1994 Ford Crown Victoria (other vehicle). This crash is of special interest because the case vehicle was equipped with Redesigned air bags and the case vehicle's front right passenger (2-year-old female) sustained serious and severe skull, brain, and cervical injuries from her deploying front right passenger air bag module's cover flap and air bag, resulting in her death. The case vehicle was traveling southeastward in southeastbound lane of a two-lane, undivided, city street and was approaching a Tee intersection. The Crown Victoria, which was traveling ahead of the case vehicle in the southeastbound lane of the same, two-lane, undivided, city roadway, came to a stop heading southeastward. The crash occurred in the southeastbound lane, just prior to the Tee intersection of the two roadways. The front of the case vehicle impacted the back of the Crown Victoria, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. In this contractor's opinion, the case vehicle's front right child passenger had unlatched her safety belt and was in the process of getting up (standing up) out of the front right seat when the case vehicle's driver noticed her actions and diverted her attention away from the driving task. Her seat track was located between its middle and rearmost positions, and she was not using her available, active, "integrated," three-point, lap-and-shoulder, safety belt system. She sustained, according to autopsy, serious and severe head and cervical injuries which included: a hinge-type fracture of her basilar skull; diffuse subarachnoid hemorrhage over her brain and along the base; a fracture of the dens (C ₂) with complete atlanto-axial dislocation {separation-at C ₁ and C ₂ }; hematomas to her right parietal and occipital scalp; abrasions to her left forehead and her right neck; a large abrasion to her anterior neck; contusions to her right cheek, upper lip, posterolateral neck, lateral right clavicle, anterior left shoulder, dorsal right hand, and lower anterior left thigh; and a laceration to her lip. This occupant's primary head and cervical injuries were caused by her contact with the front right passenger air bag module's cover flap and deploying air bag. The case vehicle's driver (31-year-old female) was seated with her seat track located between its middle and forward-most positions, and the tilt steering wheel was located in its upmost position. She was not using her available, active, three-point, lap-and-shoulder, safety belt system and, according to her interview, did not sustain any injuries as a result of this crash.					
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This on-site investigation was brought to NHTSA's attention on May 10, 2001 by NASS Zone Center 2. This crash involved a 2001 Ford F150 XLT pick-up truck (case vehicle) and a 1994 Ford Crown Victoria (other vehicle). The crash occurred in May, 2001, at 6:40 p.m., in Texas and was investigated by the applicable city police department. This crash is of special interest because the case vehicle was equipped with Redesigned air bags and the case vehicle's front right passenger [2-year-old, White (Hispanic) female] sustained serious and severe skull, brain, and cervical injuries from her deploying front right passenger air bag module's cover flap and air bag, resulting in her death. This contractor inspected the scene and vehicles on 14-15 May, 2001. This contractor interviewed the driver for the case vehicle on July 16, 2001. This report is based on the Police Crash Report; interviews with the case vehicle's driver, the investigating police officer, and the county medical examiner; scene and vehicle inspections; occupant kinematic principles; the occupant's autopsy records, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling southeastward in southeastbound lane of a two-lane, undivided, city street and was approaching a Tee intersection, intending to continue southeastward. The Crown Victoria, which was traveling ahead of the case vehicle in the southeastbound lane of the same, two-lane, undivided, city roadway, came to a stop heading southeastward and was waiting to make a left turn at the Tee-intersection and travel northeastward. According to the case vehicle's driver, she was momentarily distracted while trying to get the front right passenger (i.e., daughter) to re-buckle her seat belt. When she recognized the stopped vehicle ahead, she braked and steering slightly to the right, attempting to avoid the crash. The crash occurred in the southeastbound lane, just prior to the Tee intersection of the two roadways; see **CRASH DIAGRAM** below.

The front of the case vehicle impacted the back of the Crown Victoria, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle came to rest heading southeast in the southeastbound lane less than a meter (less than 3.3 feet) past the point-of-impact. The impact to the back of the Crown Victoria nudged it forward, but the Crown Victoria continued its left turn and parked along the southeast edge of the street heading northeast.

The 2001 Ford F-150 XLT was a rear wheel drive, 4x2, four-door, super cab, pickup truck (VIN: 2FTZX172X1C-----) with hinged "B"-pillars which can be used as back doors. The case vehicle was equipped with four-wheel, anti-lock brakes. Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FYLN-1 (350)**. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The preliminary Total, Longitudinal, and Lateral Delta Vs are, respectively: 13.2 km.p.h. (8.2 m.p.h.), -13.0 km.p.h. (-8.1 m.p.h.), and +2.3 km.p.h. (+1.4 m.p.h.). Based on this contractor's experience, these results appear slightly high. The case vehicle was towed due to damage (i.e., a restricted left front tire).

The case vehicle's contact with the Crown Victoria involved the front left half of its bumper. Direct damage began 7.5 centimeters (3.0 inches) left of the case vehicle's center (toward the driver's side) and extended, a measured distance of 71 centimeters (28.0 inches), toward the front left bumper corner. The Field "L" was 160 centimeters (63.0 inches) and extended from bumper corner to bumper corner. Residual maximum crush was measured as 13 centimeters (5.1 inches) at C₁. The case vehicle's wheelbase was unaltered from the crash. The front of the case vehicle's front bumper was rotated upward causing the left front corner of the front bumper to be pushed into and restrict the left front tire. None of the case vehicle's other tires were damaged, deflated, or physically restricted. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two wide tethers, each approximately 14 centimeters (5.5 inches) in width. The driver's air bag had two vent ports, approximately 2.5 centimeters (1.0 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with diameter 63 centimeters (24.8 inches). An inspection of the driver's air bag fabric revealed only the presence of blood spots on the air bag's fabric. These blood spots were scattered around the center and upper center of the air bag's fabric.

