12

INJURY BIOMECHANICS RESEARCH
Proceedings of the Twenty Seventh International Workshop

Alignment of Sensors Using L.A.S.E.R Beams To Instrument The Human Head Before Low-Speed Rear-End Impacts

P. Potier, J. P. Lassau

INTRODUCTION

During our experimental studies, we are confronted with the recurrent problem of accuratly and repeatably measuring the motion of subjects. In the course of rear-end impact tests, we developed a specific method aimed at reducing the weight of the devices secured on the head and allowing a good accuracy and repeatability of measurement with an easy to use device. The method presented here can futhermore be generalized to other human body parts and is based on alignment measurement with laser beam devices.

Objective

The objective of our study was to measure the head sagittal motion in a rear-end low speed impact sled test. To this end, we planned to measure one angular velocity and two linear accelerations. Our objectives were to accurately locate the sensors on the head and to orient them parallel to the head axis. The present paper deals with a technique which allows materialization of the Frankfort plane, to assess the position of the head center of gravity, and finally, to orient head sensors with a good accuracy.

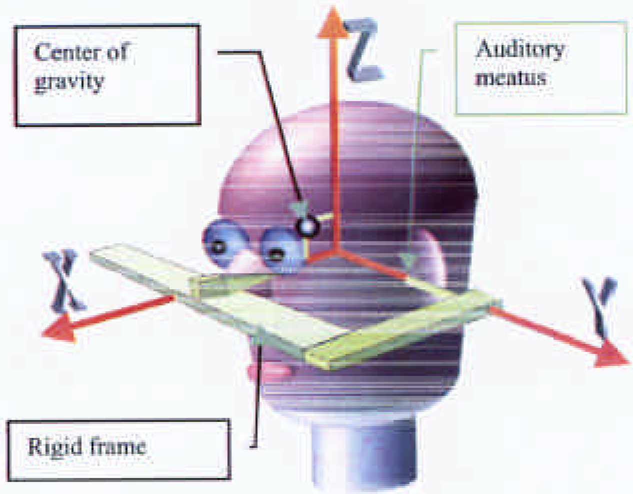
Principle

Fixation of the Frankfort plane using a rigid frame secured on the anatomical landmarks of the head. These anatomical landmarks are :

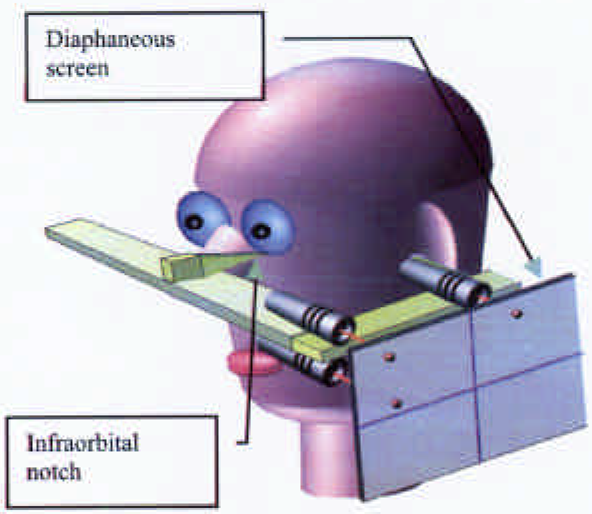
- The left auditory meatus
- The right auditory meatus
- One infraorbital notch

The projection of the Frankfort plane on the skin is drawn. Secondly, using the auditory meatus and the Frankfort plane, the projection of the theoretical center of gravity is drawn on the skin:

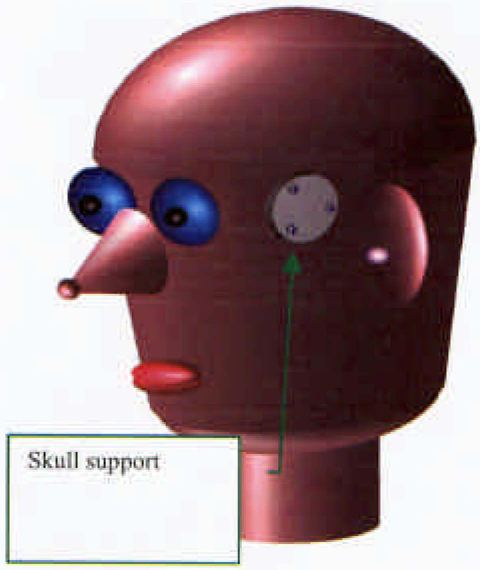
- 3cm above the Frankfort plane
- 1cm ahead of the auditory meatus



