



The Benefits of Booster Seats – Sled Tests and CIREN Case Examples

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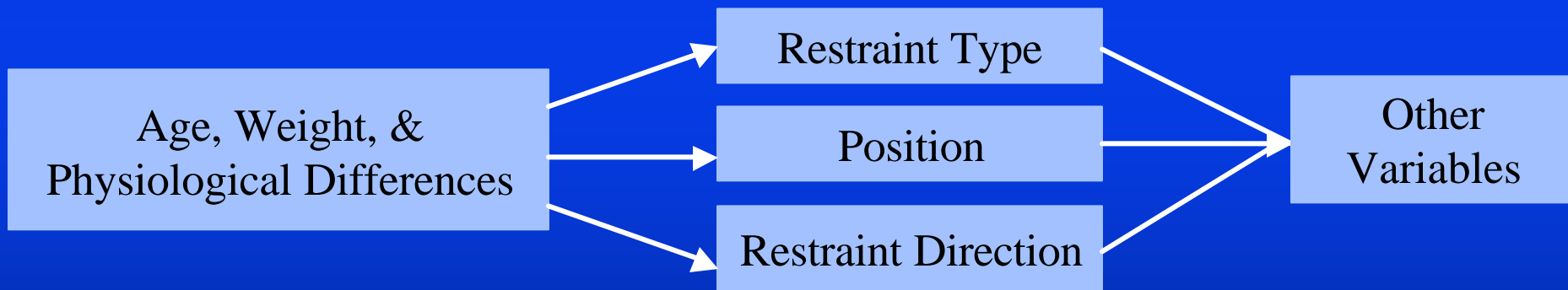
Objectives



- Increase knowledge benefits of booster seats in child passenger safety
- Understand injury risks associated with premature graduation from booster seats
- Use simulation models to further quantify injury patterns with different restraint systems