The front right passenger's air bag was located in the middle of the instrument panel. The case vehicle was equipped with a key-operated On/Off switch for the front right passenger air bag. The switch was turned to the "On" position. An inspection of the front right air bag module's cover flap and the air bag fabric revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag's fabric. However, the front right air bag module's cover flap was deformed from contacting the child front right passenger. Furthermore, there appeared to be evidence of tooth contact and dried saliva on the cover flap. The front right passenger's air bag was designed without any tethers, and the front right air bag had no vent ports. The deployed front right air bag was rectangular with a height of approximately 60 centimeters (23.6 inches) and a width of approximately 63 centimeters (24.8 inches). The inspection of the front right air bag revealed multiple areas of blood on the front and right side surfaces of the air bag. In addition, an 18 x 15 centimeter (7.1 x 5.9 inch) area of skin and blood transfer was located primarily on the top surface towards the cover flap.

The case vehicle was equipped with a **R**estraints **C**ontrol **M**odule (RCM), and the case vehicle's front safety belt systems were equipped with buckle pretensioners. A download of the **RCM** data was not available, but according the vehicle's manufacturer the following information was provided to this contractor. The system recorded longitudinal deceleration, at 1 millisecond intervals, for the first 116 milliseconds after algorithm wake-up, for the purpose of allowing system examination of the data to determine if the deployment threshold was reached. The data indicates the case vehicle had approximately 3 to 4 "g"s of longitudinal deceleration over the first 65 milliseconds, followed by a stronger spike that reached 8 "g"s filtered deceleration at the 70 millisecond point. The decision to deploy the air bag is based upon a complex mathematical algorithm and that the actual decision to command deployment must occur before the actual

deployment threshold is reach; otherwise, the air bag would be commanded to deploy too late to provide the designed protection. The algorithm predicted, based upon the deceleration spike that occurred at the 70 millisecond interval, that the air bag's protection would be required because the deceleration that the case vehicle was predicted to achieve would reach the required deployment threshold. In this particular crash, the recorded Delta V was only 10.8 km.p.h. (6.7 m.p.h.). The deceleration data following the 70 millisecond interval indicates that the rate of deceleration "leveled out". In other words, the algorithm's predicted deceleration level (i.e., the deployment threshold) was never achieved in this crash. According to the manufacturer, all indications are that the air bag's deployment algorithm performed in accordance with the design intent.

This particular system does not record seat belt status; however, an examination of the front right passenger's buckle-mounted pretensioner indicates that the pretensioner did not retract.

Inspection of the case vehicle's interior revealed additional bloody areas beside the spots found on the driver's air bag fabric and the copious amounts found on the front right passenger's air bag fabric. Specifically, there were blood spots on the windshield, right sun visor, right instrument panel, right window sill, and front right seat's back support. Furthermore, there was a large amount of blood on the driver's seat cushion and center floor-mounted console, and a little on the vertical, outside surface of the driver's seat cushion. In addition, there were scuffs on the right instrument panel and center instrument panel near the front right air bag's On/Off switch, and the air vent in the center instrument panel had been pushed inward. Finally, there was no evidence of intrusion to the case vehicle's interior, no evidence of compression to the energy absorbing sheer capsules in the steering column, and no deformation to the steering wheel rim.

The 1994 Ford Crown Victoria was a rear wheel drive, four-door sedan (VIN: 2FALP73W5RX-----). Based on the vehicle inspection, the CDC for the Crown Victoria was determined to be: **06-BDLN-1 (180)** [maximum crush was 6 centimeters (2.4 inches)–EAD stroke measurement]. The WinSMASH reconstruction program, damage only algorithm, was used on the Crown Victoria's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 14.6 km.p.h. (9.1 m.p.h.), + 14.6 km.p.h. (+ 9.1 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The Crown Victoria was driven from the scene.

According to the case vehicle's driver, immediately prior to the crash the case vehicle's, front right child passenger [91 centimeters and 18 kilograms (36 inches, 40 pounds)] was seated facing forward in an upright posture with her buttocks and lower back against the seat back, both legs outstretched forward on the seat's cushion, and her hands were fiddling with the seat belt. Her seat track was located between its middle and rearmost positions, and the seat back was upright. Based upon the vehicle inspection, the positions of the front right seat track and seat back correspond to that reported by the case vehicle's driver. In this contractor's opinion, based upon the deformation to the front right air bag module's cover flap and the front right seat's track location, this contractor believes that the front right passenger had unlatched her safety belt and was in the process of getting up (standing up) out of the front right seat when the case vehicle's driver noticed her actions and diverted her attention away from the driving task. The occupant may have had one leg (or more) underneath her and was raising up and had turned her head toward her mother (i.e., driver) just prior to the driver's avoidance actions.

The case vehicle's front right child passenger was not using her available, active, "integrated," three-point, lap-and-shoulder, safety belt system. Furthermore, the inspection of the front right passenger's seat belt webbing and latch plate showed no evidence of loading. According to the case vehicle's driver, she was trying to get her front right child passenger to (***sit down and***) re-buckle her seat belt, when she recognized the impending danger ahead.

The case vehicle's driver braked and steered right (i.e., steering is based on the off-set nature of the vehicle-to-vehicle interaction and the resulting triangular crush pattern measured on the case vehicle), attempting to avoid the crash. As a result of these attempted avoidance maneuvers and the nonuse of either a child safety seat or her available safety belts, the child passenger moved forward and slightly upward (i.e., head first) as the vehicle decelerated just prior to impact. The case vehicle's pre-impact braking most likely resulted in the right side of her head coming immediately in front of the front right air bag's module just prior to the deployment. The case vehicle's impact with the Crown Victoria enabled the case vehicle's child passenger to continue forward and upward toward the **350** degree Direction of Principal Force as the case vehicle further decelerated. Based on what appears to be teeth marks and dried saliva on the cover flap, this contractor believes that the front right, child passenger contacted the front right air bag module's cover flap with the right side of her head and facial areas. The deploying cover flap fractured the child's basilar skull and enabled a tooth in her mouth to gouge the cover flap. The deploying air bag, which followed the flap, hyper extended the child's head violently backwards, halted her forward motion, and lifted the child passenger upwards and backwards into the front right seat back. While the front right passenger was being lifted and pushed backwards, her left thigh contacted the lower portion of the right instrument panel. It is also likely that the front right passenger's head may have struck the roof and/or roof side rail or "B"-pillar prior to striking the front right passenger's seat back; however, there is no obvious visible contact evidence that this occurred. In this contractor's opinion, the most likely scenario is that she was driven backwards into her seat back. As the child was moving backwards, her lower extremities most likely impacted the center instrument panel, dislodging and cracking the air vent next to the front right air bag's On/Off switch. Based on the driver's interview and the blood evidence found on both the floor-mounted center console and the inside portion of the front right seat cushion, the front right, child passenger came to rest on the front right seat's cushion in a sitting position with her torso hunched forward and her face on the left side of the seat cushion. The case vehicle's driver removed the front right passenger and placed her on a nearby lawn pending arrival of medical personnel.

