Two Channel Interventional Cervix Coil for High Dose Rate Brachytherapy

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Introduction

One of the commonly used techniques for treatment of cervical cancer is High-Dose Rate Brachytherapy (HDRB). In this method, a high dose of radiation is applied to the cancer tissue, while keeping the radiation level to the healthy tissues as small as possible. The success of the method is strictly dependent on accurate visualization of the tumor and healthy tissue. Although Computerized Tomography (CT) cannot be used for this purpose (1) it can over-estimate the diseased region (2). Magnetic Resonance Imaging (MRI) on the other hand, has a higher sensitivity to fat and muscle tissues and therefore decreases the chance of overestimation (3); its not at the desired level for many applications including cervical cancer.

Internal coils, on the other hand, provide high SNR levels at their target regions and therefore enables increased image resolution (4). Moreover, images for HDRB needs to be obtained with the dose applicator in place since it may deform the target region. Hence, we have designed a two-channel RF coil, which is embedded inside a commercially available cervical applicator, so that it enables high resolution imaging of cervix.

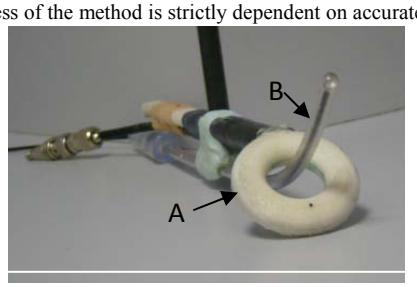
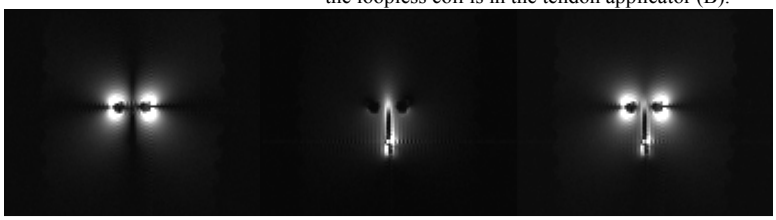


Figure 1: Picture of the proposed coil structure. The loop coil is in the loop applicator (A) and the loopless coil is in the tendon applicator (B).

Method

The Nucletron (Utrecht, Netherlands) ring applicator, which is developed for brachytherapy procedures, is redesigned. This applicator is composed of a loop and a tendon applicator. The loop applicator is located adjacent to the cervix; on the other hand the tendon applicator goes through the loop and is placed into the cervix during a procedure. It should be noted that the tendon applicator is aligned to be perpendicular to the surface of the loop. The proposed structure is given in Figure 1. Since its structure enables, the loop part of the applicator, a loop coil is embedded in it permanently. Although the loop coil is highly sensitive to the region around it, it has null sensitivity at its center since the axis of the loop for this application is approximately is along the main magnetic field direction. (Figure 2A). It is known that a loopless antenna is very sensitive to the region around it (Figure 2B), hence when it is used with the loop coil it can compensate for the nullity of the loop coil inside the cervix. Position and the shape of the tendon applicator ideal for placement of a loopless antenna inside. In our design, the loopless antenna is inserted into the tendon applicator temporarily during MRI and it can be taken out during therapy for placement of the radioactive source. As a result, a high-quality images of servix and the surrounding tissue with this design the two coils are combined.

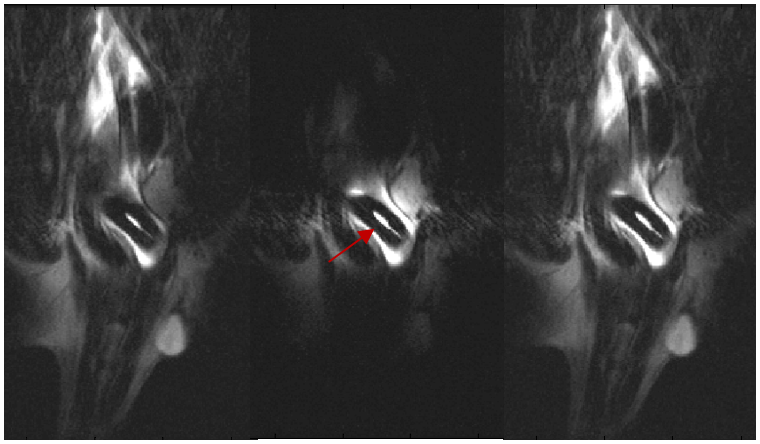


A B C

Figure 2: Phantom experiment showing the sensitivity of A) Loop coil B) Loopless coil C) Combined structure

Results

An in-vivo canine experiment was made using a Siemens 3T Trio scanner. A turbo spin echo sequence was used with the following imaging parameters: a slice thickness = 4mm, TR = 6 seconds, TE = 114 milliseconds, pixel bandwidth 250 Hz/pixel, flip angle = 120 degrees, the field-of-view = 20 by 20 centimeters. The resulting T2-weighted coronal images of the female canine are given in Figure 3. Figure 3A is obtained solely with the loopless coil. All of the pelvic space is highly visible. In Figure 3B, the image obtained with the loop coil is given. The region between the cervical canal and the uterine cavity can be seen easily. In the loop coil image (Figure 3B), endometrium and internal os can be observed much better than the conventional MR imaging strategies (Figure 3A). In Figure 3C, the combined image is given. The cervix, uterus and all pelvic viscera can be clearly seen in the combined image.



A B C

Figure 3: T2-weighted coronal images of a 4 year old female canine received with A) The loopless coil, B) The loop coil, C) Combined image

Conclusion

In this study, a simple two-channel coil is designed that can easily be mounted on a ring HDRB applicator. The coils produce high signal intensity in the target region and the cervix, the uterus and all the pelvic viscera can be clearly seen from the obtained in-vivo images. It should be noted that these coils are designed for human anatomy, hence their structure is not very suitable for animal anatomy. As a result, the performances of the coils drop. Still, the proposed structure introduces improvements over the current techniques and better quality is expected in human experiments..

References

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