COMPANION ANIMAL
Research Award

Development and visualization of a brain tumor model to evaluate the image-guided injection of holmium-166 microspheres for the treatment of inoperable brain tumors

Ruven, L.K., BSc
Department of Clinical Sciences of Companion Animals
Faculty of Veterinary Medicine, Utrecht University
Yalelaan 108, 3584CM, Utrecht, The Netherlands

l.k.ruven@uu.nl

Ruven, L.K., BSc; Klaassen, N. J. M., MSc; Morsink, N. C., MSc; Nijsen, J. F.W., PhD; Nimwegen, S.A., DVM, PhD, DECVS; Hesselink, J. W., DVM, PhD, DECAR

Introduction
The prognosis of human and veterinary patients diagnosed with brain tumors is poor due to limited treatment efficacy and side effects(1). A new experimental treatment is controlled minimally invasive intratumoral treatment with β-emitting Holmium-166 microspheres (HoMS) (2). Due to its paramagnetic properties, röntgen attenuation, and low-energy γ-radiation fraction, holmium can be visualized and quantified *in vivo* using MRI, CT, and SPECT, enabling real-time feedback of HoMS distribution after injection. The aim of this study is to evaluate MRI-compatible steerable needle placement and intratumoral HoMS distribution during image-guided injection of HoMS in a brain tumor phantom
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Material and Methods
A brain tissue phantom with incorporated tumor phantoms was developed by a mixture of polyvinyl alcohol, phytagel and manganese chloride ($MnCl_2$) in deionized water. The tumors were created using a different $MnCl_2$ concentration and a freeze-thaw cycle before placement inside the phantom. Hundred-and-seven mg HoMS were suspended in 1 mL 1% carboxymethylcellulose and in 1 mL 2% Pluronic phosphate buffer. Image-guided placement of an MR-compatible nitinol/titanium needle and subsequent injection of the HoMS suspensions in the tumors was performed in a 1.5T MRI scanner using T1, T2, and T2* sequences.

Results Tumors showed realistic contrast inside the brain phantom on MRI images(fig. 1). MRI was used to adjust needle placement successfully, after which injection followed. Resistance could be felt during injection of Pluronic, and of carboxymethylcellulose in lesser degree. The microspheres were observed in the tumor model on MRI immediately after injection(fig. 2, 3).

Discussion
The brain phantom with tumor model enabled image-guided needle placement and near-realtime evaluation of HoMS distribution. This phantom model has good potential to simulate and further optimize the complete clinical procedure, including image-guided intratumoral dose-painting. Several parameters, including differences in MRI contrast and density of the modeled tissues should be further improved to optimize the model.

References

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Figure 1 (Ruven, L.K.): MRI scan (T1) of the brain phantom model with visible brain tumor phantoms indicated in colours. MR-compatible needle is inserted in the blue-labelled tumor phantom.

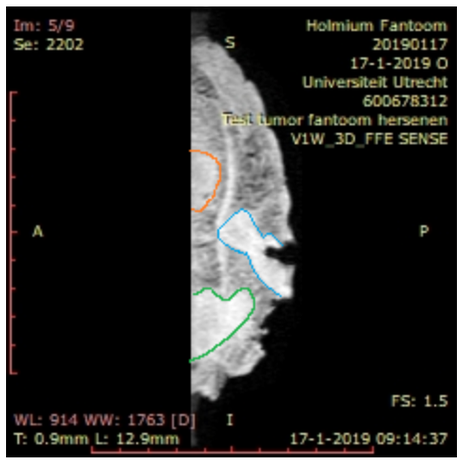


Figure 2: MRI scan (T2) of brain phantom after injection of HoMS with carboxymethylcellulose 1% in the tumor phantom.