The front right occupant was transported by ambulance to the hospital. She sustained serious and severe head and cervical injuries and was pronounced dead one hour and seven minutes post-crash. According to the autopsy, the injuries sustained by the case vehicle's front right, child passenger included: a hinge-type fracture of her basilar skull; diffuse subarachnoid hemorrhage over her brain and along the base; a fracture of the dens (C₂) with complete atlanto-axial dislocation {separation-at C₁ and C₂}; hematomas to her right parietal and occipital scalp; abrasions to her left forehead and her right neck; a large abrasion to her anterior neck; contusions to her right cheek, upper lip, posterolateral neck, lateral right clavicle, anterior left shoulder, dorsal right hand, and lower anterior left thigh; and a laceration to her lip. This occupant's

primary head and cervical injuries were caused by her contact with the front right passenger air bag module's cover flap and deploying air bag.

The case vehicle's driver [31-year-old, White (Hispanic) female; 150 centimeters and 77 kilograms (59 inches, 170 pounds)] was seated in an upright posture with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel. Her seat track was located between its middle and forward-most positions, the seat back was upright, and the tilt steering wheel was located in its utmost position.

The case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system. The driver was transported by the police to the hospital. According to the driver she did not sustain any injuries and was not treated.

CRASH CIRCUMSTANCES

The case vehicle was traveling southeastward in southeastbound lane of a two-lane, undivided, city street and was approaching a Tee intersection, intending to continue southeastward (**Figure 1**). The Crown Victoria, which was traveling ahead of the case vehicle in the southeastbound lane of the same, two-lane, undivided, city roadway, came to a stop heading southeastward and was waiting to make a left turn at the Tee-intersection and travel northeastward. According to the case vehicle's driver, she was momentarily distracted while trying to get the front right passenger (i.e., daughter) to re-buckle her seat belt. When she recognized the stopped vehicle ahead, she braked and steering slightly to the right, attempting to avoid the crash. The crash occurred in the southeastbound lane, just prior to the Tee intersection of the two roadways; see **CRASH DIAGRAM** below.



Figure 1: Northwesterly view of case vehicle's and Crown Victoria's uphill pre-crash travel path; Note: flowers by reference point mark approximate point of impact (case photo #04)

The city roadway was straight and had a 2.4% grade positive to the southeast (i.e., an upgrade in both the case vehicle's and the Crown Victoria's direction of travel), at the area of impact. The pavement was bituminous, and the width of the travel lanes for both vehicles was 4.6 meters (15.0 feet) while and the northwestbound lane was only 3.9 meters (12.7 feet). The shoulders were not improved. The southwest side of the road was bordered by an old crumbling concrete sidewalk that was adjacent to a grassy area and the northeast side was border by a grassy shoulder. The roadway had no curbs. Pavement markings consisted of a double solid yellow centerline for both the southeast and northwestbound traffic. In addition, no edge lines were present. The estimated coefficient of friction was 0.80. There were no visible traffic controls in the immediate area of the crash. The statutory speed limit was 48 km.p.h. (30 m.p.h.), and no regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the road pavement was dry. Traffic density was light, and

the site of the crash was urban residential. In addition, there were several residential driveways near the crash site.



Figure 2: Case vehicle's frontal damage with contour gauge present; Note: bumper rotated upward (case photo #08)



Figure 3: Ford Crown Victoria's impacted back bumper showing outline (between tape) of direct damage (case photo #31)



Figure 4: On-scene photo looking northwestward in the southeastbound lane showing case vehicle at final rest (case photo #45)



Figure 5: On-scene photo showing final rest position of case vehicle (foreground) and parked position (background) of Crown Victoria (case photo #41)

The front (**Figure 2**) of the case vehicle impacted the back (**Figure 3**) of the Crown Victoria, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle came to rest heading southeast in the southeastbound lane (**Figure 4**) less than a meter (less than 3.3 feet) past the point-of-impact. The impact to the back of the Crown Victoria nudged it forward, but the Crown Victoria continued its left turn and parked along the southeast edge of the street heading northeast (**Figure 5**).

CASE VEHICLE

The 2001 Ford F-150 XLT was a rear wheel drive, 4x2, six-passenger, four-door, super cab, standard bed, pickup truck (VIN: 2FTZX172X1C-----) equipped with a 4.2L, V-6 engine and a four-speed automatic transmission. The back doors were hinged at the "C"-pillars with the locking latch mechanisms located at the top and bottom of where the "B"-pillars were normally

located (**Figure 6**). Braking was achieved by a power-assisted, front and rear disc, four-wheel, anti-lock system. The case vehicle's wheelbase was 352 centimeters (138.5 inches), and the odometer reading at inspection {was 9,249 kilometers (5,747 miles).



Figure 6: Case vehicle's interior with both right side doors open showing super cab and deployed front air bags (case photo #28)

Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints; a non-adjustable back bench seat without head restraints for the back seating positions; integrated (i.e., seat back-mounted) continuous loop, three-point, lap-and-shoulder, safety belt systems at the front outboard positions; continuous loop, three-point, lap-and-shoulder, safety belt systems at the back outboard positions; and a two-point, lap belt system at the back center position. None of the seat belt systems were equipped with manually operated, upper anchorage adjusters for the "D"-rings. The vehicle was equipped with knee bolsters for both the driver and front right passenger, neither of which were deformed. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a redesigned frontal air bag for the driver and front right passenger seating positions. Both frontal air bags deployed as a result of the case vehicle's frontal impact with the Crown Victoria.

