IMPACTS OF RECENT KOREAN NCAP PROGRAMS IN AUTOMOTIVE SAFETY

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ABSTRACT

In 1999, Korean government, Korean government established the Korean New car Assessment Program after 3 years research works. KNCAP test protocol and evaluation methods are similar to USA NCAP. At the beginning year, small numbers of new domestic vehicle were introduced in the market, the KNCAP committee decided selection of test vehicle by same category of cars. The test results directly affected both consumers and manufacturers due to the same class vehicle comparisons. First year only 3 compact size vehicles were tested. But year-by-year the test volume was increased. Up to now total 24 vehicles tested.

During the programs, it has been noticed that the significant improvements of occupant safety performances and adoptions of advanced safety devices such as a driver's seat airbag systems, pre-tensioned seat belts and load-limiters in belts. As the KNCAP tests, driver's seat injury values improved up to 32% in the compact and sub-mid size class cars. Passenger 's seat occupant was improved 7.3% in terms of combined head and chest injury probabilities.

This paper reviews the performances of these crash tested by KNCAP protocol. Currently, KNCAP evaluates the new cars only a full frontal barrier test and braking test. However, this year European side impact test with 55kph impact speed. In the near future, KNCAP will be expanded to offset barrier test, pedestrian test and child restraint system test.

INTRODUCTION

Early '90, over the 13,000 valuable lives killed by the vehicle related accidents. In Korea, the number of persons killed each year in the traffic accidents is about 10,000 and more than 300,000 peoples were injured though it has shown a decreasing trend. Casualties who were in the vehicles were approximately up to 45% of the total traffic related death and unfortunately the rate is still increasing year after year.

All cars sold in Korea must meet the vehicle safety standard. But standard means the minimum requirement to the safety and cannot provide sufficient safety information to the consumers. In order to reduce the number of victims from traffic accidents and gives valuable safety related information in the new cars, the Ministry of Construction and Transportation (MOCT) has considered adoption of NCAP system. During 3 years of research works, all existing NCAP protocols were evaluated to find best suitable NCAP method in Korean traffic environments.

The main purpose of KNCAP will not only promote buying a safer car but encourage auto makers to undertake more efforts in building safer cars by publishing test results every year. KNCAP also provide information on proper use of safety devices in order to enhance user's awareness and correct understanding on safety related devices such as airbag, ABS and seat belts.

ASSESSMENT OF TRAFFIC ACCIDENTS

Since 1990, 58% of all accumulated police reported accident data was a vehicle-vehicle crash type accident as shown in Table 1. This accident type includes a frontal, side and rear crash pattern. The total reported data exceed 3 million accidents. The second largest accident type was a vehicle-pedestrian accident. It was about 38% of total accidents. The remaining 4% of total accidents was vehicle only involved accident.

Table 1. Trends of Traffic Accidents Periods of 1990 – 2000 in Korea

	Vehicle-vehicle		Vehicle-person		Vehicle only		Vehicle-train		Total	
	Accidents	Deaths	Accidents	Deaths	Accidents	Deaths	Accidents	Deaths	Accidents	Deaths
1990	110,513	4,442	133,282	6,441	11,395	1,376	113	66	255,303	12,325
1991	118,897	4,805	136,941	6,952	10,036	1,609	90	63	265,964	13,429
1992	125,006	4,455	122,951	5,802	91,39	1,321	98	62	257,194	11,640
1993	133,587	3,947	117,431	5,241	97,98	1,159	105	55	260,921	10,402
1994	149,899	4,204	105,261	4,641	10,859	1,194	88	48	266,107	10,087
1995	146,783	4,315	91,395	4,564	10,603	1,378	84	66	248,865	10,323
1996	166,677	5,390	87,292	5,070	11,037	2,160	46	33	265,052	12,653
1997	162,085	4,981	74,144	4,458	10,192	2,134	31	30	246,452	11,603
1998	158,732	3,593	70,631	3,495	10,318	1,949	40	20	239,721	9,057
1999	190,437	3,788	74,527	3,692	10,943	1,855	31	18	275,938	9,353
2000	206,971	4,208	72,932	3,890	10,569	2,135	9	3	290,481	10,236

As shown in Table 2, 33.1% of all vehicle-vehicle related accidents were rear impact type crash accidents. This data includes during the both driving and parking of vehicle. Even though frontal impact accidents were only 3% of total vehicle-vehicle related accidents, but the fatalities were 15.5%. The largest fatalities were due to the rear impact accidents. It was about 24.2% that involving rear striking vehicle occupants who had experiencing similar kinematical behaviors as those of frontal crash accidents.

