Short communication

Deformation of the human maxilla induced by occlusal loading - measured by laser triangulation

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Summary

An optical distance sensor using laser triangulation was tested for its suitability in dental research. One of the advantages with this device is that the measurement is not influenced by tilting or inclining of the involved teeth. Preliminary results suggest that the laser triangulation device can be used to detect deformations of the upper jaw by occlusal loading ranging between 16 and 30 μm.

Zusammenfassung

Ein optischer Abstandssensor nach dem Prinzip der Lasertriangulation wurde auf seine Eignung zu zahnmedizinischen Untersuchungen geprüft. Einer der Vorteile dieser Meßeinrichtung ist die Unempfindlichkeit

gegenüber Verkippungen des Meßobjektes. Erste Anwendungen zeigen, daß ein Laser-Distanz-Sensor in der Lage ist Verformungen des menschlichen Oberkiefers durch funktionelle Belastung im Bereich von 16 bis 30 μm zu erfassen.

Introduction

Fuchs and Schott (1973), Dermaut and Beerden (1981), Sanchez del Campo et al. (1983) and Pavin and Vukocevic (1984) examined deformations of the human facial skeleton. Suzuki et al. (1982) and Hobkirk and Schwab (1991) used inductive measurement devices or strain gauges with measurements restricted to the jaw. These devices are sensitive to displacement as well as to tilting. Therefore tilting has to be eliminated by hinges or similar devices, which may affect the precision of the results. The advantage of laser triangulation method is that additional tilting or inclining of the involved teeth up to 30 degrees does not influence the measurement of distances.

Material and methods

Changes of the distance between the upper left second molar (27, tooth numbering system according to FDI) and the contra-lateral upper right first premolar (14) following occlusal loading were measured by the laser distance sensor LSD 1-10 (Leuze Electronic GmbH & Co., Owen/Teck, Germany). The measuring concept of the laser triangulation is demonstrated in Fig.1. The sensor measures distances ranging between 45 and 55 mm. The reproducibility is 10 μm.

Since laser triangulation needs diffuse reflection, a non-glossy target area (5 mm × 8 mm) made of Harvard cement (Richter & Hoffmann, D 1000 Berlin, Germany) was attached to the enamel surface of the upper left second molar (27). The distance sensor was fixed to the central incisors as well as to all teeth of the right upper jaw by means of an aluminium bar . The device was adjusted to an individual plaster cast of the subjects . The occlusal loading was produced by biting upon a bar at maximum force between the upper and lower left canine (23 and 33). In order to ensure that the target as well as the sensor were unaffected by the loading force the canine 23 was unsplinted both mesially and distally. 35 measurements were carried out on two subjects (one female and one male) without any signs of periodontal disease or temporo mandibular joint disturbances.

Results

The distance between the upper right premolar 14 and the upper left second molar 27 was significantly reduced in the range between 16 and 30 μm under maximum occlusal loading of the upper left canine (23) (Fig. 2). The same effect was observed when pressure was exerted on the canine by the thumb.

On the other hand deformations caused by laterotrusion of the mandible without tooth contact were found to be 10 μm. This is just the reproducibility of the device.

Discussion

Ney and Schulte (1988) measured mandibular deformations during jaw opening ranging between 10 μm and 48 μm. They used non-contact inductive sensors. These results are comparable with the dimensional changes of the upper jaw observed in our present paper. Koeck and Sander (1978) investigated the compression of the mandible during mastication. They reported deformations up to 100 μm. These larger values may be caused by the lever device which connected the teeth with the non-contact inductive distance sensor outside the oral cavity.

The *disadvantages* of the laser triangulation method are the dimensions of the sensor (95 mm × 64 mm × 27 mm) as well as its weight (0.25 kg). Therefore, the fixation in the oral cavity is difficult, as well as with inductive methods. The *advantages* are that additional tilting or inclining of the involved teeth does not influence the accuracy of the measured distances. It is a non-contact method like some inductive devices. Based on our data it can be concluded that deformation measurements with laser triangulation is an useful method with interesting aspects.