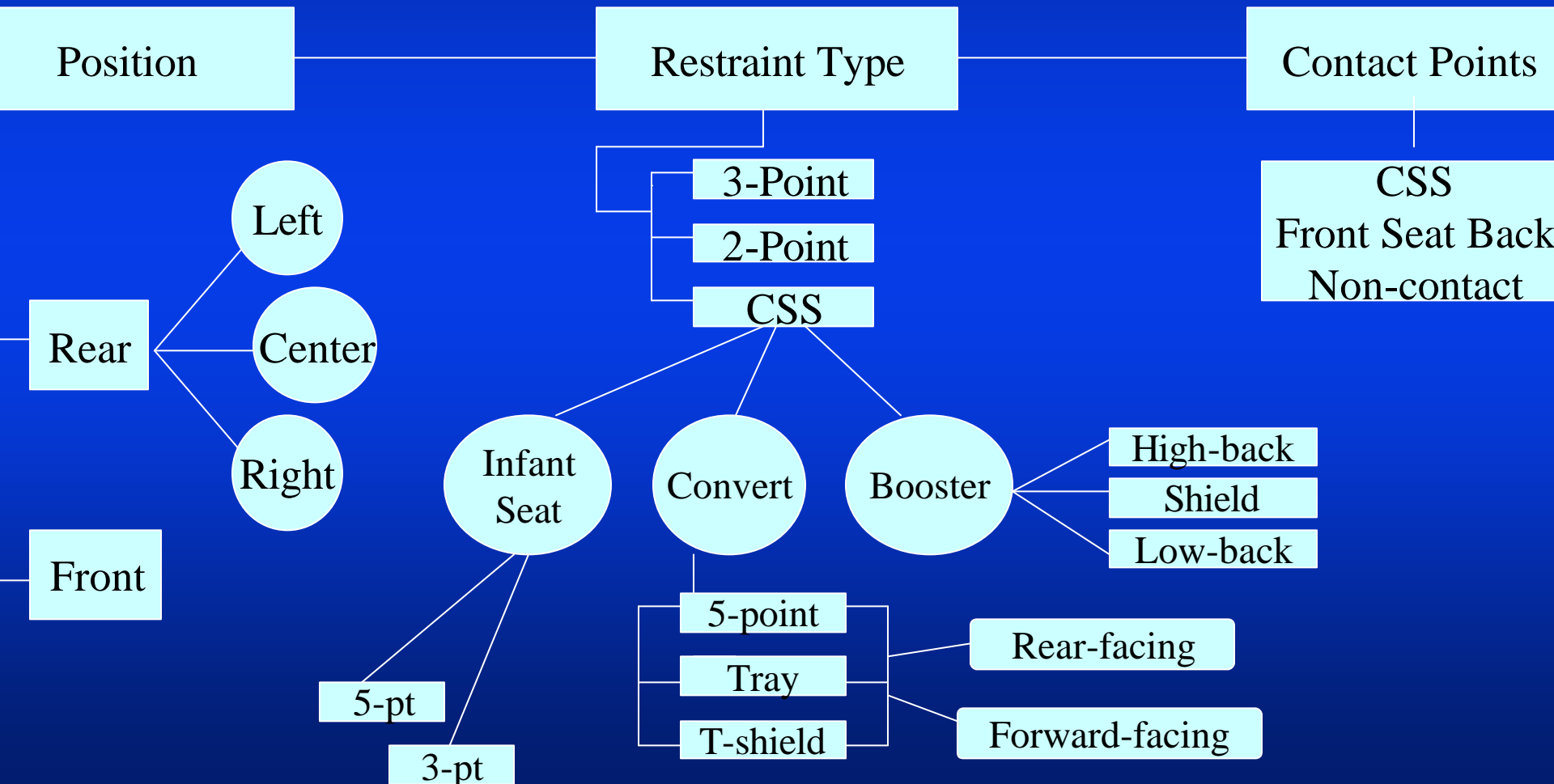


Kids are different!





Other Variables

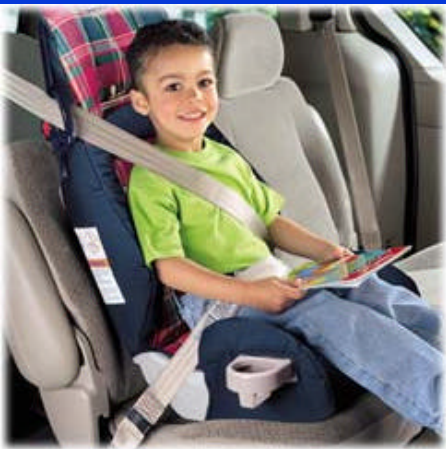




Booster Seats

- Height of 4'9" – appropriate for vehicle belt only
- Booster seats recommended for children 4-10 years old
- Stature (seated height) more important than age, weight