Table 2. Accidents Types in Vehicle-Vehicle Related Accidents (1990 –2000)

		Number of accidents		Number of dead			Number of injured	
			%		%	Fatal ratio		%
Total		1,669,587	100	48,128	100	2.9	2,593,295	100
Frontal		63,210	3.8	7,616	15.8	12.1	119,748	4.6
Rear	driving	404,932	24.3	9,229	19.2	2.3	635,922	24.5
	parking	146,563	8.8	2,422	5.0	1.7	247,836	9.6
Side (front end)		99,653	6.0	2,402	5.0	2.4	149,702	5.8
Passing		28,670	1.7	1,553	3.2	5.4	44,748	1.7
Curve driving		27,465	1.7	522	1.1	1.9	39,964	1.5
Lane changing		62,979	3.8	1,062	2.2	1.7	91,656	3.5
Crossing		127,136	7.6	4,642	9.7	3.7	200,988	7.8
Left turning		83,382	5.0	1,672	3.5	2.0	121,760	4.7
Right turning		36,569	2.2	684	1.4	1.9	51,226	2.0
Others		587,756	35.2	16,307	33.9	2.8	888,049	34.2

Table 3 and Figure 1 show that the percentage of injured parts of traffic accidents involved persons who had experienced at least hospitalized 2 or 3 days. Up to serious injured cases, the incidence of injury is the most frequently observed in the necks, followed by legs, head and chest. In the fatal accidents, injury to the head is the major cause of death, followed by chest, legs and neck. The body of injured occupant in the vehicle is shown in Figure 2. In the death accidents, the most common injury is head and chest

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Table 3. Injured Parts in Accidents Types in Vehicle-Vehicle Related Accidents (1990 –2000)

		Total	Head	Face	Neck	Chest	Abdomen	Leg	Others
Total	Dead	10,236	6,647	327	587	924	318	816	617
	Injured	426,984	66,009	17,666	155,827	21,547	6,667	94,028	65,240
Vehicle	Dead	4,373	2,775	170	241	428	140	356	263
	Injured	303,806	46,848	12,766	124,833	14,728	4,558	54,820	45,253
Bicycle	Dead	1,221	864	37	61	88	36	67	68
	Injured	30,658	4,390	1,132	8,317	1,321	404	9,925	5,169
Pedestrian	Dead	3,764	2,416	101	234	333	120	324	236
	Injured	70,972	11,311	2,858	17,248	3,771	1,287	22,964	11,533
Others	Dead	878	592	19	51	75	22	69	50
	Injured	21,548	3,460	910	5,429	1,727	418	6,319	3,285

