SEAT BELT PERFORMANCE AND AFTER-MARKET WEB-LOCKING DEVICES: AN EXPERIMENTAL STUDY

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ABSTRACT

This experimental research is aimed to evaluate the consequences of the slack offered by after-market web-locking components ("comfort clips") on the performance of three-point seat belts.

The tests were performed by simulation of a frontal impact at 50 km/h, recording chest and pelvis displacement of the dummy and variations in belt loading.

We tested all the devices on sale in Italy up to September 1989: each device has been tested five times, with a configuration of the restraint system according to Fiat Tipo.

The laboratory results show a very bad performance of the devices under the test conditions, with a mean increase of 15–20% for chest and 40% for pelvis displacement.

The most worrying finding was the breakage of the belt, in 7 cases over 35; in other 3 cases, there was severe belt incision.

All these laboratory data demonstrate danger in the use of these web-locking components.

BACKGROUND

There is no question about the effectiveness of seat belts in preventing or reducing injuries to car occupants [6,7].

Despite the worldwide acceptance of these car restraint systems, Italy was the only European country not to provide a compulsory rule about their use. Up to 1987, it was even possible to buy cars without front seat belts: hundred of thousands of Fiat Panda, Ritmo, Regata, 126, 127, Autobianchi A 112, and even a special 1050 cc version of Volkswagen Golf were sold without seat belts.

After a long gestation, a seat belt law is operating from 26 April 1989, for all the drivers and front passengers of cars registered after 1978; if the car is missing of front seat belts, it is compulsory to retrofit them. For cars before 1978, the installation (and use) of front seat belts is due from 26 October 1989, if fitting holes are present on the car.

Italian car users had a poor compliance to the law, and after the first days the fastening rate ranked very low. Even the retrofitting rule was ignored: it has been estimated by belt manifacturers that some four million Italian circulating cars are still lacking in seat belts.

According to a study from an Italian insurance company [5], only 47% of the car occupants involved in accidents in the months following the new law were using their seat belts (61% in Northern Italy, decreasing to 12% in the South of the country).

Because of absence of information, seat belt usage was misunderstood and adversed even by authorities.

By summer 1989, a lot of Italian dealers were marketing devices designed to clamp the web and pull it to a comfortable distance from the body of the car occupant. These articles found a great success and it has been estimated that their sellings exceeded one million of pieces.

Similar articles were found to be on sale also in France and in the United Kingdom.

This experimental research is aimed to evaluate the consequences of the slack offered by these "comfort clips" on the performance of automatic three-point seat belts.

Materials and Method

We collected any type of "comfort-clip" available on the Italian market in summer 1989. They can be divided into two groups (Picture 1):

A. "Hook" type, to be inserted between the web and the loop at the pillar;

B. "Pincers" type, to be inserted after the loop, near the shoulder.

The tested devices are seven, four of which of the "hook" type; their commercial name is reported in Table I.

The tests were performed in Autoliv laboratories in Turin (Italy), by simulation of a frontal impact at 50 (±0,2) km/h with an anthropomorphic dummy.

The devices were tightly worn to the dummy and then retracted to obtain 100 mm of slack, equally distributed to the thoracic and abdominal harnesses. By comparative tests, this amount of slack on the dummy was assumed to be pair to 3–5 cm on a normally dressed person.

The configuration of the restraint system was according to Fiat 160 ("Tipo.") saloon 5-doors, with an alternate choice of the belt retractor at the left or at the right side, simulating the position of the driver or the front right passenger.

Data about chest and pelvis displacement after the impact and variations in belt loading were collected and stored in a database; some tests were high-speed filmed. The obtained data were compared with the current omologation rules.

Each device has been tested five times, replacing both the comfort clip and the seat belt. The reference group, with the same type of seat belts and the same configuration, comprises 40 sled tests.