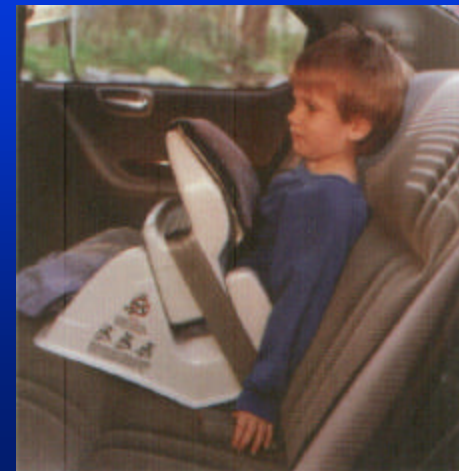
High Back Booster



Low Back Booster



Shield Booster
Not recommended



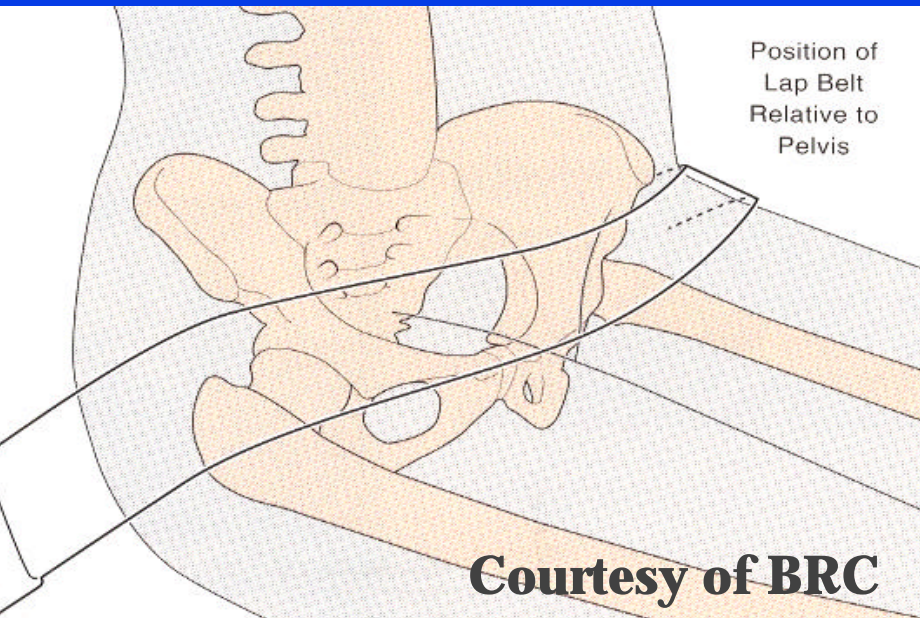


Reasons for Booster Seats



Improve fit of vehicle belt

- Lap belt (prevent submarining)