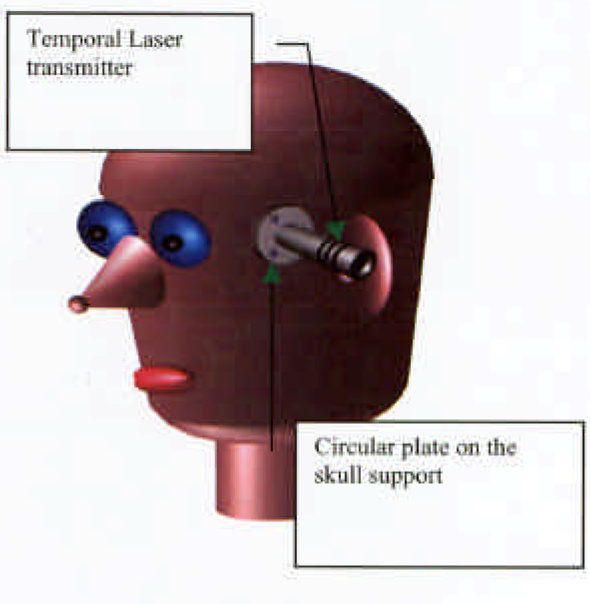
The rigid frame is equipped with 3 LASER transmitters allowing projection 3 red beams of light on a perpendicular screen 2.5m away. The Y-axis of the rigid frame and the Y-axis of the transmitters are parallel by conception. Nevertheless, the parallelism between the three transmitters can be checked using the methodology that we described to align the temporal transmitter.



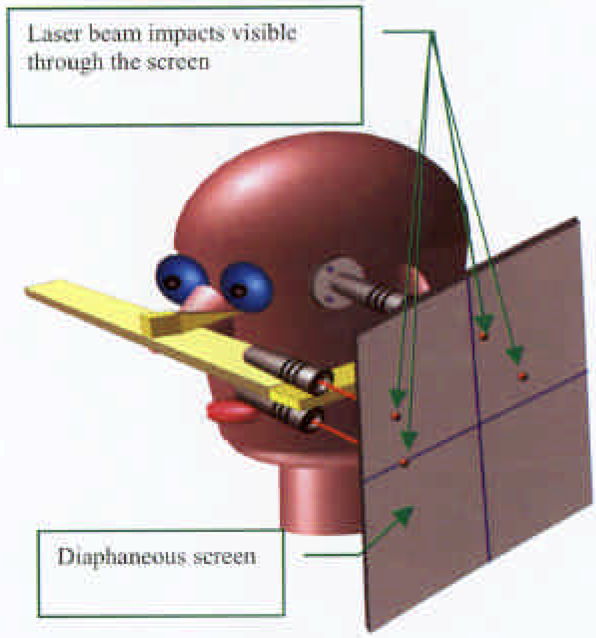
Instrumentation of the head with the temporal skull supports. The skull is equipped with two supports to which can be fixed circular plates using three screws. On the left hand side an angular velocity transducer is fixed on the circular plate. On the right hand side, three accelerometers are fixed on the circular plate using a cubic mounting block. Adjusting shims can be placed between the skull support and the circular plate to alter the orientation of the sensor axis. The distance between the Y-axis of the skull support and the Y-axis of the Francfort plane are measured (on X-axis and Z-axis). Thus, we know the position of the skull support relative to the center of gravity of the head.



Installation of the LASER transmitter on the skull support. We have three identical circular plates that can be mounted on the skull-support. Two of these are equipped with the sensors (Angular velocity transducer and accelerometers). The third is équipped with a LASER transmitter. We use three screws to fix the circular plates on the skull supports. The LASER beam axis and the angular velocity transducer axis are perpendicular with the circular plate plane by conception. The three accelerometers are perpendicular to each other when fixed on the mounting block. The mounting block is fixed on the circular plate using one of the free faces allowing the perpendicular orientation of the upper accelerometer and consequently the correct orientation for the others. Using adjusting shims between the circular plate and the skull support, the LASER beam allows the circular plate to be placed perpendicularly to the head Y- axis.



Projection of the LASER on a perpendicular diaphanous screen close to the transmitter lenses. When the beams are projected on the screen, we draw marks to preserve the location of the temporal beam in relation to the rigid frame beams. Considering the short distance between the screen and the sources, the alignment error is negligible. Thus, we can say that the distances between the marks on the screen are the distances of the beam sources.

