

Disc Pressure Effects on the Spine, Influenced by Extra Equipment and a Massage System in Car Seats

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ABSTRACT

Car seats with a variety of adjustments and massage systems are available in many cars. It could increase comfort. In a vehicle, particularly a car, it is difficult to increase comfort by variation in posture, since the person has to concentrate on traffic conditions and steering. A car seat has to support the body, since various forces occur, such as acceleration, slowing down and lateral forces. The driver / passenger is well supported by the car seat, and spends a certain time there in an unchanged position. Due to these facts it is meaningful to integrate a massage activity system (MAS) into a car seat. In this way, it is possible to devote oneself fully to the task of driving and the surrounding traffic. A MAS can take control of revitalising and changing the sitting position of the car occupants. Until now, the effect of the use of massage systems and additional equipment such as lumbar support on the intervertebral discs has never been studied.

For this experiment a pressure sensor was implanted with a canula in the middle of an intervertebral disc of a voluntary subject. In this way the local pressure in the disc was measured in an automobile with a massage system in the seat.

All measurements were taken in an ideal seat position. In this position the pressure in the disc was very low (0.5bar).

From these results we are able to improve our knowledge about extra equipment and massage systems and the subsequent reaction of the discs.

INTRODUCTION

Car seats with a multitude of adjustments are available in the premium category for all upmarket car manufacturers. In modern society the automobile is an essential companion in everyday life. One opportunity to achieve a competitive advantage is the development of car seats for people who value comfort. Lots of people drive long distances. There are many possibilities for relieving strain on drivers, and achieving well being. A special focus is given to the seat form, comfort, noise, odour, user friendliness, smooth "appealing" surfaces, etc. An additional feature is the introduction of massage seats to increase the level of well being in the car. In a vehicle, particularly in a car it is difficult to move during the journey, i.e. to alter the position, as the person has to concentrate on traffic conditions and steering. A car seat has to support the body as, when driving, various forces occur, for example acceleration, slowing down and lateral forces. The driver / passenger is well supported by the car seat and spends a certain time there in an unchanged position. Due to these facts it is meaningful to integrate a massage activity system (MAS) into a car seat. The way massage systems work, their effectiveness and use is often discussed by customers and experts in this area Deursen et al, (2003). Dupuis et al, (1991). Fitz et al, (1998). The features in car seats are also discussed by the medical press (e.g. *Ärzte Zeitung* 1999), and newspaper (e.g. *Frankfurter Allgemeine Zeitung* 2001, *Motor-Informationen-Dienst* 2001).

The effects of pressure in the disc has been measured in a lot of activities of daily live (ADL's) Nachemson (1966) and Wilke (1993).

Until now these disc pressure tests have not been performed in car seats using extra equipment and massage systems. Zenk et al. (2007) measured the effects of the pressure in the disc in different seat positions.

THE RESEARCH QUESTION

The research question of this study is: does an extra equipment massage activity systems, active support system and the lumbar support, influence the pressure on the intervertebral discs and by how much?

MESSAGE SYSTEM DESIGN

In order to answer this research question, first of all a massage seat was designed. According to Deursen et al., (2003) a rotation of the vertebrae has positive effects on the musculoskeletal system. Therefore, a system was developed to rotate the vertebrae alternately. A system was built, in which parts of the back cushion inflate disparately on both sides of the spine. This means that for instance at Th3 level, and at L3 level, there is an inflation on the left side and at Th9 an inflation on the right side. This is reversed after a few seconds: Th3, and L3 are inflated on the right side and Th9 is inflated on the left side.

One inflation process on the left and right takes 60 seconds and comprises also a longitudinal massage process at the end of the rotations. The uniqueness of this system is that it covers the thoracic and lumbar region. Other manufacturers systems are mostly focused on the lumbar region and make one movement only.

The longitudinal movement consists of a massage function comparable to a grip technique in classical medical massage.

The rotation function is a physiotherapeutic treatment technique.

In physiotherapy, particularly in the area of neurology, the so called passive movement is linked with a rotation. The idea of this method is that it allows the therapist to regulate the patient muscle tension.

The seat achieves this function through the rotation lift elements. These lift elements rotate the body using the spine as an axle in a minimal movement. The rotation of the spine is again linked to accompanying movements (Kapandji, 1992; White and Panjabi 1990). If we follow this development, the resulting accompanying movements should have a minimal lengthening effect on the musculature as well as alternating slight pressure on the discs.