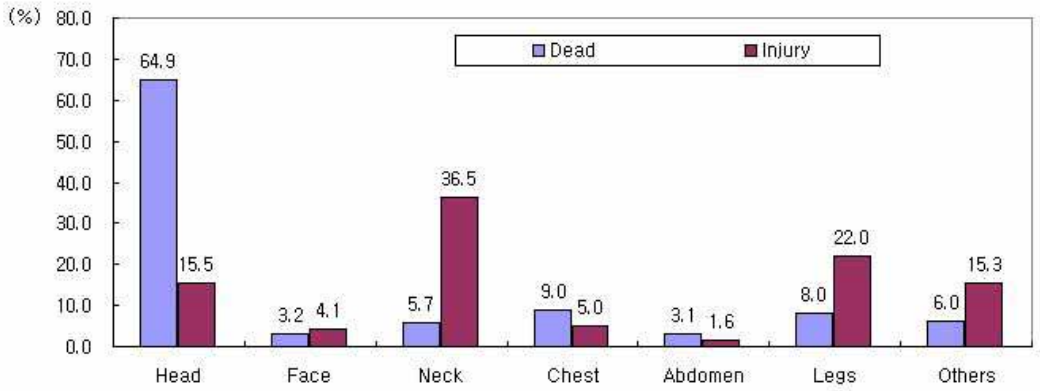

Figure 1. Injured and Dead Patterns of Overall Traffic Accidents

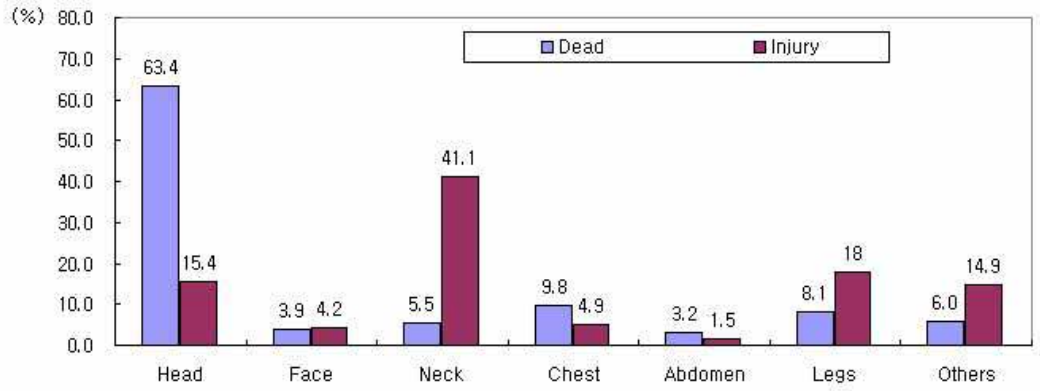

Figure 2. Injured and Dead Patterns of Occupant of Vehicle Involved Traffic Accidents

Among the major accident, the most frequent impact speed was less than 30kph and it was 15.7% of total accidents. The next impact speeds were 60kph (13.0%), 50kph (9.9%) and 70kph (8.9%). But in the case of death were involved, 60kph (9.6%) of impact speed was the most common accidents. 30% of the total death accidents was occurred around 60 – 80kph of the impact speed range. The fatality rate was 67% when the impact speed was below the 50kph. But

when the impact speed was higher than 70kph, the fatality rate was sharply increased up to 80%.

Table 4. Distributions of Vehicle Impact Speed in Major Traffic Accidents

	Injured Accidents		Dead Accidents	
	No.	%	No.	%
> 30kph	451	15.7	62	5.6
40kph	221	7.7	34	3.1
50kph	284	9.9	72	6.5
60kph	372	13.0	106	9.6
70kph	254	8.9	104	9.4
80kph	179	6.2	89	8.0
90kph	94	3.3	52	4.7
100kph	72	2.5	47	4.2
110kph	33	1.2	24	2.2
120kph	26	0.9	21	1.9
< 121kph	29	1.0	17	1.5
others	854	29.8	481	43.4
Total	2,869	100	1,109	100

This accidents data analysis indicates that significant improvement of vehicle safety performances are needed to protect the occupants during the accidents. In order to reduce number of fatalities, especially from the occupant of vehicle, the Ministry of Construction and Transportation (MOCT) has been seriously considered adoption of NCAP (New Car Assessment Program) implemented by government bodies in many well-developed countries. After 3years of research, the MOCT of Korea launched first KNCAP test and the results were published in the public in 1999.

KNCAP TEST AND EVALUATION METHODS

The method of the crash tests currently conducted by KNCAP is a full frontal crash tests which similar to USA NCAP. All existing vehicle were passed the Korean safety standards and certified by the MOCT. The safety standard includes 48.3kph frontal crash test with hybrid III dummies which similar to US FMVSS 208. In order to promote building safer cars, KNCAP selected higher impact speed, 56kph.

The assessment of vehicle safety performance was evaluated by the injury level of occupants both driver and passenger. The KNCAP was adopted US star rating system based on the damage values of head and chest. Also each parts of occupant body was marked by four different colors to display the safety performances as shown in Figure 3.