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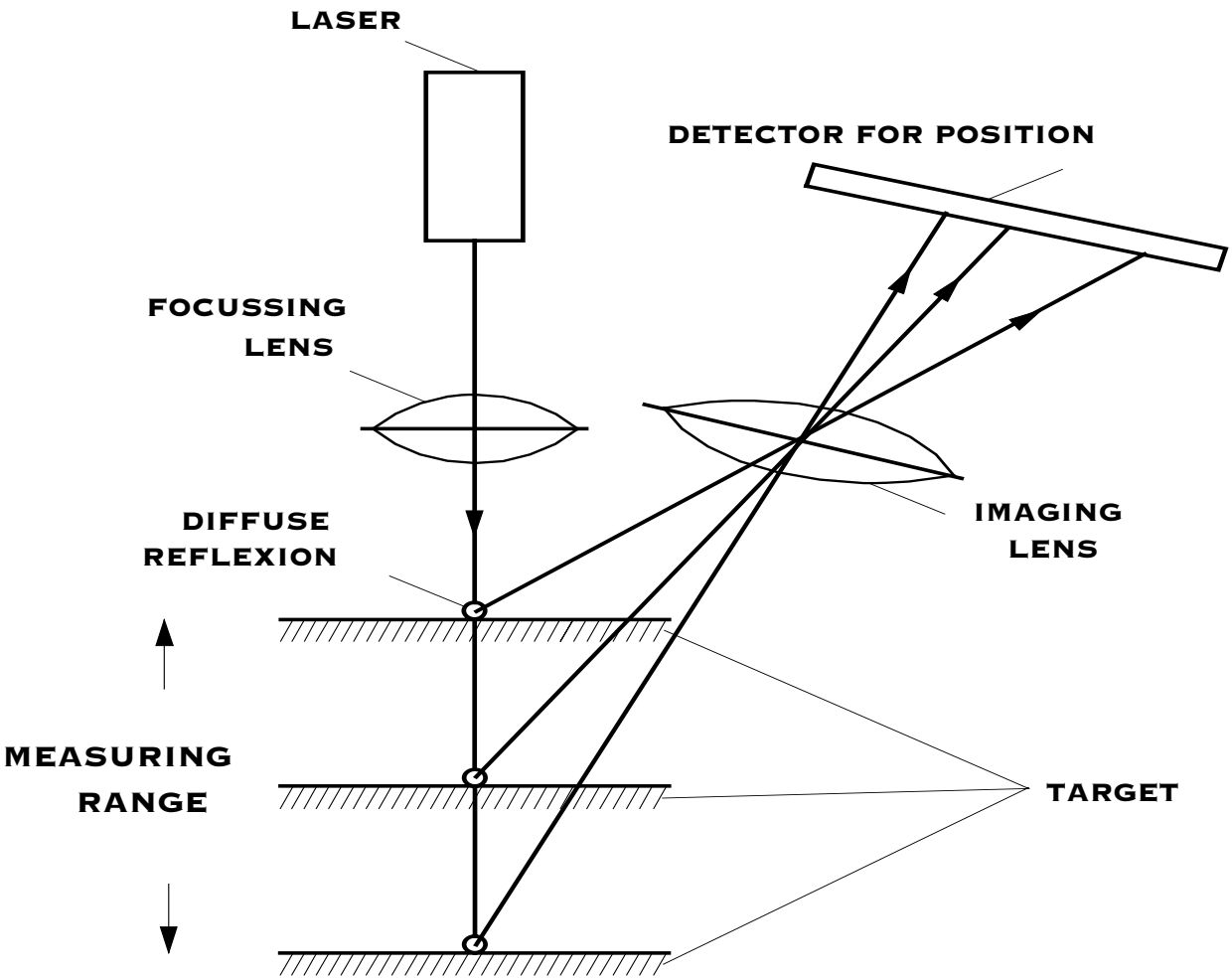

Fig. 1: Principle of triangulation measurement. The laser diode and the focussing lens are producing a spot onto the diffuse surface of the target (shown in three positions with various distances). The reflected light is collected by the imaging lens onto a spot on the position sensitive detector. With different positions of the target this spot is placed on different parts of the detector. The centre of this spot is calculated electronically and from this the position of the target.

