In-Vivo tissue identification using bioimpedance spectroscopy with conventional anaesthesia needles

Kari J.[1], Seppä V.-P.[2], Annala K.[3], Kronström K.[1]
[1]Injeq Ltd, Tampere, Finland
[2]Tampere University of Technology, Dept of Electronics and communications engineering, Tampere, Finland
[3]Tampereen Lääkärikeskus Ltd., Dept of Anaesthesiology, Tampere, Finland

Background: Various medical procedures require precise insertion of a needle into a specific tissue type or anatomical structure. Bioimpedance spectroscopy (BIS) based techniques for needle guidance have been studied before [1], but the technology presented here enables for the first time the use of BIS in standard commercial 22G spinal needles. The aim of this study was to explore the ability of this technology to distinguish the tissue type at the needle tip.

Methods: A conventional 22G injection needle was connected to the prototype measurement system (Injeq ltd) consisting of a biocompatible customised stylet (Fig.1), custom BIS measurement device, and tissue recognition software. The system performs the BIS in a bipolar configuration between the tip of the stylet and the surrounding needle.

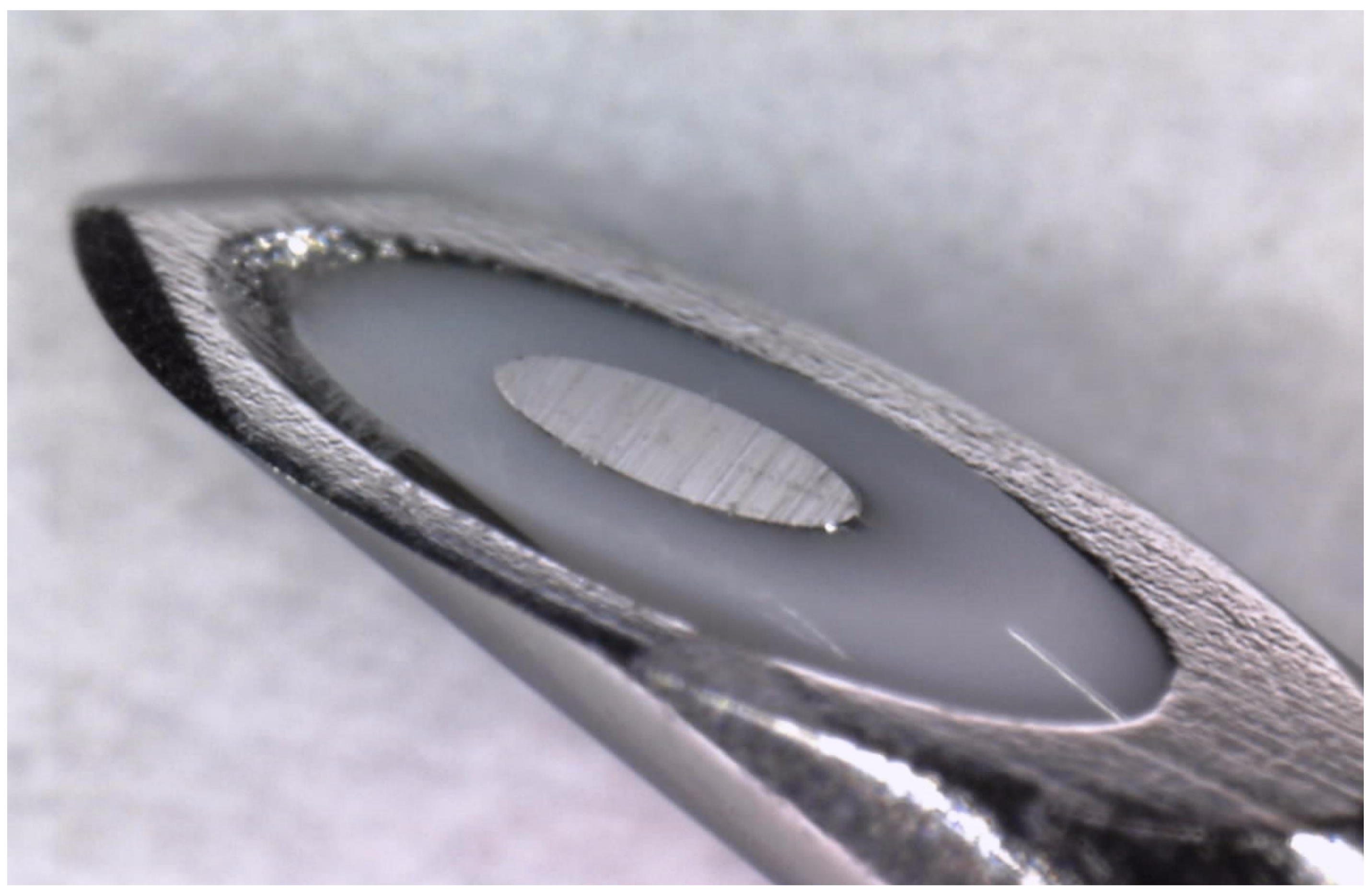

Figure 1: Bioimpedance probe (BIP) inside a standard 22 G spinal needle