CASE VEHICLE DAMAGE

The case vehicle's contact with the Crown Victoria involved the front left half of its bumper (**Figure 7**). Direct damage began 7.5 centimeters (3.0 inches) left of the case vehicle's center (toward the driver's side) and extended, a measured distance of 71 centimeters (28.0 inches), toward the front left bumper corner. The Field "L" was 160 centimeters (63.0 inches) and extended from bumper corner to bumper corner. Residual maximum crush was measured as 13 centimeters (5.1 inches) at C₁. The case vehicle's wheelbase was unaltered from the crash. The front of the case vehicle's front bumper was rotated upward causing the left front corner of the front bumper to be pushed into and restrict the left front tire (**Figure 8** below). None of the case vehicle's other tires were damaged, deflated, or physically restricted. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

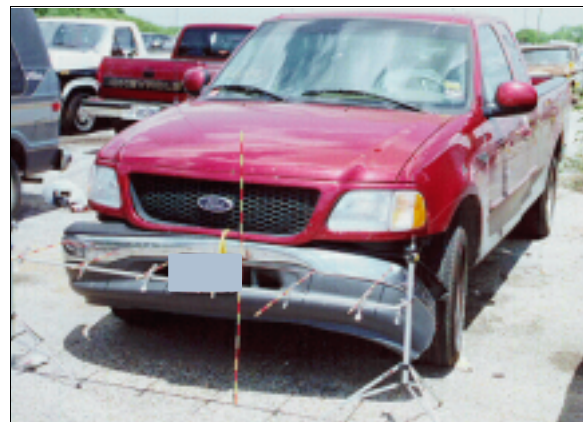


Figure 7: Case vehicle's damaged front viewed from left of front with contour gauge present showing direct damage width between tape and front left bumper corner (case photo #07)

Inspection of the case vehicle's interior revealed bloody areas, additional to the spots found on the driver's air bag fabric and the copious amounts found on the front right passenger's air bag

fabric (**Figure 9**). Specifically, there were blood spots on the windshield, right instrument panel, right window sill, and front right seat's back support. Furthermore, there was a large amount of blood on the driver's seat cushion and center floor-mounted console (**Figure 10**), and a little on the vertical, outside surface of the driver's seat cushion (**Figure 11** below). In addition, there were scuffs on the right instrument panel and center instrument panel near the front right air bag's On/Off switch, and the air vent in the center instrument panel had been pushed inward (**Figure 12** below). Finally, there was no evidence of intrusion to the case vehicle's interior, no evidence of compression to the energy absorbing sheer capsules in the steering column, and no deformation to the steering wheel rim.



Figure 9: Vertical view of case vehicle's front right passenger seating area showing blood evidence on front surface of deployed air bag (case photo #23)



Figure 8: Reference line view of minor deformation to case vehicle's front bumper (case photo #09)

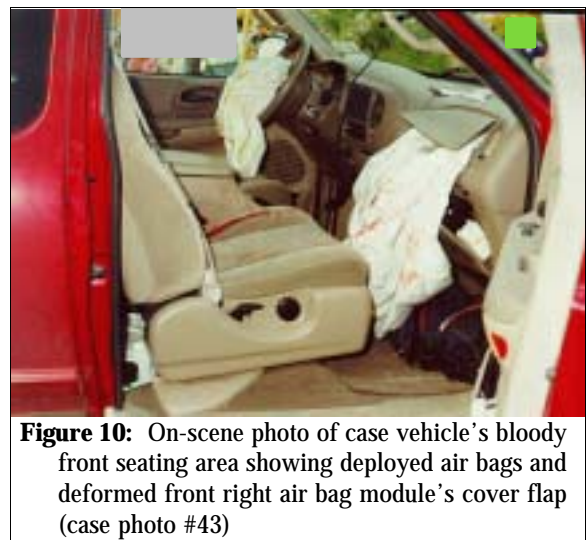


Figure 10: On-scene photo of case vehicle's bloody front seating area showing deployed air bags and deformed front right air bag module's cover flap (case photo #43)

The case vehicle was equipped with four-wheel, anti-lock brakes. Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FYLN-1 (350)**. The

WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The preliminary Total, Longitudinal, and Lateral Delta Vs are, respectively: 13.2 km.p.h. (8.2 m.p.h.), -13.0 km.p.h. (-8.1 m.p.h.), and + 2.3 km.p.h. (+ 1.4 m.p.h.). Based on this contractor's experience, these results appear slightly high. The case vehicle was towed due to damage (i.e., a restricted left front tire).



Figure 12: Close-up of contacted air vent on case vehicle's center instrument panel just above passenger air bag's ON/OFF switch; Note: switch is in the ON position (case photo #22a)

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained frontal air bags at the driver and front right passenger positions. Both frontal air bags deployed as a result of the frontal impact with the Crown Victoria. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of asymmetrical rounded, "H"-configuration cover flaps made of thick vinyl with overall dimensions of 19 centimeters (7.4 inches) at the middle horizontal seam, 12 centimeters (4.7 inches) at the top and bottom horizontal seams, 19.5 centimeters (7.7 inches) vertically for the upper flap and 7.5 centimeters (3.0 inches)



Figure 11: Case vehicle's driver knee bolster; Note: blood smear to side of driver's seat cushion (case photo #19)



Figure 13: Vertical view of case vehicle's driver seating area showing deployed air bag with only scattered tiny blood spots around bag's center and upper center areas (case photo #20)

vertically for the lower flap. An inspection of the air bag module's cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two wide tethers, each approximately 14 centimeters (5.5 inches) in width. The driver's air bag had two vent ports, approximately 2.5 centimeters (1.0 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with diameter 63 centimeters (24.8 inches). An inspection of the driver's air bag fabric revealed only the presence of blood spots on the air bag's fabric. These blood spots were scattered around the center and upper center of the air bag's fabric (**Figure 13** above).