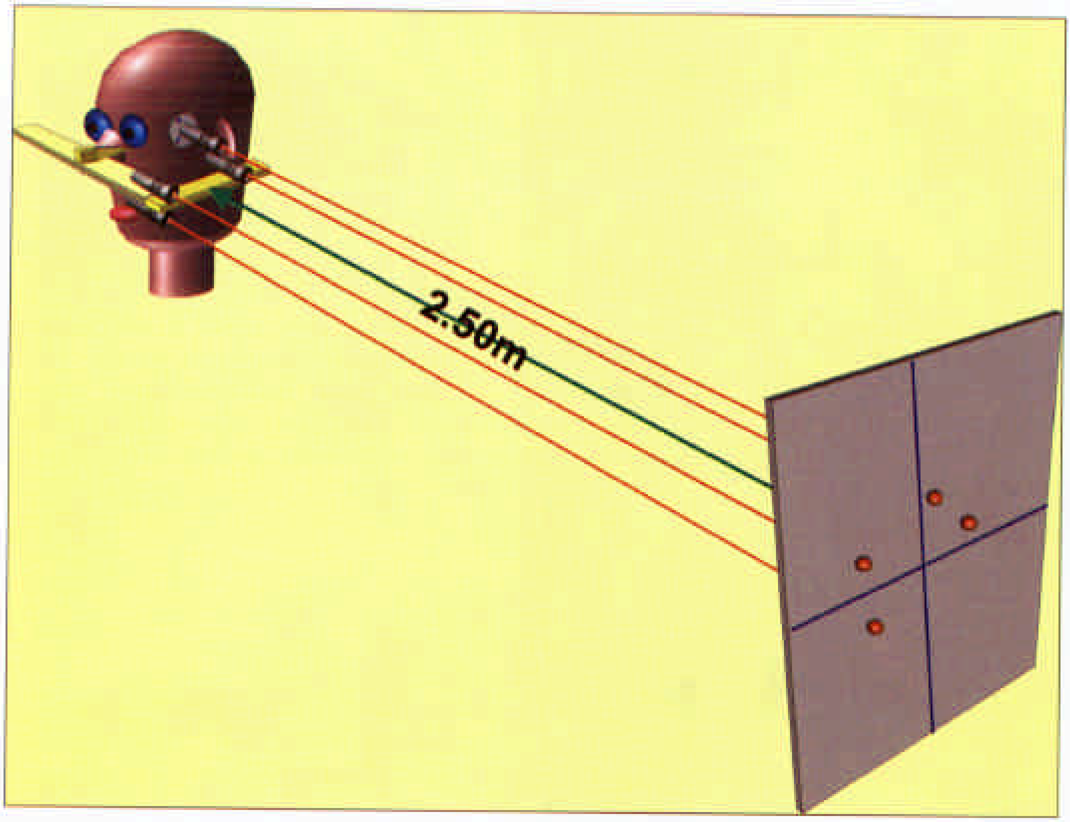


Superposition of the temporal LASER beam and the three other LASER *beams on the marks.* Placing the screen 2.50m away from the transmitters is as in the following figure. Considering this configuration, the distance between the transmitters and the screen works like an alignment error amplifier.

First, we place the screen 2.50m from the transmitters in order to superimpose the rigid frame beams on the respective marks. Secondly, to superimpose the temporal beam on the respective mark, using adjustable shims between the skull support and the circular plate. The alignment is optimum when the temporal beam on the distant screen is superimposed on the mark drawn on the close screen. Each time we change the thickness of the adjusting shims, we check the temporal beam alignment. Carrying out this step, we consider that the temporal laser beam is parallel to the Y-axis of the head and consequently that the circular plate is positioned in the *X,Z* plane.

Installation of the sensor. The circular plate supporting the LASER transmitter is removed. The positions of the adjusting shims are noted. The circular plate supporting the angular velocity transducer is screwed into position leaving the adjusting shims in the same position.

Instrumentation of the other side. The same methodology is applied on the controlateral temple to position the accelerometers and their mounting.



CONCLUSIONS

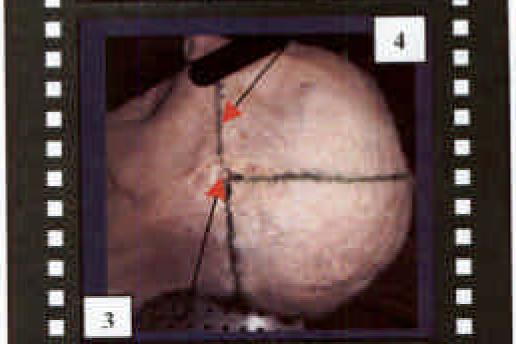
During each step of this procedure the errors have been evaluated, including the error of alignment between the transmitter source and its case.