In between the inflations a massage wave is created from the upper part of the back to its lower part on both

sides of the spine. This application and its assumed vitalizing effect is often used in physiotherapy. Biewald (2004) shows that these therapeutic treatments can regulate muscle tension. This passive movement provides a possibility of influencing muscle tension.

In pre-tests it was shown that the longitudinal massage of the system from below to above has the effect that the driver becomes sleepy. This is obviously not wanted in car driving. This negative effect was not found in the opposite direction which was therefore implemented in the system. Several prototypes were needed to get a final working system, which is now patented PA2006018184.

This system was built in a BMW "multifunction seat" with active support system see figure 1.



Fig. 1 "multifunctional seat" with MAS

EXPERIMENTAL DESIGN

The question that needs to be addressed is:

How much is the spine load and the pressure in the commonly used car sitting positions and what happens to the discs if the driver activates extra equipment such as lumbar back support or a massage system.

BMW collaborated with a hospital in Munich to find out the reaction of the discs by using extra equipment in car seats.

The test subject was a 50 percentile man. Two pressure sensors were implanted by surgery into the discs L4-L5 and L5-S1.

For the research, a BMW series 7 with "multifunction seat" with active support was used. The car and seat were special prepared for this research. It was possible to measure the exact angle position of the seat. If facilities like lumbar support and massage were used this was recorded by a laptop with (EDIABAS) software.

The subjects were seated in the BMW 7 car seat and adapted the seat to his favorite sitting position. After finding his favorite optimal sitting position, the pressure in both discs was measured. The exact seat position in the car was also recorded by the laptop. The pressure

between the body and the seat was measured in all sitting positions by a pressure mat (tekscan). All positions were documented with a photo.

The pressure on the disci intervertebrales was measured in:

- Optimal sitting position of the subject
- Using car seat massage system
- Using car seat movement system
- Using the BMW active support in the seat cushion
- Using maximal lumbar back support

The operation was conducted in a clinic located in Munich renowned for disc operation on the spine.

The test subject for the examination was equivalent to the 50th percentile man with an “athletic” physique. The Test subject 42 years old, 176cm, 83 kg. The study was voluntary, the topic and the operation were approved by the ethic commission in Berlin.

IMPLANTATION OF THE SENSORS

The intervertebral discs consist of two elements: a ring of collagen fibre, the annulus fibrosus and a colloidal gel in the nucleus pulposus. The regeneration of the disc is done by the diffusion of the synovial fluid during the compression and decompression of the whole spine Tittel (1994). The load is transferred from one vertebral body to the other by the way of the nucleus pulposus and the annulus fibrosus. White and Panjabi (1990) described that the nucleus has sufficient moisture to act like a gelatinous mass. This fluid pressure pushes the surrounding structures in all directions away from the nucleus centre. The collagen fibre ring is pushed radially outward. Pressure distribution is also altered by bending, torsion and shear force.

For this research study the pressure sensors were implanted, using a minimal invasive technique with a canula in the middle of the intervertebral disc (nucleus pulposus). The surgery was undertaken using the endoscope technology.



Fig. 2 X-ray picture dorsal view of the lumbar spine with both sensors

The sensors were implanted in the most vulnerable area of the spine:

The disc L4-L5 and L5-S1.

In figure 2 pressure sensors are shown in an X-ray picture. In the discs L4-L5 it is possible to identify the canula used to implant the sensor.



Fig.3 Schematic picture of the sensor

Both implanted sensors (type: K4121-00-1629-D) were produced by Mammendorfer Institut for physics and medicine.

Length 640mm

Effective diameter 1.45mm

Sensitivity 0.15mV/VmmHg

The whole measurement system comprised: sensor, measuring amplifier, PC was ± 0.1 bar and the working range is 0-50 bar.

The research program took one day; both sensors were removed on the same day in another surgery.

EXPERIMENTAL SETUP

The car with the test seat is shown in figure 4.



Fig. 4 Test car with “multifunction seat” and sensormat



Fig. 5 Test person with the intradiscal sensor in the car

The car used for the research was a BMW 7-series with “multifunction seat” with active support. It is possible to adjust the seat in 20 different ways.