Figure 14: Case vehicle's front seating area showing deployed air bags, deformed front right passenger air bag module's cover flap, and cell phone on windshield (case photo #17)

The front right passenger's air bag was located in the middle of the instrument panel. The case vehicle was equipped with a key-operated On/Off switch for the front right passenger air bag. The switch was turned to the "On" position. There was a single, essentially rectangular, modular cover flap with a rounded left upper corner. The cover flap was made of a thick vinyl over a thick cardboard type frame. The flap's dimensions were: 39.5 centimeters (15.6 inches) at the forward horizontal seam, 16 centimeters (6.3 inches) along the right vertical seam, and 15 centimeters (5.9 inches) along the left vertical seam, measured from the middle of the rounded corner. The profile of the case vehicle's instrument panel resulted in a 3 centimeter (1.2 inch) setback of the leading edge of the cover flap relative to the protruding right instrument panel. An inspection of the front right air bag module's cover flap and the air bag fabric revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag's fabric. However, the front right air bag module's cover flap was deformed from contacting the child front right passenger (**Figures 14** and **15**). Furthermore, there appeared to be evidence of tooth contact and dried saliva on the cover flap (**Figure 16** below). The front right passenger's air bag was designed without any tethers, and the front right air bag



Figure 15: On-scene photo of case vehicle's bloodied front right passenger air bag and contacted air bag module's cover flap (case photo #38)

had no vent ports. The deployed front right air bag was rectangular with a height of approximately 60 centimeters (23.6 inches) and a width of approximately 63 centimeters (24.8 inches). The inspection of the front right air bag revealed multiple areas of blood on the front and right side surfaces of the air bag (**Figure 17**). For example, there was a 27 x 12 centimeter (10.6 x 4.7 inch) elongated blood splatter that began on the top left surface but was primarily on the left upper portion of the front surface. Furthermore, there was a 7 x 12 centimeter (2.8 x 4.7 inch) vertical area of blood ending toward the 7 o'clock position, and an 8 x 8 centimeter (3.1 x 3.1 inch) area of blood spots in the upper right quadrant of the front surface. On the right side surface there were two elliptical areas [one 6 x 14 centimeters (2.4 x 5.5 inches) and the other 17 x 10 centimeters (6.7 x 3.9 inches)] that partially overlapped the right side of the front surface but were primarily on the surface near the seam that separates the two. They were located toward the 2 and 4 o'clock positions, respectively. In addition, an 18 x 15 centimeter (7.1 x 5.9 inch) area of skin and blood transfer was located primarily on the top surface towards the cover flap.



Figure 16: Close-up of contact evidence (tooth mark and saliva area) on case vehicle's front right air bag module's cover flap (case photo #27)



Figure 17: Front surface of case vehicle's deployed front right passenger air bag showing copious blood splatter evidence (case photo #24)

RESTRAINTS CONTROL MODULE

The case vehicle was equipped with a **Restraints Control Module (RCM)**, and the case vehicle's front safety belt systems were equipped with buckle pretensioners. A download of the **RCM** data was not available, but according to the vehicle's manufacturer the following information was provided to this contractor. The system recorded longitudinal deceleration, at 1 millisecond intervals, for the first 116 milliseconds after algorithm wake-up, for the purpose of allowing system examination of the data to determine if the deployment threshold was reached. The data indicates the case vehicle had approximately 3 to 4 "g"s of longitudinal deceleration over the first 65 milliseconds, followed by a stronger spike that reached 8 "g"s filtered deceleration at the 70 millisecond point. The decision to deploy the air bag is based upon a complex mathematical algorithm and that the actual decision to command deployment must occur before the actual deployment threshold is reached; otherwise, the air bag would be commanded to deploy too late to provide the designed protection. The algorithm predicted, based upon the deceleration spike that occurred at the 70 millisecond interval, that the air bag's protection would be required because the deceleration that the case vehicle was predicted to achieve would reach the required deployment threshold. In this particular crash, the recorded Delta V was only 10.8 km.p.h. (6.7 m.p.h.). The

deceleration data following the 70 millisecond interval indicates that the rate of deceleration “leveled out”. In other words, the algorithm’s predicted deceleration level (i.e., the deployment threshold) was never achieved in this crash. According to the manufacturer, all indications are that the air bag’s deployment algorithm performed in accordance with the design intent.

This particular system does not record seat belt status; however, an examination of the front right passenger’s buckle-mounted pretensioner indicates that the pretensioner did not retract (**Figure 18**).



Figure 18: On-scene close-up photo of case vehicle’s bloody front right seat showing safety belt system’s buckle with pretensioner not retracted, indicating non-usage (case photo #40)

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

According to the case vehicle’s driver, immediately prior to the crash the case vehicle’s, front right child passenger [2-year-old, White (Hispanic) female; 91 centimeters and 18 kilograms (36 inches, 40 pounds)] was seated facing forward in an upright posture with her buttocks and lower back against the seat back, both legs outstretched forward on the seat’s cushion, and her hands were fiddling with the seat belt. Her seat track was located between its middle and rearmost positions, and the seat back was upright. Based upon the vehicle inspection, the positions of the front right seat track and seat back correspond to that reported by the case vehicle’s driver. In this contractor’s opinion, based upon the deformation to the front right air bag module’s cover flap and the front right seat’s track location, this contractor believes that the front right passenger had unlatched her safety belt and was in the process of getting up (standing up) out of the front right seat when the case vehicle’s driver noticed her actions and diverted her attention away from the driving task. The occupant may have had one leg (or more) underneath her and was raising up and had turned her head toward her mother (i.e., driver) just prior to the driver’s avoidance actions.

The case vehicle’s front right child passenger was not using her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, the inspection of the front right passenger’s seat belt webbing and latch plate showed no evidence of loading (**Figure 18**). According to the case vehicle’s driver, she was trying to get her front right child passenger to (*sit down and*) re-buckle her seat belt, when she recognized the impending danger ahead.