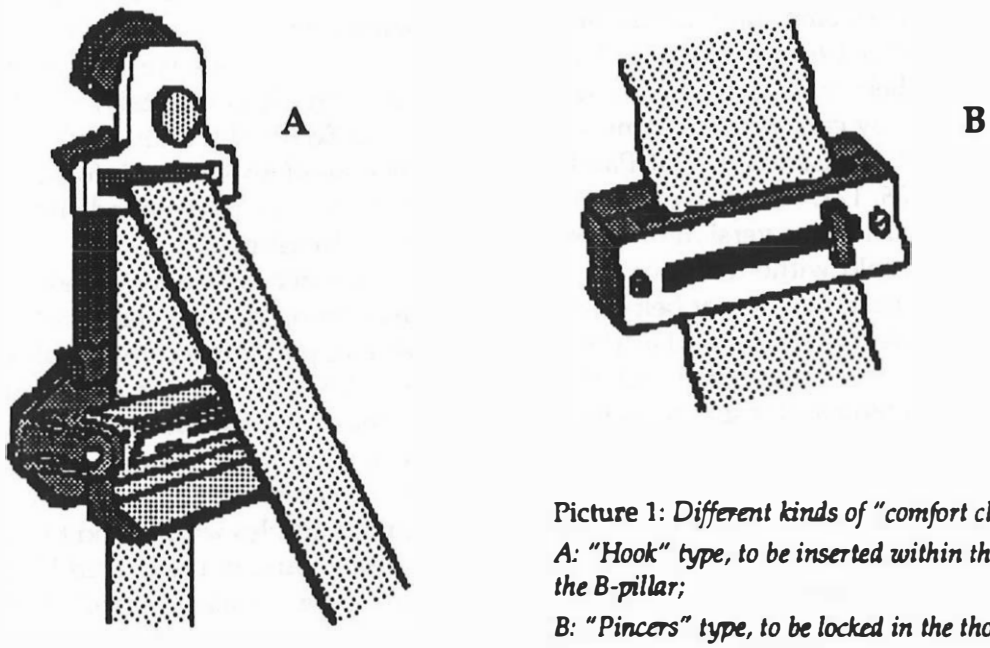
Results

A summary of the results is shown in Table I, for each crash test with "comfort clips" and for the reference group.

The worst finding was the breakage of the seat belt (Picture 2), in 7 cases over 35, equally distributed among "hook" and "pincers" types; in other 3 cases, the web was severely twisted and lacerated.

In all findings of belt breakage, a clear incision on the plastic coverage of the loop is present at the rearward-facing angle.

Nearly all the remaining tests show a net worsening of belt performance, with values around +20% for chest displacement and over +40% for pelvis displacement (Picture 3).



Picture 1: *Different kinds of "comfort clips".*
A: "Hook" type, to be inserted within the web and the B-pillar;
B: "Pincers" type, to be locked in the thoracic harness, near to the belt loop.

Commercial name		*Test 1*	*Test 2*	*Test 3*	*Test 4*	*Test 5*
Clip Confort	*Chest*	Breakage	290.00	Breakage	Breakage	310.00
	Pelvis		177.00			179.00
Tap-Plast	*Chest*	Breakage	292.00	267.00	299.00	281.00
	Pelvis		180.00	153.00	168.00	173.00
Free Belt	*Chest*	281.00	306.00	305.00	277.00	287.00
	Pelvis	171.00	165.00	180.00	162.00	176.00
Cliper	*Chest*	Breakage	258.00	296.00	290.00	312.00
	Pelvis		157.00	180.00	174.00	173.00
Jolly	*Chest*	280.00	Breakage	292.00	300.00	298.00
	Pelvis	172.00		165.00	176.00	182.00
Lampa Clips	*Chest*	298.00	302.00	266.00	Breakage	293.00
	Pelvis	175.00	176.00	157.00		164.00
Rapid Lux	*Chest*	300.00	312.00	272.00	296.00	306.00
	Pelvis	163.00	174.00	157.00	169.00	181.00
Standard belts (mean values of 40 tests)	*Chest*	250.17	(Min. = 202; Max. = 276)			
	Pelvis	118.82	(Min. = 97; Max. = 173)			

Table I: *Results of the crash tests. Values (in millimetres) for chest and pelvis displacement, referred to each single test with clips, and to the mean of 40 tests with standard three-point seat belts. Configuration according to Fiat "Tipo." 5-door saloon.*

In nearly half of the cases (16 over 35, that is 45,7%) the recorded values were out of ECE 44 omologation criteria (admitted values: 100–300 mm for chest displacement; 80–200 mm for pelvis displacement).