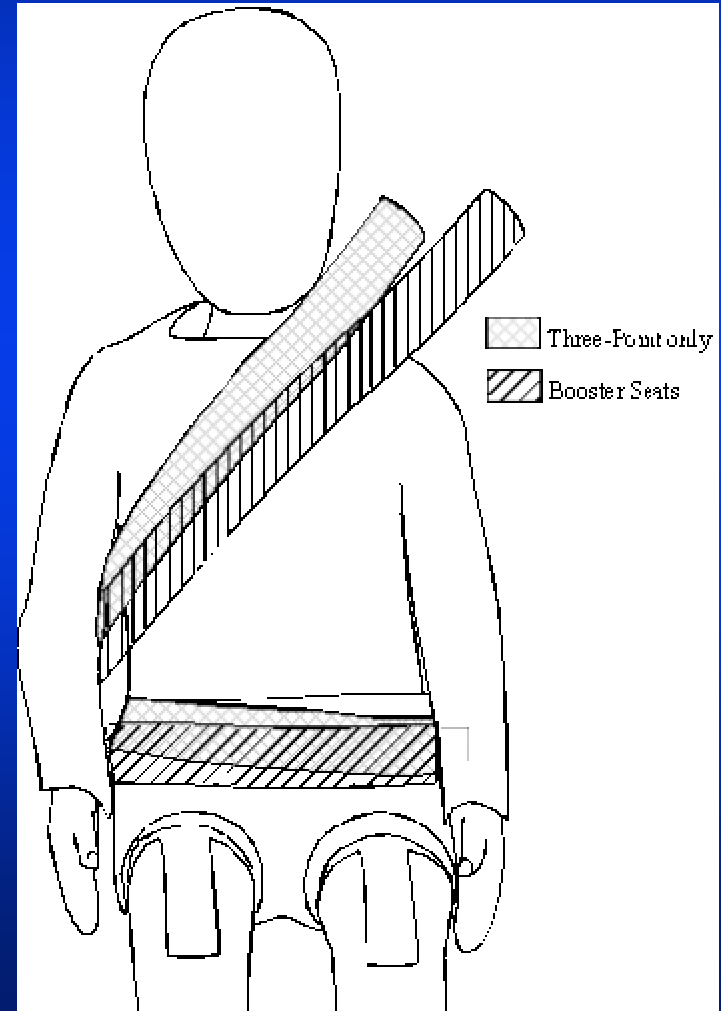


Reasons for Booster Seats



improve fit of vehicle belt

- **Shoulder belt – across chest and shoulder**





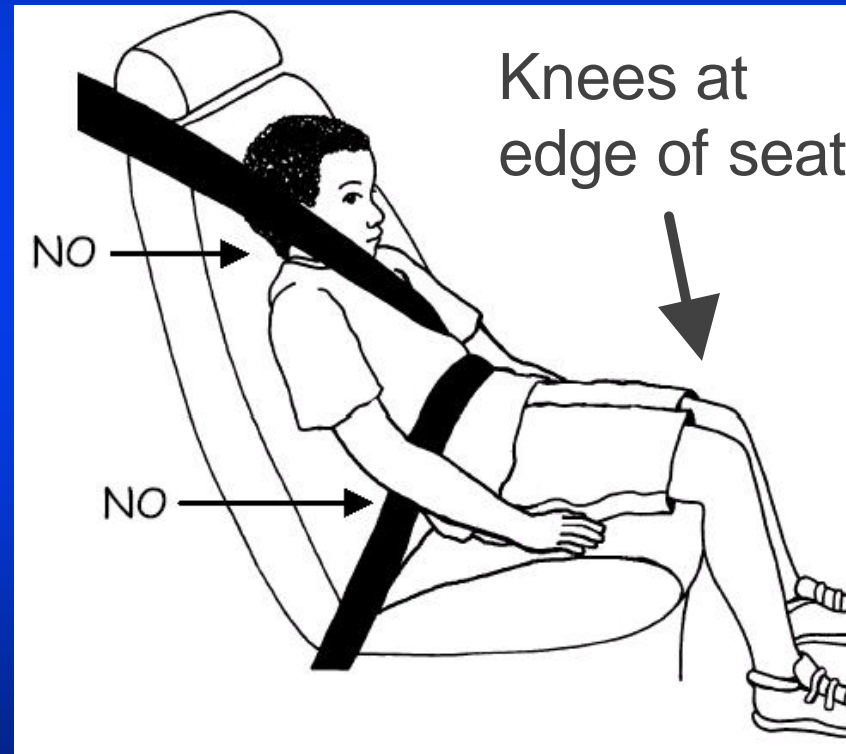
Reasons for Booster Seats



Practical concerns

Prevent slouching due to leg length

Degrades fit for both lap and shoulder belt





Reasons for Booster Seats

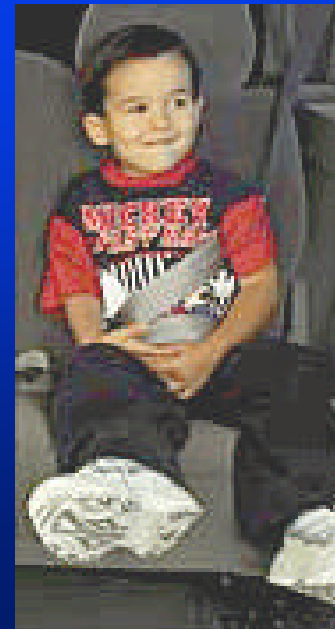
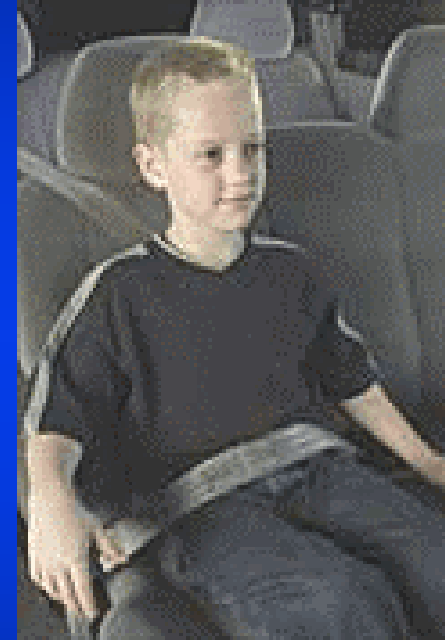