The case vehicle’s driver braked and steered right (i.e., steering is based on the off-set nature of the vehicle-to-vehicle interaction and the resulting triangular crush pattern measured on the case vehicle), attempting to avoid the crash. As a result of these attempted avoidance maneuvers and the nonuse of either a child safety seat or her available safety belts, the child passenger moved forward and slightly upward (i.e., head first) as the vehicle decelerated just prior to impact. The case vehicle’s pre-impact braking most likely resulted in the right side of her head coming immediately in front of the front right air bag’s module just prior to the

deployment. The case vehicle's impact with the Crown Victoria enabled the case vehicle's child passenger to continue forward and upward toward the 350 degree Direction of Principal Force as the case vehicle further decelerated. Based on what appears to be teeth marks and dried saliva on the cover flap (**Figure 16** above), this contractor believes that the front right, child passenger contacted the front right air bag module's cover flap with the right side of her head and facial areas. The deploying cover flap fractured the child's basilar skull and enabled a tooth in her mouth to gouge the cover flap. The deploying air bag, which followed the flap, hyper extended the child's head violently backwards, halted her forward motion, and lifted the child passenger upwards and backwards into the front right seat back. While the front right passenger was being lifted and pushed backwards, her left thigh contacted the lower portion of the right instrument panel. It is also likely that the front right passenger's head may have struck the roof and/or roof side rail or "B"-pillar prior to striking the front right passenger's seat back; however, there is no obvious visible contact evidence that this occurred. In this contractor's opinion, the most likely scenario is that she was driven backwards into her seat back. As the child was moving backwards, her lower extremities most likely impacted the center instrument panel, dislodging and cracking the air vent next to the front right air bag's On/Off switch (**Figure 12** above). Based on the driver's interview and the blood evidence found on both the floor-mounted center console and the inside portion of the front right seat cushion (**Figures 10** and **Figure 18** above), the front right, child passenger came to rest on the front right seat's cushion in a sitting position with her torso hunched forward and her face on the left side of the seat cushion. The case vehicle's driver removed the front right passenger and placed her on a nearby lawn pending arrival of medical personnel (**Figure 19**).

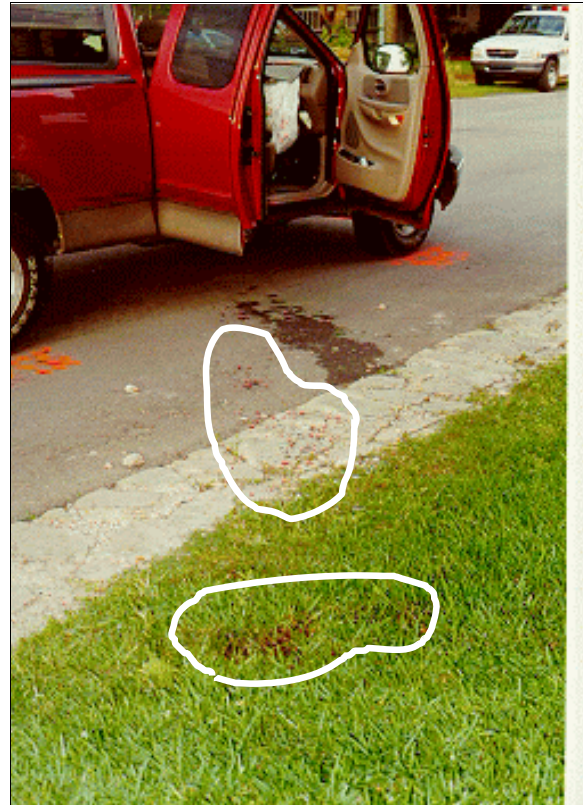


Figure 19: On-scene photo looking east showing blood evidence trail (highlighted) dripped by case vehicle's front right passenger when her body was removed from vehicle and placed on grass (case photo #39)

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right occupant was transported by ambulance to the hospital. She sustained serious and severe head and cervical injuries and was pronounced dead one hour and seven minutes post-crash. According to the autopsy, the injuries sustained by the case vehicle's front right, child passenger included: a hinge-type fracture of her basilar skull; diffuse subarachnoid hemorrhage over her brain and along the base; a fracture of the dens (C₂) with complete atlanto-axial dislocation {separation-at C₁ and C₂}; hematomas to her right parietal and occipital scalp; abrasions to her left forehead and her right neck; a large abrasion to her anterior neck; contusions

Case Vehicle Front Right Passenger Injuries (Continued)

IN01-015

to her right cheek, upper lip, posterolateral neck, lateral right clavicle, anterior left shoulder, dorsal right hand, and lower anterior left thigh; and a laceration to her lip. This occupant's primary head and cervical injuries were caused by her contact with the front right passenger air bag module's cover flap and deploying air bag.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Hemorrhage, subarachnoid, diffuse film over brain with accumulation at base [Aspect = Unknown]	140684.3 serious	Air bag, front right passenger's	Probable	Autopsy
2	Fracture, hinge-type, complete, basilar skull, location not further specified	150206.4 severe	Front right module's cover flap	Certain	Autopsy
3	Fracture dens (i.e., C ₂) with complete dislocation {separation} between 1 st (atlas) and 2 nd (axis) cervical vertebrae (i.e., atlanto-axial) ¹	650228.3 serious	Air bag, front right passenger's	Probable	Autopsy
4	Hematoma {hemorrhage}, subgaleal on right parietal scalp, 8 x 4 cm (3.1 x 1.6 in) and posterior occipital scalp, 4 x 5 cm (1.6 x 2.0 in)	190402.1 minor	Front right module's cover flap	Certain	Autopsy
5		190402.1 minor			
6	Abrasion, 2 x 1 cm (0.8 x 0.4 in), left forehead	290202.1 minor	Air bag, front right passenger's	Probable	Autopsy
7	Contusions right cheek including mid surface: 2 x 2 cm (0.8 x 0.8 in), and lateral surface, faintly: 1.5 x 1 cm and 3 x 2 cm (0.6 x 0.4 and 1.2 x 0.8 in), respectively	290402.1 minor	Front right module's cover flap	Certain	Autopsy
8	Contusion, 2 x 1 cm (0.8 x 0.4 in), inner upper lip	290402.1 minor	Front right module's cover flap	Certain	Autopsy
9	Laceration, 0.2 cm (0.08 in), inner upper lip	290602.1 minor	Front right module's cover flap	Certain	Autopsy
10	Abrasion, superficial, posterolateral right neck	390202.1 minor	Air bag, front right passenger's	Certain	Autopsy
11	Contusion, 4 x 3 cm (1.6 x 1.2 in), posterolateral neck	390402.1 minor	Air bag, front right passenger's	Certain	Autopsy

