K. Chinzei, K. Miller, "Compression of Swine Brain Tissue; Experiment In Vivo," in Proc. International Society of Biomechanics Tokyo Congress 97, 1997, p. 318.

COMPRESSION OF SWINE BRAIN TISSUE; EXPERIMENT *IN VIVO*

Kiyoyuki Chinzei and Karol Miller

Biomechanics Division, Mechanical Engineering Laboratory, MITI, Tsukuba, Japan
Email: chin@mel.go.jp; kmiller@mel.go.jp

Introduction

Recent developments in Computer-Integrated and Robot-Aided Surgery [1], as well as advances in virtual reality techniques [2], call for closer examination of the mechanical properties of very soft tissues (such as brain, liver, kidney, etc.). The ultimate goal of our research into the biomechanics of these tissues is development of corresponding, realistic mathematical models. Such models would find applications in surgeon training and operation planing systems, based on the virtual reality techniques, registration [3], and control of surgical robots. The presented contribution, intended as a step towards the said goal, shows the experimental results of *in vivo* compression of swine brain tissue.

Materials and Methods

In vivo compression of swine brain tissue was performed in a testing stand, as shown in Fig. 1. The main testing apparatus was a two-linear-degree-of-freedom robot equipped with a sensitive load cell, build in our Laboratory. A head of a six-month-old, anesthetized swine was fixed rigidly in the robot base, Fig. 1. An opening in a skull of about 2.5 x 2.5 cm was prepared at the frontal lobe. The robot's cylindrical (10 mm diameter) end effector was placed so that it touched the exposed brain surface. The measurement began when the robot's end effector started vertical descent. The loading velocity was 1 mm/s. The robot movement was controlled and measured precisely by linear displacement sensors. The loading force was measured by a sensitive strain-gauge load cell.

The experiment consisted of two stages: loading and stress relaxation. This paper focuses on the results obtained during the loading phase. For compressive strains larger than 35%, measured *in vitro* [4], we observed unrecoverable damages in the tissue. Therefore, only one loading cycle was performed. The start of the loading phase was indicated by the first non-zero reading of the load cell. The end of loading phase and simultaneously the start of stress relaxation phase was indicated by the point of equalizing of the reading of the vertical displacement.

Results

Figure 2 shows loading force versus displacement curve. Surprisingly, even for high compression levels, the force-displacement relation is close to linear, with proportionality constant of 0.099 N/mm.

Discussion and Conclusions

This study presents the results of the *in vivo* compression of swine brain tissue. Close to linear force-displacement relation was observed. How to use the *in vitro* experimental results for defining models of brain mechanical properties remains an open question. Further research is needed to determine brain tissue constitutive models, which would incorporate the influence of the blood and cerebrospinal fluid pressure and flow.

Acknowledgments

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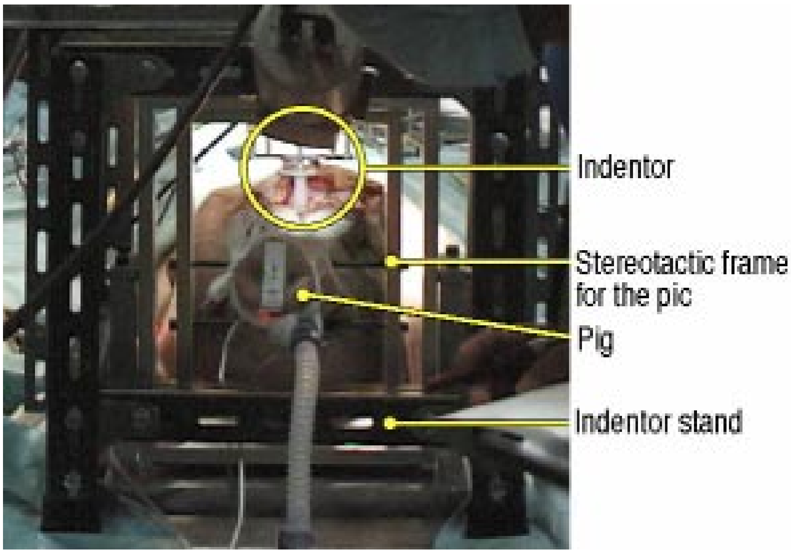

Fig. 1. Experimental stand

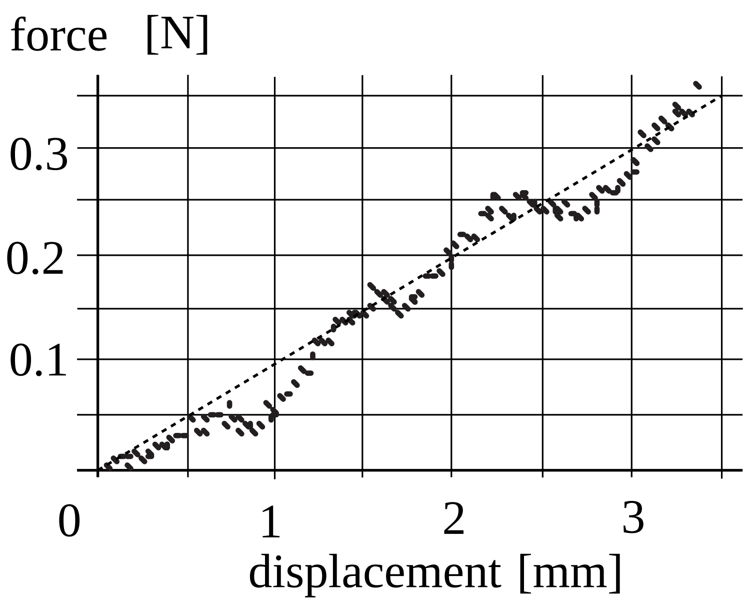

Fig.2. Force - displacement curve obtained in vivo