Figure 3. Typical sample of KNCAP Test Results Sheet

인체 각 부위별 보호구분/차량 중량별 비교기준

인체 각 부위별 보호 구분 (시속 56km 고정벽 정면충돌)					【표2】
구 분	승객보호	우 수	양 호	보 통	열 등
	색 상	녹색	노랑색	주황색	적 색
머리상해기준값(HIC)		500이하	501 ~ 1,000	1,001 ~ 1,500	1,501이상
흉부가속도값(g)		45이하	46 ~ 60	61 ~75	76이상
대퇴부 압축하중값(kgf)		500이하	501 ~ 1,020	1,021 ~1,500	1,501이상

Figure 3. Typical sample of KNCAP Test Results Sheet (cont.)

In the KNCAP, braking test was newly introduced in 2001. In order to avoid accidents, brakes must be capable to stop the cars in a short distance with maintaining same lane. The test measured stopping distances of vehicles when driver applied specified braking pressure at 100kph speed. The test was conducted both in dry and wet road conditions. Typical braking test result was displayed in Figure 4.

2002년 후반기 제동성능시험 결과

Figure 4. Typical Braking Test data Sheet

DISCUSSUONS AND RESULTS FROM KNCAP TESTS

During the last four years (1999 – 2002), total 24 vehicles were crash tested. Since small numbers of new vehicles were introduced in the market every year, KNCAP committee decided to selection of test vehicle with same class category as well as consideration of vehicle sales volume. Until recently the Korean new car sales have been dominated by recreation vehicle (RV) - SUV and Van type cars, mediums size passenger cars and sub-mid size cars as shown in Table 5. The KNCAP uses vehicle categories that align closely with the Code of Korean Vehicle Classifications (CKVC). The CKVC segment of Small is divided by Compact and Sub-mid in the KNCAP. The RV categories vehicle (SUV and Van) segments are combined in the KNCAP either Medium or Large depended on the engine sizes and vehicle weights.

Table 5. Sales Volume of Korean New Car market

Passenger Vehicle Categories	Sales in Calendar Year			
	2001		2002	
	Volume	Shares %	Volume	Shares %
Sub-compact	82,140	8	57,178	5
Small	219,014	20	253,497	21
Medium	283,446	27	295,554	24
Large	72,883	7	98,353	8
SUV	188,456	18	297,496	24
Van	219,222	20	223,132	18

Currently, the class of vehicle in Korea was usually divided by either engine size or total weight of vehicle. For instance, at the first year (1999), 3 sub-mid sizes of passenger cars were selected. The test results directly influenced with market. When one vehicle's safety performance was way below compared with competitive cars, sale volume of the model of vehicle significantly dropped and eventually vanished in the market. Same philosophy is continued. Last year, sub-mid size and sub-compact class were selected and tested.

Table 6. Total Number of KNCAP Test Vehicles

KNCAP Class	Vehicle Weight (kgf)	No. of Frontal Crash		No of Braking Test	
		Passenger Car	Minivans	Passenger Car	Minivans
Sub-compact(800cc)	> 849	3			
Compact(1,300cc)	850 ~ 1,099	5		2	
Sub-mid(1,500cc)	1,110 ~ 1,349	6		3	
Medium (2,000cc)	1,350 ~ 1,599	4	4		4
Large (<2,000cc)	< 1,600		2		2
Sub total		18	6	5	6
Total		24		11	

Benefit from KNCAP in vehicle safety

To analysis KNCAP results to determine if there has been any improvement in the front seat occupant protection, the overall injury risk values is calculated from results published by KNCAP since 1999. Also, any improvement of the physical advanced safety devices such as airbags, advanced seat belt system is surveyed. The Table 7 shows the total test results in star rating and percentage of chance of serious injury

Table 7. Lists of KNCAP Test Results (1999-2002)

Class	Year	Cars	Section	Star rating	
Sub-compact (800cc)	2002	Kia Visto	Driver's seat (airbag)	★★★★	17%
			Passenger's seat	★★★	24%
		Daewoo MatizⅡ	Driver's seat	★	63%
			Passenger's seat	★	68%
		Hyundai Atoz	Driver's seat (airbag)	★★★	23%
			Passenger's seat	★★★	29%
Compact (1,300cc)	2001	Kia Rio	Driver's seat	★★★	35%
			Passenger's seat	★★★	22%