¹ According to the autopsy report, her cervical spinal cord was grossly intact.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
12	Abrasion, 13 x 11 cm (5.1 x 4.3 in), from undersurface of chin to upper chest and over anterior neck with linear sparing; abrasion extends 4 cm (1.6 in) to left of midline and 7 cm (2.8 in) to right of midline	390202.1 minor	Air bag, front right passenger's	Certain	Autopsy
13	Contusion, 3 x 2 cm (1.2 x 0.8 in) over lateral right clavicle	790402.1 minor	Air bag, front right passenger's	Certain	Autopsy
14	Contusions: 1.5 x 1 and 2 x 2 (0.6 x 0.4 and 0.8 x 0.8 in) over anterior left shoulder	790402.1 minor	Air bag, front right passenger's	Certain	Autopsy
15	Contusions dorsal surface right hand [i.e., 3 x 2 (1.2 x 0.8 in)] and 2 nd , 3 rd , and 4 th fingers	790402.1 minor	Right side interior surface, excluding hardware and/or armrest	Probable	Autopsy
16	Contusion, 2 x 2 cm (0.8 x 0.8 in) to lower anterior left thigh	890402.1 minor	Right instrument panel and below	Probable	Autopsy

CASE VEHICLE DRIVER KINEMATICS

The case vehicle's driver [31-year-old, White (Hispanic) female; 150 centimeters and 77 kilograms (59 inches, 170 pounds)] was seated in an upright posture with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel. Her seat track was located between its middle and forward-most positions, the seat back was upright, and the tilt steering wheel was located in its upmost position.

The case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was no reported of belt pattern bruising and/or abrasions to the driver's body, and the inspection of the driver's integrated seat belt webbing and latch plate showed no evidence of usage during this crash.

The case vehicle's driver braked and steered right (i.e., based upon the available evidence), attempting to avoid the crash. As a result of these attempted avoidance maneuvers and the nonuse of her available safety belts, the driver moved forward and slightly upward as the vehicle decelerated just prior to impact. The case vehicle's impact with the Crown Victoria enabled the driver to continue forward and upward toward the **350** degree Direction of Principal Force as the case vehicle further decelerated. Because of her short stature [150 centimeters (59 inches)], her close proximity (i.e., seat track position) to the air bag module, and the upmost position of her tilt steering wheel, her face, neck, and upper chest loaded her deploying air bag. As a result, the air bag most likely deflected the driver backwards into her seat back. The *redesigned* nature of the

driver's air bag may well have prevented her from sustaining any serious injuries in this crash. The driver does not recall her exact posture at final rest, most likely because her attention was focused on her daughter (i.e., the front right passenger). At final rest, she was most likely in her seat, near her pre-crash position. The case vehicle's driver exited the vehicle without assistance and removed the front right passenger to the southwest roadside.

CASE VEHICLE DRIVER INJURIES

The driver was transported by the police to the hospital. According to the driver she did not sustain any injuries and was not treated. Her only complaint was of "soreness".

OTHER VEHICLE

The 1994 Ford Crown Victoria was a rear wheel drive, five-passenger, four-door sedan (VIN: 2FALP73W5RX-----) equipped with a 4.6L, V-8 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, front disc and rear drum, four-wheel, anti-lock system. The case vehicle's wheelbase was 291 centimeters (114.4 inches), and the odometer reading is unknown because the interior was not inspected.



Figure 20: Ford Crown Victoria's back showing width of direct contact on bumper and slight separation of trunk lid as only visible deformation (case photo #46)



Figure 21: Ford Crown Victoria's back bumper damage with tape indicating length of direct contact; Note: only very minor damage was found (case photo #47)



Figure 22: Undercarriage view of Ford Crown Victoria's back bumper reinforcement bar and left EAD stroke (case photo #51)

The Crown Victoria's contact with the case vehicle involved its back bumper. Direct damage began 49 centimeters (19.3 inches) left of the vehicle's center and extended, a measured distance of 84 centimeters (33.1 inches), along the back bumper toward the back right bumper corner (**Figures 20** and **21** above). Field "L" involved the entire back bumper and was measured as 170 centimeters (66.9 inches). There was no detectable crush at the bumper, but maximum crush was measured as 6 centimeters (2.4 inches)–left EAD stroke measurement (**Figure 22** above).

Based on the vehicle inspection, the CDC for the Crown Victoria was determined to be: **06-BDLN-1 (180)**. The WinSMASH reconstruction program, damage only algorithm, was used on the Crown Victoria's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 14.6 km.p.h. (9.1 m.p.h.), + 14.6 km.p.h. (+ 9.1 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The Crown Victoria was driven from the scene.

The following material is taken from the book: FORENSIC PATHOLOGY, 2ND EDITION by Vincent J. DiMaio, M.D., and Dominick J. DiMaio, M.D., CRC Press, Boca Raton, Florida, 2001; Chapter Six: Trauma to the Skull and Brain: Craniocerebral Injuries, *Fractures of the Skull*, pages 152 through 155.

BASILAR SKULL FRACTURES are quite common in forensic medicine. The base of the skull, by virtue of its construction and irregular shape, is weak. Almost any diffuse impact to the vertex of the skull will produce basilar fractures. Basal skull fractures can occur from blows anywhere along the circumference of the skull below the cranial vault. They can run anterior-posteriorly, posterior-anteriorly, side to side and any combination of these three. Basal skull fractures may be missed on X-rays of the skull. With a basal fracture, intracranial passage of a nasogastric tube or nasopharyngeal airway can occur.

