Impression technique for the assessment of oedema
Technical improvement and methodological evaluation of a new technique

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Abstract—A new instrument for the assessment of oedema based on the impression method is described. The measurement parameters are defined and the errors corresponding to the electrical and mechanical stability of the instrument are measured. The overall accuracy is calculated theoretically for the translocated volume. The accuracy and reproducibility are evaluated on plastic foam. The clinical procedure to measure oedema with this instrument is described. We show that the accuracy of the translocated volume parameter is very dependent on the overall stability of the instrument and that this instrument has an overall relative error of less than 7.3 per cent for a representative measurement. Experimental measurements on plastic foam show that the measurement parameters could be reproduced with standard deviations of less than 6 per cent and that the standard deviations for translocated volume are within the calculated overall relative error. Measurements on four patients with chronic oedema in an extremity show significantly different results on locations where pitting could be recognised compared to the contralateral nonoedematous extremity.

Keywords—Accuracy calculation, Fluid volume, Impression force, Oedema, Skin model

1 Introduction
Oedema is a condition in which abnormal quantities of body fluids are gathered in the extra- and/or intra-cellular spaces. The symptom is swelling of the tissue. Oedema can have a wide variety of aetiology, for example, heart and kidney failure, thrombosis and disturbed lymph circulation. Surface measurements and volumetry are common methods for the assessment of oedema in the extremities (Swedborg, 1977).

In the beginning of this century Schade (1912) measured the elasticity of oedema by recording tissue relaxation time after impression. Schwartz (1916) showed that it was possible to measure the degree of oedema by impressing the skin with various weights attached to a piston and measuring the impression depth. The instrument thereby constructed was called the elastometer and was based on assumptions about the pitting phenomenon. This phenomenon, i.e. the increase of hydraulic conductivity in subcutaneous oedemaous tissue compared to normal tissue, has been described by several authors (Guyton et al., 1966; Aukland and Nicolaysen, 1981; Bøgen, 1987).

2 Instrumentation
The principle of the impression measurement is based on the instantaneous impression of the tissue (skin) to a predefined depth. The impression will then be sustained and the force required to do this is measured. A stable stand is therefore necessary to hold the impression head
with its force sensor in a fixed position. The impression head is moved by a stepper motor with low drift electronic regulation.

The oedema test instrument software runs on an IBM personal computer system (PC) or a compatible system and the hardware is composed of a stand, specially constructed for high stability, a force transducer (Showa MR05K, Japan), a stepper motor (Airpax Co., L92421P2, USA) and a main electronic unit for both the force transducer and the stepper motor. A photograph of the device is shown in Fig. 1a and in Fig. 1b the stepper motor and pressure head is pictured. The hardware is constructed to satisfy the international safety standard IEC-601.

The stepper motor and the force transducer are connected to a D/A convertor and an A/D convertor, respectively (PC-30 Boston Technology, England).

The software is menu driven and is handled with great ease. In the main menu it is possible to choose the values for impression length \( L \), recording time \( T \), diameter of the impression plate \( D \) and trigger force \( TF \). Parameters

![Diagram of the menu system for the oedema investigation software.](image)

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