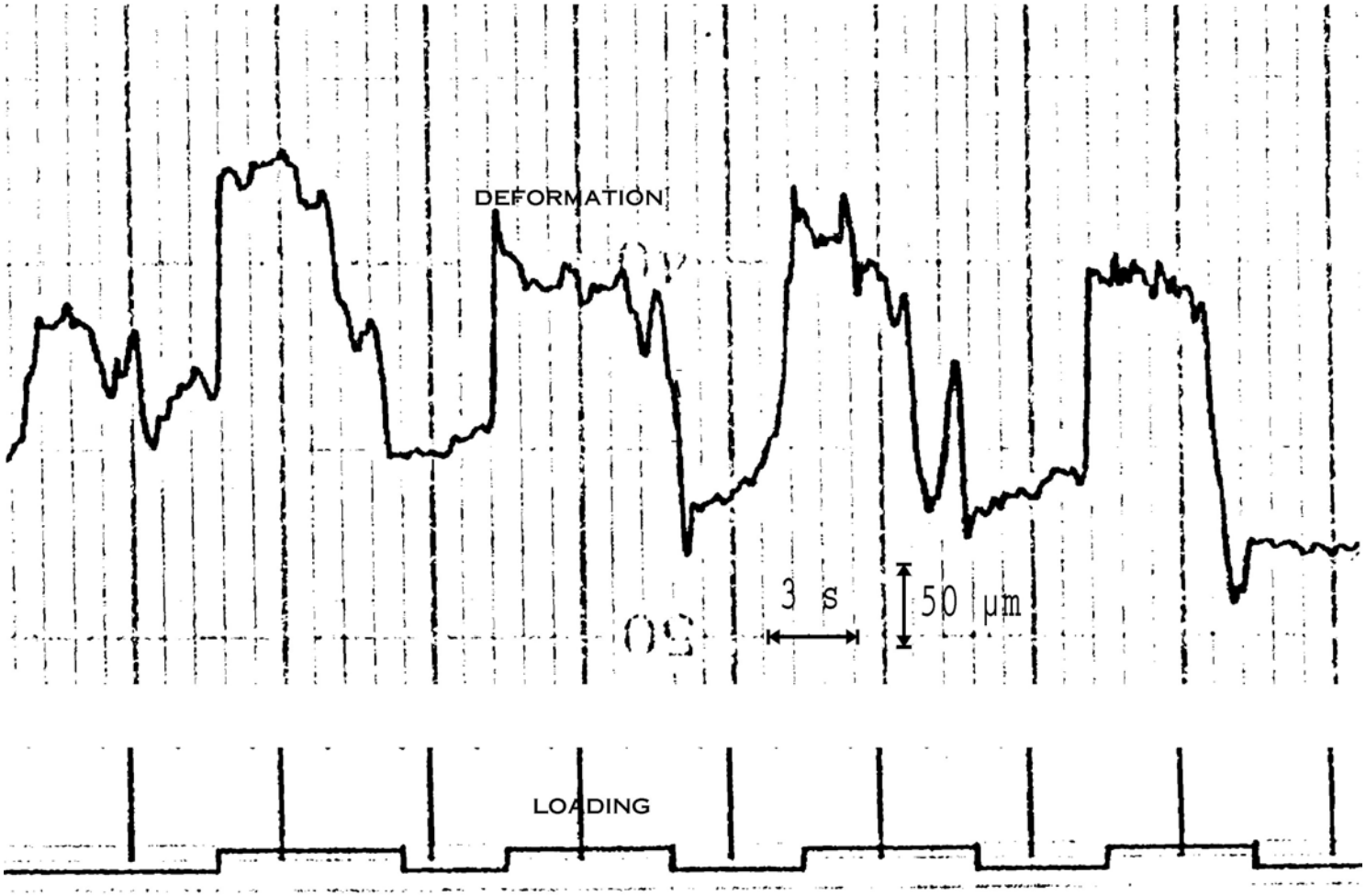

Fig. 2: Original recording of measurement. The upper line is the deformation as detected by the laser distance sensor. The lower line is indicating every biting action.