ELECTRONIC MEASUREMENT SYSTEM FOR RECORDING AND EVALUATING DYNAMIC PLANTAR PRESSURE DISTRIBUTION

Marko Pečina¹, Karlo Obrovac², Hrvoje-Ivan Pečina² and Maja Jelić²

¹Department of Orthopaedic Surgery University of Zagreb, Šalata 7, Zagreb, Croatia and
²Outpatient Orthopaedic Clinic "Kinematika" Laginjina 16, Zagreb, Croatia
e-mail: karlo.obrovac@zg.tel.hr

Abstract

Many attempts have been made to develop a suitable technique for the measurement of the distribution of pressure underneath the plantar surface of the foot. The authors would like to present their experience with the system known as the Emed system which supports the diagnosis and therapy control in many medical fields, especially in orthopaedics. The aim of this paper is to show on the basis of more than 1000 analyzed patients the advantages of dynamic pressure distribution measurements under the plantar surface of the foot. The examples of two patients demonstrate the possibilities of the objective dynamic diagnostics of the foot deformities and the importance of the gained correction using specially designed orthopaedic insole.

Keywords: plantar pressure, electronic measurement

1. Foot pressure measurement

Foot pressure measurement has long been an area of interest for many different professional groups, including orthopaedic surgeons, prosthetists and orthotists, footwear manufactures, rehabilitation engineers, clinicians and those involved in biomechanical research. These professions need a clinical system of measuring foot pressure that is reliable, easy to calibrate and user-friendly, preferably suitable for the investigation of foot and its related problems on a daily basis. Many attempts have been made to develop a suitable technique for the measurement of the distribution of pressure underneath the plantar surface of the foot.¹⁻¹⁰

We would like to present our experiences with the system known as the Emed system which has been developed in Germany by Novel GmbH. It has been on the market since 1986. Emed system is an electronic measurement system for recording and evaluating dynamic pressure distribution on flat and curved surfaces. The measurement method is based on capacitive sensors. The signals, produced from a maximum of 4000 pressure sensors, are displayed as a conform color picture on a monitor or create a printout on an ink jet color printer. Soft and hardware options allow for the application of the Emed system to various measurement tasks in medical and technical fields. The Emed system platforms are available in different sizes and with various local resolutions. A large variety of EMED systems exist, and each comes with modified software package depending on the system specification and capability. The systems differ in size, weight, number of sensors, resolution and sampling frequency. The measurement variables of all EMED systems are pressure (in N/cm²), time (in seconds), and location of the pressure (in x/y coordinates). The system enables both static and dynamic measurement with a maximum speed of 150,000 sensors per second. All EMED systems are based on the capacitive measurement technology. The repositioning element (like a spring-balance) of a capacitive sensor is exactly defined. Furthermore, shear forces are elastically compensated and do not change the characteristics of the capacitive sensor over time. The sensors cannot smear nor change their characteristics by rubbing or by friction. The matrix configuration of the sensors provides identification for each single sensor for calibration. The EMED system are calibrated with a patented method: all sensors are simultaneously statically or dynamically loaded and a specific calibration curve for each sensor is calculated.

The EMED software package is divided into four parts: data calibration, data collection, analysis and display/printout.

The Emed - extern software packages includes true-to-scale color printouts of the measured pressure distribution; rotating pressure mountains; maximal and average value pictures; coordinates of maximal pressure and center of pressure progress; colored isobar display; evaluation of areas of interest (partial areas of the whole measurement area); definition of areas of interest either manually or automatically based on percentage definition of dimensions; force-time and pressure-time integrals; 3-D cross-section analysis of pressure mountains in x, y and z direction collective comparison; overlay and parallel pictures; time, location and body-weight normalization; contact time comparisons of areas of interest; intra- or inter-individual statistics with standard deviations; coefficient of variation, and ranges, etc.

The Emed system supports the diagnosis and therapy control in many medical fields and for example in orthopaedics: diagnosis of foot form and function, pre- and postoperative assessment of foot function, design of shoes and insoles⁴⁻¹⁰, gait analysis⁴⁻¹⁰, function of prostheses⁹, stress tests on tissue, early recognition of diabetic neuropathy and optimal shoe design for
prevention and treatment of ulceration\textsuperscript{77}. The system has been used extensively by researchers and is supported by a considerable number of publications.

The aim of our publication is to show advantages of the dynamic pressure distribution measurements under the plantar surface of the foot. The dynamic measurement determines loading during actual roll-over processes, quantified by parameters such as the length and width changes of the foot, the varus or valgus position, the contact area of the foot, the function of the toes, joints and ligaments and many other parameters. We will demonstrate, on the basis of more than 1000 analyzed patients on the EMed-Mini system and some of them tested in-shoe pressure measurement (PEDAR), the possibilities and advantages of the electronic measurement system for recording and evaluating dynamic plantar pressure distribution.

baropodogram shows quiet different distribution of the plantar pressure. On the dynamic baropodogram is significant increase of pressures on the lateral metatarsal edges of both feet, due to varus position (Fig 1).

2. Female patient V.L. suffered because of varo-excavatus deformation predominantly on the right foot, as is seen on her dynamic baropodogram. After orthopaedic insoles have been manufactured by CAD/CAM system plantar pressure analysis with Pedar system shows regular, that is as physiological as possible pressure distribution on both plantar surfaces (Fig. 2). The patient is very satisfied with the result of her treatment.

![Fig. 1. Dynamic and static baropodogram of top-level basketball player](image)

2. Cases Reports

1. The analysis of plantar pressure in a top-level basketball player shows on static baropodogram augmentation of pressure under the heads of III and IV metatarsal bone of the left foot, while the dynamic
Fig.2. Magic mountain of pressures under bare feet and in-shoe pressures analysis of the female patient
3. Conclusion

The authors in this paper present only two cases, but on the basis of more than 1000 analyzed patients on the Emed system and some of them tested in-shoe pressure measurement (PEDAR), it is possible to conclude how useful is the electronic measurement system in the diagnosis and treatment of foot deformities.

References