With an estimated total error lower than one degree, we consider that using this methodology allowed us to respect the initial specification, more easily and less expensively than with any other technique.

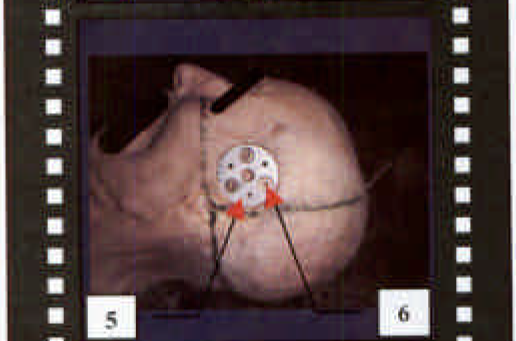
Application

The Frankfort plane is fixation using a rigid frame (1) secured on three anatomical landmarks :

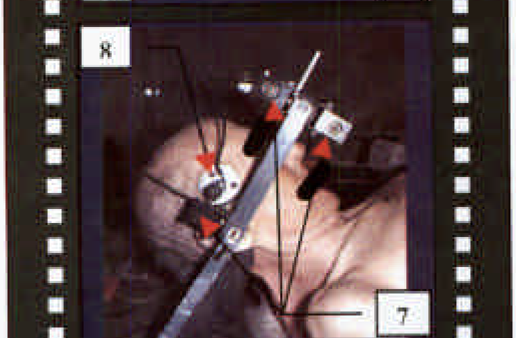
One infraorbital notch (2)
The right auditory meatus (3)
The left auditory meatus



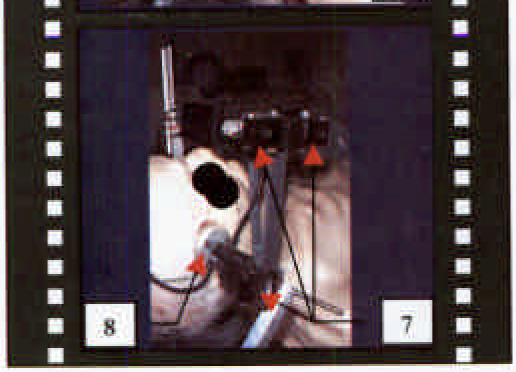
The Frankfort plane (4) is fixation on the skin. Then, using the Frankfort plane, the Y-axis skin projection of the theoretical center of gravity is fixation. Doing this, we can measure the distance between the sensors and the center of gravity Y-axis.



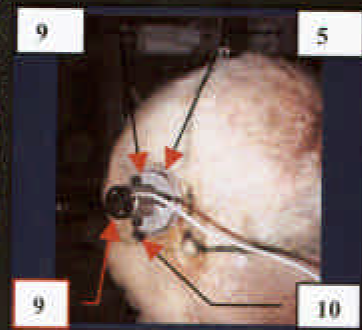
The skull support (5) is fixed with screws (6) and the distance between the sensor location and the center of gravity Y-axis is measured.



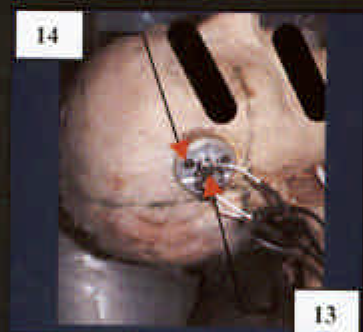
The circular plate (8) with the LASER transmitter is installed. The rigid frame with the LASER transmitters (7) is installed.



Another view of the device with :
-The rigid frame
-Three LASER transmitters on the rigid frame(7)
-One LASER transmitter on the circular plate (8) fixed on the skull support.



When the alignment is optimum, the circular plate with the LASER transmitter is removed The circular plate with the sensor (9) is fixed on the skull support (5) leaving the adjusting shims (10). in the same position. This side the skull is equipped with an angular velocity transducer (9).



The other side is equipped with 3 accelerometers on a cubic mounting block (13). This block, fixed on the circular plate, is mounted on the skull support with 3 screws (14) and the adjusting shims. This allows the conservation of the alignment obtained using the LASER transmitter.

This front view shows both left and right hand side instrumentation.

One of two test configurations without head rest.

The second test configuration with headrest (15).