The high-speed film examination evidenced, in some cases, severe submarining and body displacement during impact.

The instrumentation set for the tests could not give precise informations on chest and shoulder loading during the impact.

Discussion

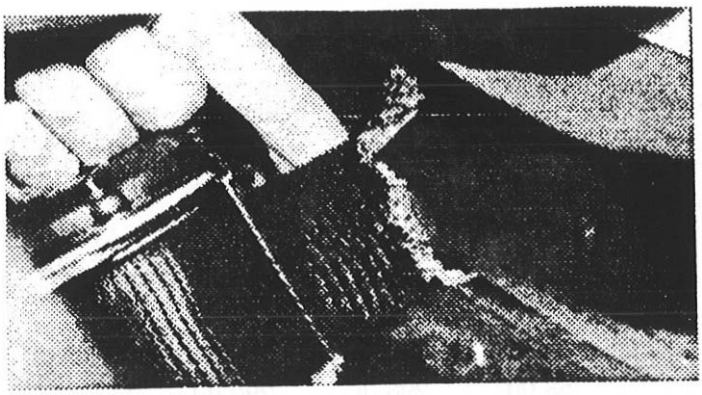
All the laboratory results clearly demonstrate a very bad performance of the aftermarket "comfort-clips" under the test conditions.

If we consider that a normally buckled seat belt is already exposed to some 10–15 cm of slack because of spool effect, delay in retractor locking and web fibers stressing [3,8], it is not surprising that adding some centimetres of extra slack worsens the situation.

The mechanisms by which the belt is broken seem strictly related with the permanent clamping of the web. A constant finding is the narrowing of the belt in one corner of the B-pillar loop, with various degrees of tearing; the cases in which the web is only incided show that early deterioration is due to the narrowing in the rearward-facing corner of the loop.

This can be explained by supposing that if the comfort clip excludes the small recall force of the retractor coil, then the loop is no more subject to moderate pressure from the web, but is free to rotate with its bolt as a pivot. During the impact, the belt will work with a badly positioned loop and will twist itself with possible tearing (Picture 4).

The increased chest displacement could give a greater rate of head contacts with the



Picture 2: *Web breakage after the crash test.*

steering wheel or the dashboard; since a head trauma is always an "all or nothing" event, a few centimetres may determine the difference between an unhurt and a wounded driver or passenger. The slack at the abdomen is highly dangerous, since it can allow the belt to slip over the pelvis with severe submarining.

These two effects may considerably reduce the performance of belts and cause derangements in its action, with possible side lesions [1,2,4] (seat belt syndrome).

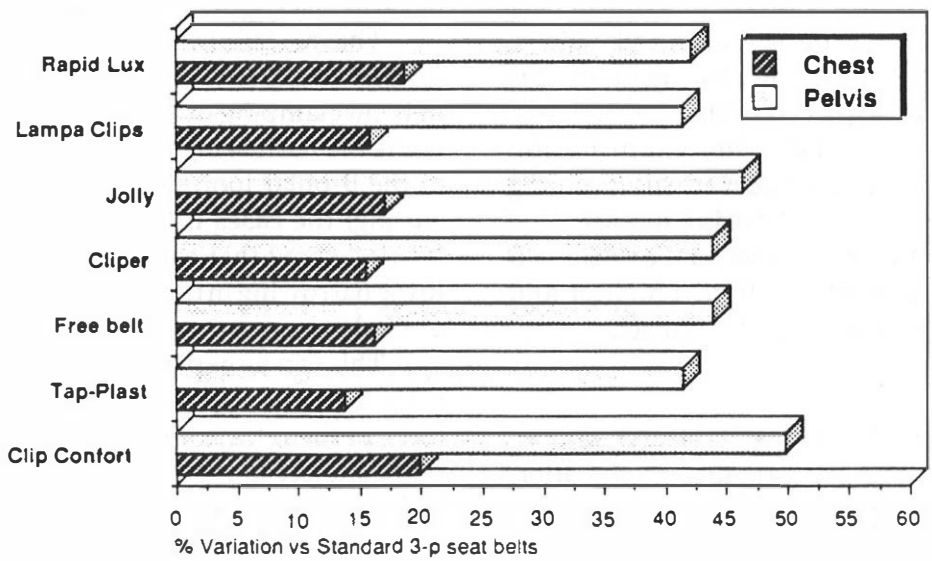
In some car models, the installation of a thick plastic component between the coverage of the B-pillar and the web may cause friction, or actually lock the retraction of the seat belt, allowing the belt to hang down.