Class	Year	Cars	Section	Star rating	
		Daewoo Lanos Ⅱ	Driver's seat	★	48%
			Passenger's seat	★★	40%
		Hyundai Verna	Driver's seat	★	50%
			Passenger's seat	★★★	23%
	2002	GM Daewoo Kalos	Driver's seat (airbag)	★★★★	13%
			Passenger's seat	★★★★	18%
		Hyundai Click	Driver's seat (airbag)	★★★★	11%
			Passenger's seat	★★★	28%
Sub-mid (1,500cc)	1999	Kia Sephia Ⅱ	Driver's seat (airbag)	★★★	24%
			Passenger's seat (airbag)	★★★	21%
		Daewoo Nubira Ⅱ	Driver's seat (airbag)	★★★★	14%
			Passenger's seat (airbag)	★★★★	15%
		Hyundai Avante	Driver's seat (airbag)	★★★★	11%
			Passenger's seat (airbag)	★★★★	13%
	2002	Kia New Spectra	Driver's seat (airbag)	★★★★	12%
			Passenger's seat	★★★★	14%
		Hyundai Avante XD	Driver's seat (airbag)	★★★★	12%
			Passenger's seat	★★★	22%
		Hyundai Lavita	Driver's seat (airbag)	★★★★	13%
			Passenger's seat	★★★	23%
Medium (1,800cc)	2000	Kia Optima	Driver's seat (airbag)	★★★★★	10%
			Passenger's seat	★★★	25%

Class	Year	Cars	Section	Star rating	
		Daewoo Magnus	Driver's seat (airbag)	★★★★	11%
			Passenger's seat	★★★	34%
		Renault Samsung SM5	Driver's seat (airbag)	★★★★	16%
			Passenger's seat	★★★	33%
		Hyundai EF Sonata	Driver's seat (airbag)	★★★★★	10%
			Passenger's seat	★★★	21%
Medium (Mini ban)	2001	Kia Carens	Driver's seat (airbag)	★★★★	12%
			Passenger's seat	★★★★	19%
		Kia Carstar	Driver's seat (airbag)	★★★★	19%
			Passenger's seat	★★★★	18%
		Daewoo Rezzo	Driver's seat (airbag)	★★★★	19%
			Passenger's seat	★★	37%
		Hyundai Santamo	Driver's seat (airbag)	★★★★	17%
			Passenger's seat	★★★★	18%
Large (Mini ban)	2001	Kia Carnival Ⅱ	Driver's seat (airbag)	★★★★★	9%
			Passenger's seat	★★★★	11%
		Hyundai Trajet XG	Driver's seat (airbag)	★★★★	11%
			Passenger's seat	★★★	27%

In the improvements of advanced safety devices, only medium or larger passenger vehicles have a driver airbag system as a standard at the beginning year of KNCAP. Up until 2002, all the vehicles have a driver side airbag option as standard except one sub-compact vehicle, Matiz. But this year the vehicle will be equipped with airbag as standard. Even though, the Korean vehicle safety standard does not required airbag system as standard, but all vehicle makers install the driver airbag voluntary. They now realized the impacts of KNCAP results. This gives the significant improvement in traffic safety environments.

As the results, the traffic fatality was 8,079 in 2001. In 2000, total traffic related death was 10,236. This is 21% reduction in fatality. The list of the safety device improvements is shown in Table 8.