practical concerns

Uncomfortable shoulder belt position

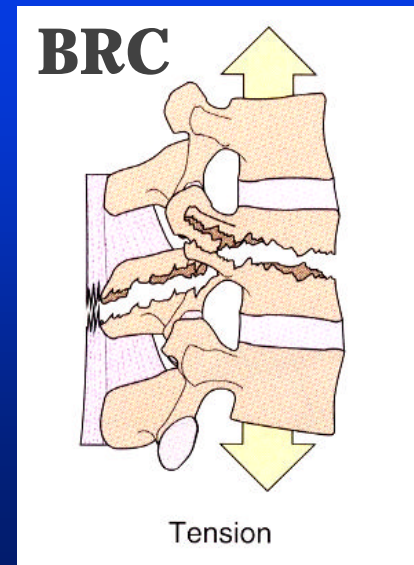
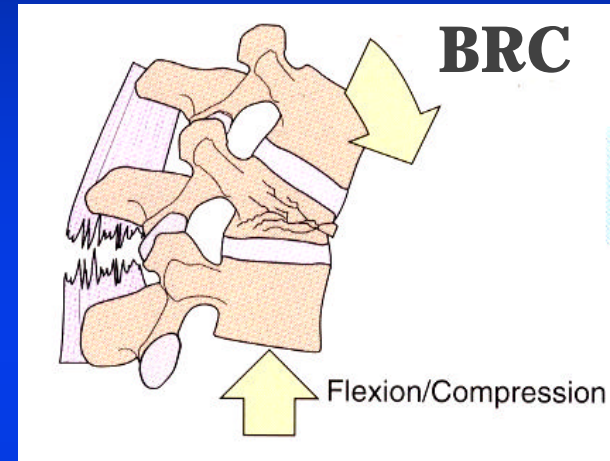
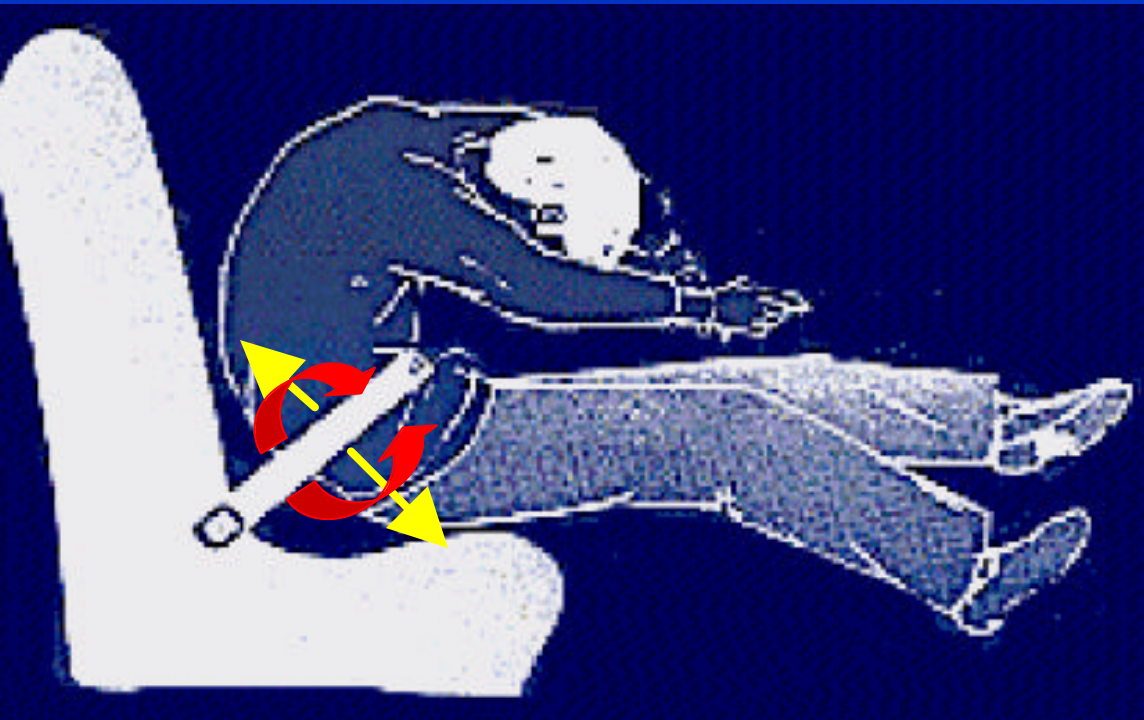
Leads to misuse of shoulder belt

Behind back, Under arm





Chance Fracture





Sled Tests



Quantifying the injury patterns



Sled Tests



Similar to FMVSS 213

- 48 km/h (30 mph) impact speed
- 3rd row bench seat, Windstar minivan
- Hybrid III 6 year old dummy

4 Sled Tests

- High Back Booster Seat
- Low Back Booster Seat
- Shoulder belt behind back
- Shoulder belt under arm





Sled Tests



High Back Booster Seat



Low Back Booster Seat



Sled Tests



Shoulder Belt Behind Back



Shoulder Belt Under Arm



Sled Test







- Measured forces during crash simulation
 - Head Excursion
 - Lap Belt Force
 - Shoulder Belt Force
 - Flexion of Lumbar Spine
 - Lumbar Tension



Sled Tests – Injury Measures






				
	HBB	LBB	Shoulder Behind Back	Shoulder Under Arm
Head Excursion (cm)	64.3	58.5	91.6	73.1