It is important to observe that the manifacturer was identifiable only in two packages of clips.

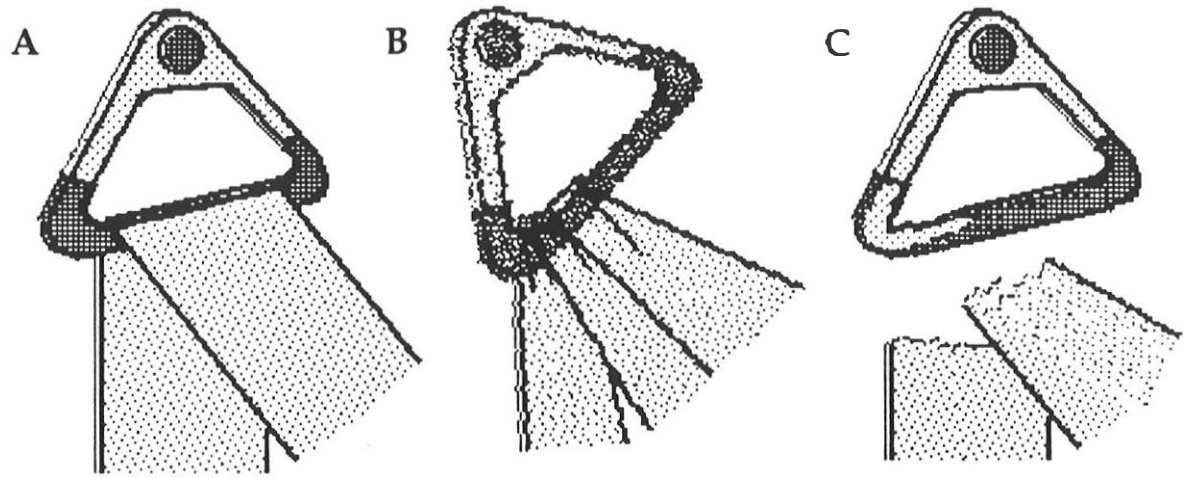
In some cases, there were concise instructions to the use, where any responsibility was denied for eventual damages due to belt slack exceeding one-three centimetres.

Conclusively, the "comfort clips" exchange a feeling of comfort (or psychological freedom) with a real danger of belt malfunctioning during an impact. These objects should be removed from the market, and their use should be discouraged or forbidden.

From a practical point of view, it does not seem profitable to install more and more sophisticated and expensive restraint systems



Picture 3: *Comparison of chest (dark columns) and pelvis (light columns) displacement with "comfort clips" vs the mean values obtained with standard three-point seat belts.*
The tests with breaking of belts are not considered in this diagram.



Picture 4: *Possible mechanism of belt breaking during the deceleration. From the normal position (A), the belt loop can tilt so that the web is forced in a corner (B) and can be severely damaged by sharp plastic coverages or by the metallic structure of the loop (C).*

on new cars (for instance, belt pretensioners), if cheap and sometimes raw components like the tested ones can easily jeopardize the efforts of technology.

It is difficult to figure how a prevention of this sabotage to seat belts can be worked out: even without the described devices, the clamping of seat belts is possible with clothes-pins, paper-clips, or by forcing something within the web and the loop.

While a "foolproof" restraint system is still beyond the horizon, it is clear that users' education still represents a central topic in the improvement of seat belt effectiveness.

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