The total of 8 needles was used and 3 injections were performed on each needle to subcutaneous fat, skeletal muscle and achilles tendon of an anaesthetised piglet under visual guidance (Fig.2). Similar tissues are encountered during epidural or spinal anaesthesia procedure. The BIS data was acquired during the insertion phase that lasted approximately 5 s. Blood was measured in the test tube. The measurement data (Fig. 3) was analysed using the developed Bayesian classification algorithm that classified a sample to one of the four classes based on the underlying statistical model [2]. The results were obtained using five-fold crossvalidation to validate this model. The study was authorized by the Animal Experiment Board.

Results: The overall classification accuracy (Table 1) is very high despite the artefacts induced by the movement of the needle and possible inhomogeneities of the tissues. With the available data, fat and blood are classified perfectly while there are some errors between muscle and tendon.

		Classification			
		Fat	Muscle	Tendon	Blood
Reality	Fat	100 %	0 %	0 %	0 %
	Muscle	0 %	93 %	7 %	0 %
	Tendon	0 %	1 %	99 %	0 %
	Blood	0 %	0 %	0 %	100 %

Table 1: Cross-validated classification results

Conclusion: The in-vivo animal study using the developed technology indicates that the proposed measurement system can reliably distinguish between the most common tissues found around the spinal column even during motion of the needle.

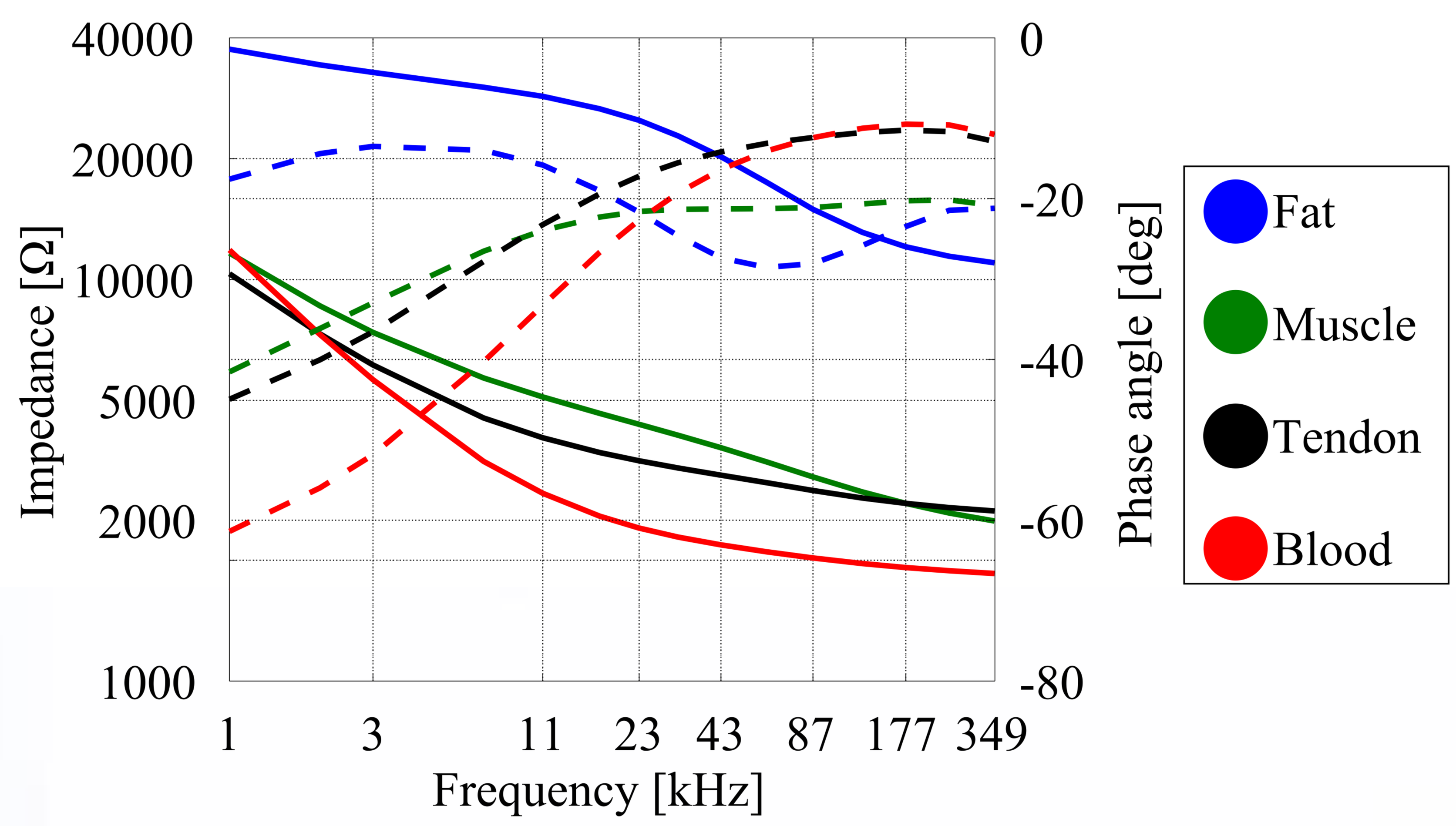

Figure 3: Average impedance magnitude (solid lines) and phase angle values (dashed lines) as a function of frequency