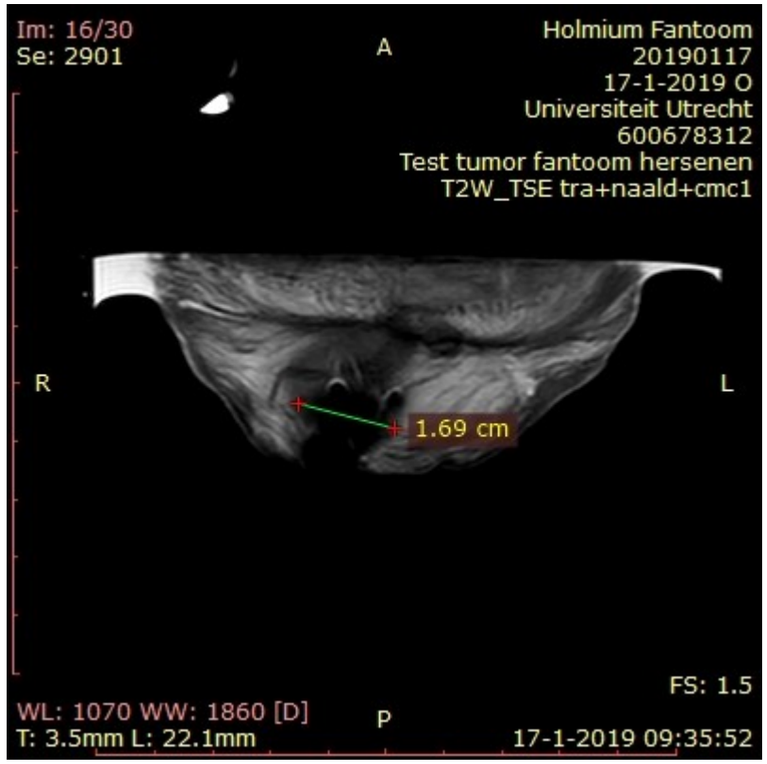
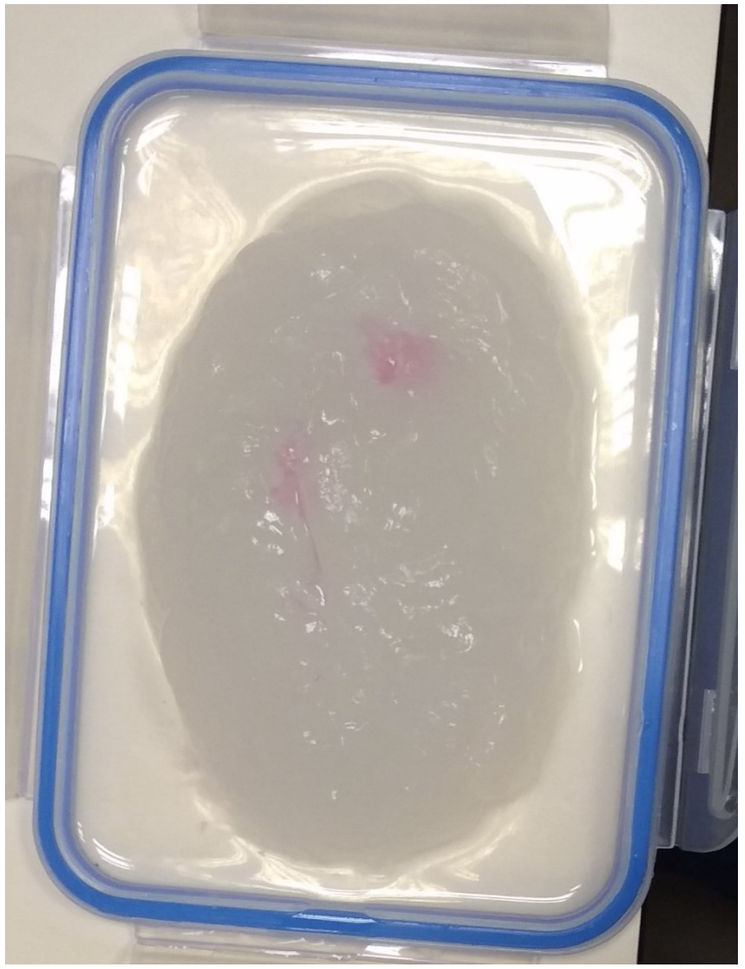


Figure 3: Photo of the brain tumor phantom after two HoMS injections (pink) suspended in 1% carboxymethylcellulose (left) and 2% Pluronic (right).



Disclosure

JFW Nijsen is inventor on the patents related to the $HoPO_4$-MS which are assigned to University Medical Center Utrecht Holding BV and/or Quirem Medical (patent families: USA Patent No. 6,373,068 B1, PCT/NL03/00485, EP07112807.8, 10190254.2, P114198PC00, P112614NL00). He is co-founder and chief scientific officer of Quirem Medical, and has a minority share in the company Quirem Medical. The activities of J.F.W. Nijsen within Quirem Medical are approved and supported by Dirkjan Masman (Director Technology Transfer Office Radboudumc) and Mathias Prokop (Head of Radiology and Nuclear Medicine at Radboudumc). All authors have revised and have approved the final manuscript.