Sled Tests – Injury Measures







				
	HBB	LBB	Shoulder Behind Back	Shoulder Under Arm
Lap Belt Force (N)	3180	3011	4078	2611
Shoulder Belt Force (N)	5080	5340	-	4000



Sled Tests – Injury Measures



				
	HBB	LBB	Shoulder Behind Back	Shoulder Under Arm
Lumbar Flex Moment (Nm)	24	20	73	41
Lumbar Tension (N)	1437	2114	5303	4704



Applying simulations data to real pediatric crashes



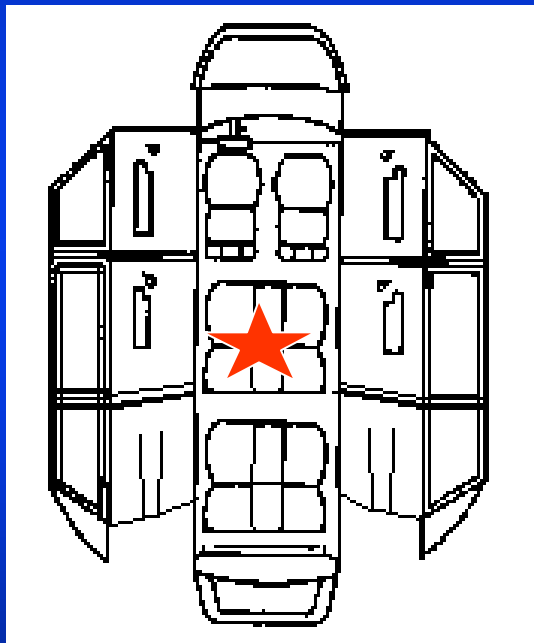
CIREN: Case Studies



		Case 1	Case 2
Patient	Age	4 yrs old	5 yrs old
	Weight	37 lbs	60 lbs
	Height	36 in	45 in
Restraint	Type	3-point belt shoulder belt behind back	3-point belt shoulder belt under arm
	Position	middle row/middle seat	right rear
Crash	PDOF	+340	+350
	Crush	21 cm (8.3 in)	55 cm (21 in)
	Delta V	22 km/hr (13.6 mph)	43 km/hr (27 mph)
	Impact	Frontal	Frontal



CIREN Cases 1: Case Vehicle



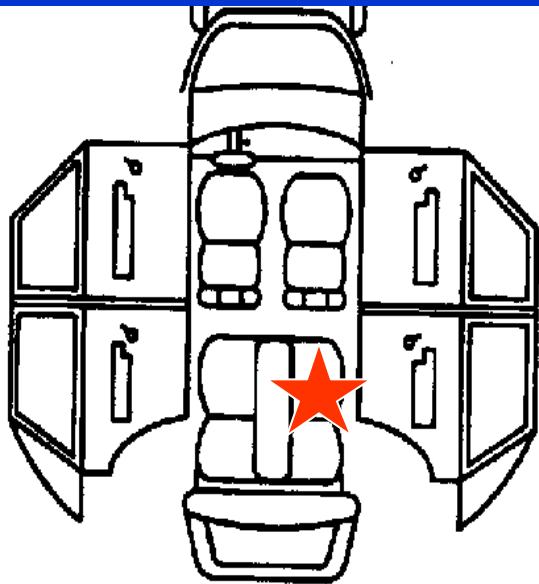
Seating Position



Frontal View of Case Vehicle
1993 Mercury Villager



CIREN Cases 2: Case Vehicle



Seating Position

Max Crush - 55 cm (21 in)



**Frontal View of Case Vehicle
1993 Jeep Cherokee**



Case 2: External Injuries



Distended
Stomach





Summary:

Role of Sled Test

- Compare among restraint systems forces in crash simulation
- Shoulder Belt Misuse Scenarios vs Booster
 - Head excursions increase
 - Lap belt forces similar
 - High shoulder belt forces on abdomen
 - Higher flexion moment and tension on lumbar spine
 - potential for Chance Fractures



Summary:

Role of Booster Seats



- Benefits of Booster Seats
 - Creates comfortable shoulder belt position
 - Alleviates misuse of shoulder belt
 - Placing behind back
 - Placing under arm
 - Creates more comfortable seating position to prevent slouching
 - Submarining



Thank You

