# Design and Fabrication of a Driver for MR Elastography of the Head and Neck: Initial Results

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**Background:** MR elastography is a technique that has been successfully applied to study the liver, breast, brain, heart, prostate and lungs (1-6). However, only few studies have successfully applied this technique in the head and neck (HN) due to lack of suitable drivers. A new HN driver is proposed that is easy to implement and comfortable to use.

**Introduction:** HN cancers originate from the upper aero-digestive tract, including the lip, oral cavity, nasal cavity, para-nasal sinuses, pharynx, and larynx (7). Existing drivers for studying the thyroid (8), tongue and tonsils (9) are not suitable to generate shear waves deep inside the skull base. Features that are important for a HN driver are: (a) able to adapt to patient's neck curvature to provide comfortable support; (b) able to provide optimal wave energy transfer. The purpose of this work was to (i) design a driver with features suitable for MRE of the HN and (ii) to assess the driver's performance in human subjects.

**Materials and Methods**:

***Driver Design and Fabrication:*** A transducer (Philips, Hamburg, Germany) measuring 22 × 13.5 × 5.2 cm with a 10-cm diameter piston intended for MRE of the liver was employed. It was embedded inside a 5-cm thick high-density polyurethane foam slab (53 × 53 cm), glued on to a 2-cm thick plywood (53 × 53 cm). Three rigid plastic headrest moulds (trims A, B and C) commonly used in radiotherapy treatment (Silverman, Civco Medical Solutions) were obtained to form three different tops to couple with the transducer base. A square opening (5 × 5 cm) near the apex of the curve was cut from each mould. Three piston extensions (length: 5.5 cm (A), 5.8 cm (B) and 7 cm (C); cross-section: 4 × 4 cm) were made using Perspex to couple with the piston. Fig. 1 shows the individual components. Fig. 2 shows the complete driver after assembly.

Fig. 1

Fig. 2

Fig. 3

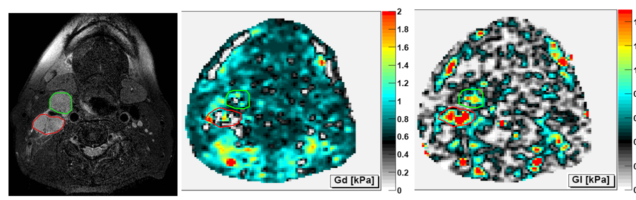


Fig. 4

***MRE Protocol:*** MR images were acquired on a 3.0 T scanner using a two-element flexible RF coil (SENSE Flex-M or -S, Philips). Driver performance was tested using a motion-sensitized spin-echo MRE pulse sequence with sinusoidal displacement encoding gradients, phase-locked to the mechanical vibration (10). Axial T2-weighted images with fat-suppression (TR/TE 1676/70 ms; 2 mm thick and 7 slices) were acquired to identify HN anatomy. MRE data were acquired from seven 2-mm thick slices in the axial plane (TR/TE: 525/50 ms, FOV: 176 $\times$ 176 mm, matrix: 88 $\times$ 88 and voxel size: 2 $\times$ 2 $\times$ 2 mm, NEX: 1, dynamics: 8). Scan was applied three times to obtain three orthogonal components of the 3D displacement vector. Tissue elasticity (Gd) and viscosity (Gl) measurements were obtained from organs of interest.

***Subjects:*** Five healthy males (mean age 35 years) underwent MRE of the parotid gland and three of the men were invited to undergo MRE twice on two separate days for reproducibility assessment. One healthy female (35 years) was invited to undergo MRE of the thyroid. Two patients (male: 54 years; female: 75 years) with known metastatic lymph nodes arising from nasopharyngeal carcinoma on imaging and one female patient (23 years) with confirmed thyroid cancer were invited to undergo MRE. The study protocol was approved by the ethics committee of our institution and informed consent was obtained from all subjects.

***Data and Statistical Analysis:*** For ROI measurements, the viscoelasticity maps corresponding to the three central slices were used. ROIs delineating the right and left parotid glands of the volunteers were drawn manually on the T2-weighted images by a radiologist and copied onto the viscoelasticity maps. For patients, ROIs were drawn around the margins of the primary tumor or metastatic lymph nodes. From each ROI, the mean and standard deviation of Gd and Gl were obtained. Reproducibility was assessed with the within subject coefficient of variation (CoV) calculated as the within-subject standard deviation divided by the mean. A paired t-test was used to compare right and left normal parotid glands. All statistical analyses were done using the statistical package SAS, version 9.1.

**Results:**

***Driver Presentation:*** Three headrest tops A, B and C were successfully made for volunteer and patient testing. A phantom model demonstrates how this driver design could provide a secure support for the HN while enabling an effective transfer of mechanical wave from the transducer (Fig. 3).

***Normal Parotid and Thyroid:*** MRE was successfully performed on all six volunteers. There was no statistically significant difference between the right and left parotid gland for both elasticity ($p = 0.96$) and viscosity ($p = 0.64$) measurements. For the normal parotid gland (80 Hz), mean elasticity and viscosity were 1.118 $\pm$ 0.13 kPa and 0.484 $\pm$ 0.141 kPa, respectively. Preliminary repeatability data obtained for the parotid gland showed a CoV of elasticity and viscosity of 4.7% and 9.8%, respectively. Initial MRE data obtained from the normal thyroid at 50 Hz had a mean elasticity of 0.584 $\pm$ 0.262 kPa and viscosity of 0.418 $\pm$ 0.219 kPa.

***Metastatic Lymph Nodes and Thyroid Cancer:*** Two patients who had metastatic lymph nodes and one patient with thyroid cancer (papillary) completed the MRE examination successfully. Figure 4 shows a patient with metastatic lymph nodes and the corresponding viscoelasticity maps. Initial metastatic lymph nodes results showed a mean elasticity of 0.663 $\pm$ 0.104 kPa and viscosity of 0.578 $\pm$ 0.186 kPa. From the 23 years old female who had thyroid cancer, initial mean Gd was 0.169 $\pm$ 0.139 kPa and mean Gl was 0.280 $\pm$ 0.072 kPa.

**Conclusion:** A new HN driver has been implemented using an existing transducer, suitable headrest moulds and piston extensions. This driver offered an elegant solution to supporting the neck comfortably while allowing an effective means of transferring mechanical waves in the HN. This driver was tested in volunteers and patients without discomfort. Our initial results showed that reproducible Gd and Gl measurements of the normal parotid gland could be obtained using this new driver. Our CoV for Gd (4.7%) and Gl (9.8%) were comparable to the values reported by Huwart et al. (11) for the liver using a similar transducer (Gd: 9%; Gl: 7%). In addition, there was no significant difference between right and left parotid viscoelasticity results suggesting that wave propagation was reasonably even in the neck. In conclusion, we developed a method for the application of MRE to study organs in the HN. Our driver design was tested successfully in human volunteers and in patients with metastatic NPC nodes and thyroid cancer showing clear differences in mechanical properties compared to normal tissues. This work is an important step allowing a more widespread application of this emerging technique to study HN pathologies.

**References:**

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