HINGE FRACTURES are transverse fractures of the base of the skull that completely bisect the base of the skull, creating a "hinge." The authors divide them into three categories (**Figure 23**). Type I run in the coronal plane, extending from the lateral end of one petrous ridge, through the sella turcica, to the lateral end of the contralateral petrous ridge. Type II run from front to the contralateral back, passing through the sella turcica. Type III run from side to side in the coronal plane but do not pass through the sella turcica. *Type I hinge fractures are the most common form of transverse fractures of the base of the skull.* They have traditionally been ascribed to impacts on the side of the head and, less commonly, to impacts on the tip of the chin. In the latter instance, one would expect a laceration of the tip of the chin, through not necessarily fracture of the mandible.

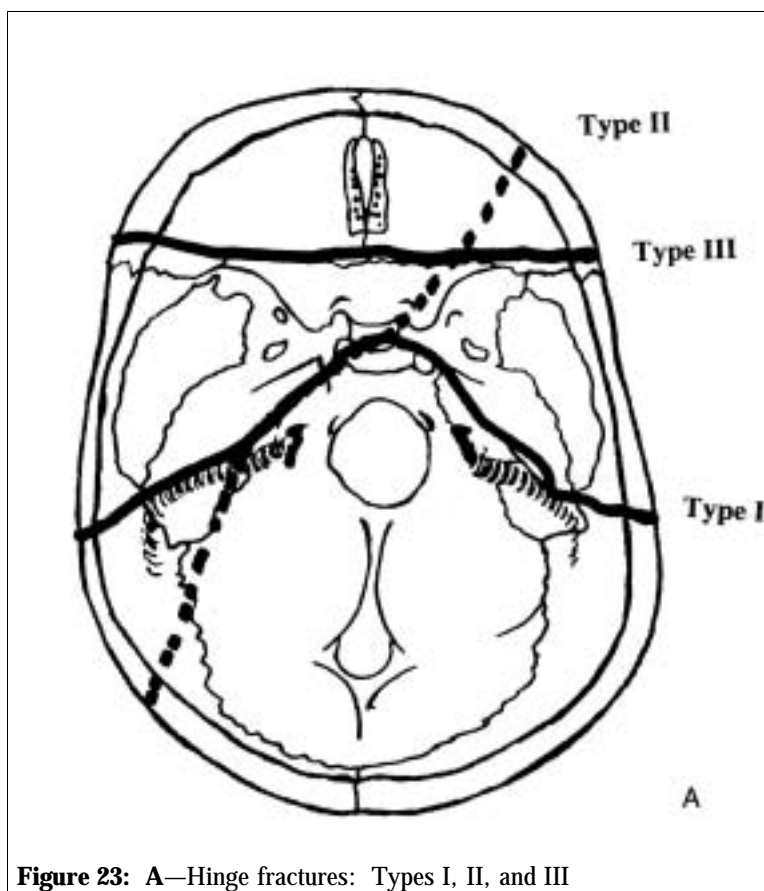


Figure 23: A—Hinge fractures: Types I, II, and III

RING FRACTURES are circular fractures of the base of the skull that surround the foramen magnum. Typically, they run from the sella turcica partly down the petrous ridges, before turning posteriorly, and then medially, joining in the posterior fossa, enclosing the foramen magnum (**Figure 24**). They may be due to impacts on the top of the head that drive the skull downward onto the vertebral column, falls on the buttocks that drive the spine into the base of the skull, and impacts to the tip of the chin. In ring fractures from impacts on the tip of the chin, almost invariably there is a laceration of the chin. Even though the force of impact is transmitted through the mandible to the base of the skull, in most instances, fractures of the mandible are not present. Experiments have revealed that more force is needed to fracture the mandible than to produce a basal fracture.

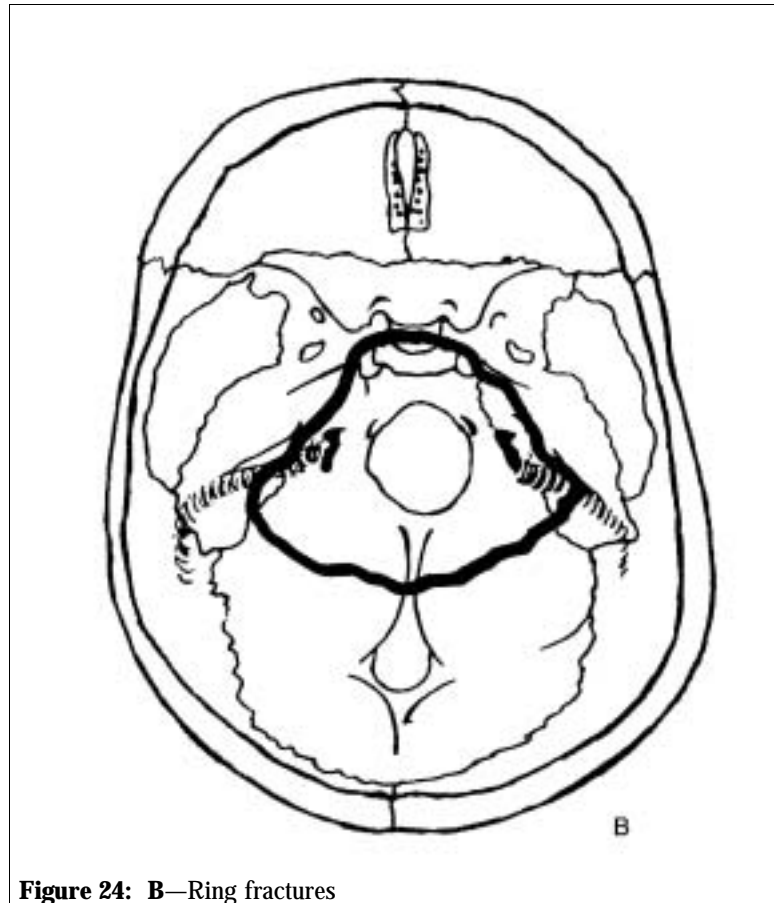


Figure 24: B—Ring fractures

