sensor with ultrasonic (as in our study) or computed tomography techniques (5).

JAN BOLINDER, MD, PhD
ANDERS FRID, MD

From the Departments of Medicine and Clinical Physiology, Karolinska Institute, Huddinge Hospital, Stockholm, Sweden.

Address correspondence and reprint requests to Jan Bolinder, MD, Associate Professor, Department of Medicine, Huddinge Hospital, S-141 86 Huddinge, Sweden.

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Reply

We appreciate the letter by Bolinder et al. who questioned whether the subcutaneous adipose tissue of the forearm is thick enough to allow the subcutaneous implantation of a glucose sensor.

We have no human data on the exact localization of the sensor inserted. However, we speculate that a sensor is kept in subcutaneous adipose tissue from experiments with dogs. In these experiments, the needle-type glucose sensor was 0.8 mm in diameter and 20 mm in length. After penetrating the epidermis, a dual-lumen cannula was inserted parallel to the epidermis at a distance of 5 mm. Then, after withdrawal of the inner needle, a half-length of the sensor (10 mm) was inserted through the plastic sleeve left in situ. Therefore, the tip of the sensor might be 2–3 mm beneath the epidermis [= 10 × sine (15)] on the condition that a sensor was inserted at an angle of 10–20° with the epidermis (sine for 15° is 0.25).

We also examined the canine tissue around the sensor-inserted site, after withdrawal of the sensor. These histological examinations showed that the sensor-insertion site was kept in the subcutaneous adipose tissue, and the tip of the sensor did not reach muscle fascia. From these findings, we are convinced that the sensor tip is kept in subcutaneous adipose tissue. However, we agree with the suggestion that the use of ultrasonic or computer tomography techniques are needed to demonstrate the exact localization of the sensor in human subjects.

There still remains the question of whether a sensor inserted in subcutaneous tissue measures glucose concentration precisely in interstitial fluid of the subcutaneous adipose tissue. Recent studies with the microdialysis method or wick technique clearly demonstrated that the extracellular glucose concentration in subcutaneous tissue was almost identical with that in venous blood. Our glucose sensor is designed to measure glucose concentration in the tissue where oxygen tension is low (~30–40 mmHg; 1). Therefore, during implantation of the glucose sensor, tissue reaction to the sensor and protein fixations to the membrane covered on the sensor might affect the availability of oxygen. These mechanisms might be partly responsible for the reduction by 20% of the subcutaneous glucose concentration determined by the sensor and the delayed response to glycemic fluctuation (2,3).

In any case, further studies would be necessary to reach a final conclusion on where the best place for the sensing site is, because sensor output might be dependent on local conditions, such as interstitial fluid circulation and oxygen availability. The histological examinations will also solve these questions.

We are energetically working on the development of a glucose sensor with suitable sensor characteristics in vivo for long-term implantation.

MOTOAKI SHICHIRI, MD, PhD
YOSHIMITSU YAMASAKI, MD, PhD
RYUZO KAWAMORI, MD, PhD

From the Department of Metabolic Medicine, Kumamoto University Medical School, Kumamoto, and the First Department of Medicine, Osaka University Medical School, Fukushima-ku, Osaka, Japan.

Address correspondence and reprint requests to Motoaki Shichiri, MD, PhD, Professor, Department of Metabolic Medicine, Kumamoto University Medical School, 1-1-1 Honjo, Kumamoto 860, Japan.

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Novopen—A Useful Aid Also for Blind Diabetic Patients

In Norway, insulin pens, especially NovoPen (Squibb-Novo, Princeton, NJ), have become widely used (1–3). Approximately 30% of Norwegian insulin-dependent diabetic (IDDM) patients use insulin pens in multi-injection regimens. In the literature there are no reports on the usefulness of insulin pens for blind diabetic pa-