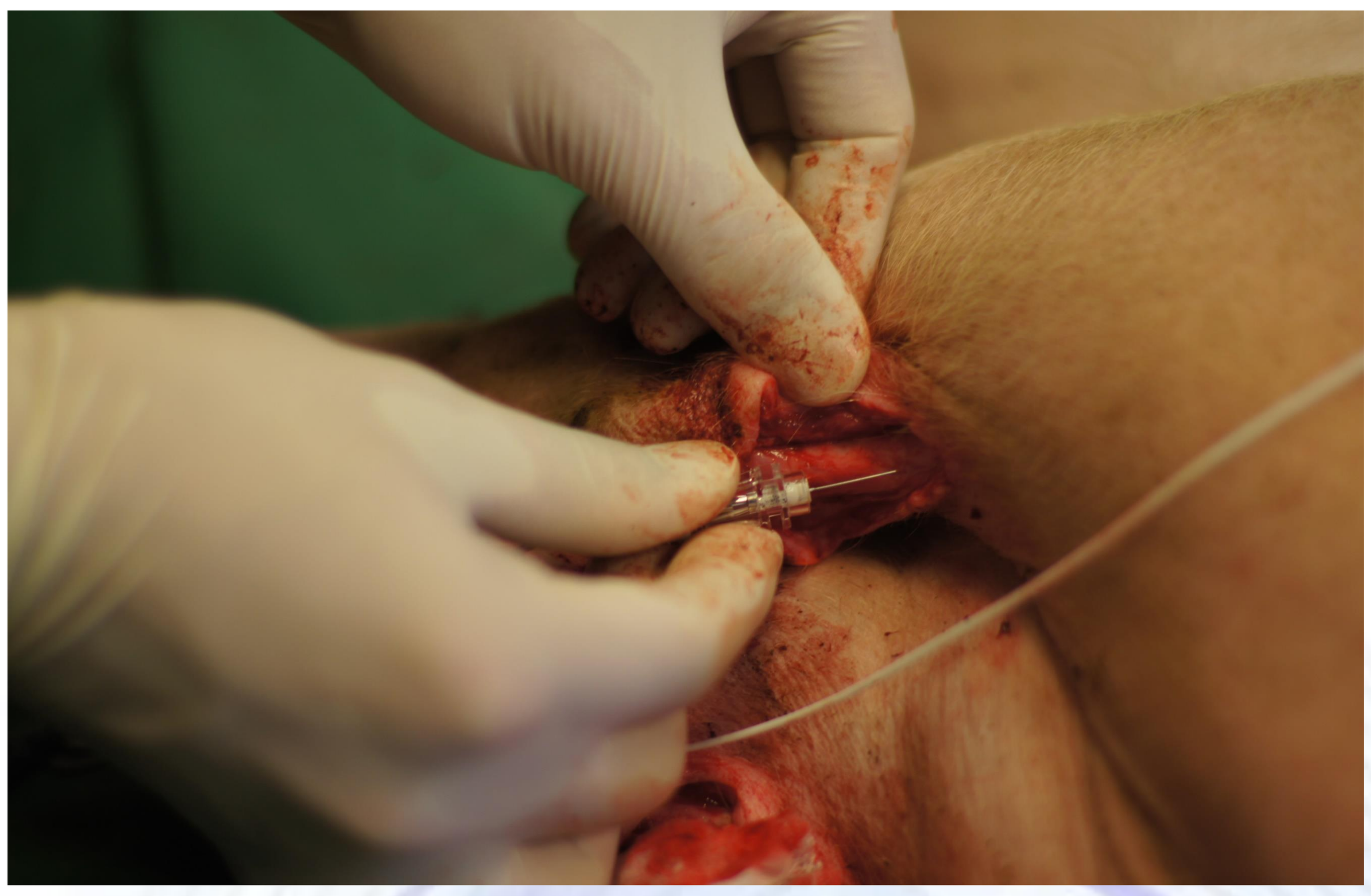

Figure 2: A measurement from achille's tendon of a piglet under visual guidance using 22 G BIP Needle.

References:

1. Kalvøy, H., et al. 2009. Impedance-based tissue discrimination for needle guidance. Physiol. Meas. 30 129
2. Duda, E., Hart, P., Stork, D. Pattern Classification. 2nd edition. 2000. Wiley-Interscience. 680 p.