Table 8. Lists of Advanced safety Device Installations

△: Option ○:Standard ×: N/A

Maker	Cars	Type	Airbag		Pre-tensioner
			Driver	Passenger	
Sub-compact (>848kgf)					
Kia	Visto	4 Door	△→○	△	△→○
Daewoo	Matiz Ⅱ	4 Door	△	△	×
Hyundai	Atoz	4 Door	△→○	△	△→○
Compact(850 ~ 1099kgf)					
Kia	Rio EL	4 Door	△	△	△→○
Daewoo	Lanos Ⅱ	4 Door	△	△	△→○
Hyundai	Verna	4 Door	△	△	○
GM-Daewoo	Kalos	4 Door	○	△	○
Hyundai	Click	4 Door	○	△	○
Sub-mid (1110 ~ 1349kgf)					
Kia	Sepia Ⅱ	4 Door	△	△	×
Daewoo	Nubira Ⅱ	4 Door	△	△	△
Hyundai	Avante	4 Door	△→○	△	△
Kia	New Spectra	4 Door	○	△	○
Hyundai	Avante XD	4 Door	○	△	○
Hyundai	Lavita	4 Door	○	△	○
Medium(1350 ~ 1599kgf)					
Kia	Optima	4 Door	○	△	○

Daewoo	Magnus	4 Door	○	△	△→○
Renault-Samsung	SM5	4 Door	○	△	×
Hyundai	EF Sonata	4 Door	○	△	○
Medium(1350 ~ 1599kgf) : Minivan(RV)					
Kia	Carens	7 Passengers	△→○	△	△→○
	Carstar	7 Passengers	△→○	△	△→○
Daewoo	Rezzo	7 Passengers	△→○	△	×
Hyundai	Santamo	7 Passengers	△→○	△	△→○
Large(< 1600kgf) : Minivan(RV)					
Kia	CarnivalⅡ	9 Passengers	○	△	△→○
Hyundai	Trajet XG	9 Passengers	○	△	○

In the Compact and Sub-mid size vehicles, the injury values are significantly improved. As shown in Table 9, the test results of 2002 shows improved safety performance in the both driver and passenger compared with those of 2001. With a driver airbag as a standard, driver's seat was improved up to 32% in combined head and chest injury probability as shown in Table 10. The passenger's seat was improved only 7.3%. All passenger seats have no airbag system, but some cars were equipped with advanced seat belt system.

Table 9. Lists of KNCAP Test Dummy Injury Values in Compact Size Vehicles

Year	Section	Driver's seat					Passenger's seat				
		HIC		Chest Acc. (g's)			HIC		Chest Acc. (g's)		
2001	Rio	1138	26.3	52.2	12.4	35	798	9.8	52.9	13.2	22
	LanosⅡ	1298	38.6	55.9	15.8	48	1236	33.5	48.2	9.7	40
	Verna	1340	42.1	53.2	13.2	50	953	15.7	46.2	8.6	23
	Average	1259	35.7	53.8	13.8	44.3	996	19.7	49.1	10.5	28.3
2002	Kalos	430	2.9	49.3	10.3	13	775	9.1	49.4	10.3	18
	Click	482	3.4	43.9	7.5	11	772	9.0	61.4	21.0	28
	New Spectra	484	3.4	46.4	8.6	12	784	9.3	39.1	5.4	14
	Avante XD	491	3.5	45.9	8.6	12	964	16.2	43.9	7.5	22
	Lavita	464	3.2	47.7	9.7	13	870	12.2	51.7	12.4	23
	Average	470	3.3	46.6	8.9	12.2	833	11.1	49.1	11.3	21.0

Table 10. Improvements of Occupant Injury Values in Compact Size cars

Section	Driver's seat		Passenger's seat	
	2001	2002	2001	2002
HIC	1259	470	996	833
Chest Acc. (g's)	53.8	46.6	49.1	49.1
Head Injury probability (%)	35.7	3.3	19.7	11.1
Chest Injury probability (%)	13.8	8.9	10.5	11.3
Complex Injury probability (%)	44.3	12.2	28.3	21.0

FORWARD TEST PROGRAMS

Since 1999, it is now 5th year of KNCAP project. During the course of years, safety performances of new cars of each class against full frontal collisions have been improved significantly especially on the driver's seat occupant.

This year KNCAP will introduce the European side impact test with 55kph impact speed. This will save a lot of lives from the side collision type accidents. In the near future, KNCAP will be expanded to offset barrier test, pedestrian test and child restraint system test. Especially, the pedestrian protection is one of the critical subjects to be urgently needed protocol as KNCAP project. The fatality of pedestrian is still about 40% of all casualties. Continuously, KNCAP will try to encourage making safer vehicle in both onboard occupants and pedestrians.

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