

## Quantitative Diagnostics of Prostate Cancer using Dynamic Palpation

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**Introduction** Prostate cancer affects 41,000 men and results in 10,000 deaths every year in the UK[1]. Diagnosis is usually performed by analyzing the prostatic-specific antigen (PSA) blood concentration or by digital rectal examination (DRE) tests. PSA levels can be affected by different factors such as urinary retention, ejaculation, usage of antibiotics etc. therefore becoming an unreliable diagnostic technique. DRE only provides qualitative diagnostic data which has been proven problematic in accuracy and may consequently lead to poor clinical decisions. Nevertheless, such procedures present disadvantages such as false negatives –due to the stochastic nature of the tumor localization and the position where the needle is inserted–, risk of rectal bleeding, haematuria, urinary tract infections etc. [2]. Although techniques based on instrumental palpation have been developed to assess the existence of an anomaly [3], they do not allow determining key parameters such as the size and depth of the lesion at the same time. Furthermore, they only rely on the stiffness of the material but do not take into account its viscoelastic behavior which provides useful information about the microstructure of the prostate and its healthiness under mechanical palpation [4]. In this study an *in-silico* prostate with cancerous nodules is subjected to dynamic mechanical palpation and experimentally validated to establish a novel mathematical algorithm that enables quantitative characterization of cancerous nodules in prostatic tissue.

**Key Results** The viscoelastic behavior of prostates with different cancer grades and positions under displacement driven dynamic palpation were modeled. It has been found out that, although both size and depth of cancerous nodules can significantly alter the force feedback, they can be decoupled by sweeping the surface at different depths of indentation. Furthermore it is shown how phase shift and force feedback amplitude become less dominant diagnostic magnitudes in the practical range of testing frequencies. More importantly, validated by the ex-vivo experimental data, it is proposed that the percentage of cancerous tissue can be quantitatively characterized using effective viscoelastic parameters of prostate, possibly without imaging and histological information.

**Conclusion** A new diagnostic framework has been developed to characterize size and depth of cancer nodules in prostate tissue, where important diagnostics parameters such as depth and size of cancerous nodule are obtained by non-invasive dynamic palpation to indicate the

aggressiveness and prognostics of the disease and therefore of great help to the practitioners to decide on the most appropriate treatment. Moreover a methodology based on prostate viscoelastic behavior to quantitatively assess the cancer extent and grade, has also been established.

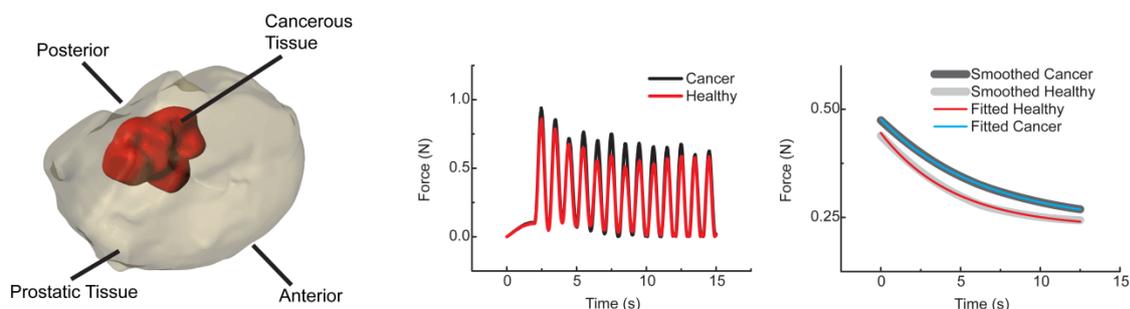


Figure 1. *In-silico* prostate model. Dynamic palpation force feedback for cancerous and healthy tissue and model fitting.

## REFERENCES

- [1] <http://www.cancerresearchuk.org/cancerinfo/cancerstats/types/prostate/>.
- [2] *Early Diagnosis and Treatment of Cancer*, ed. S.C. Yang. 2010: Saunders Elsevier.
- [3] Sangpradit, K., et al., *Finite-Element Modeling of Soft Tissue Rolling Indentation*. IEEE Transactions on Biomedical Engineering, 2011. **58**(12): p. 3319-3327.
- [4] Phipps, S., et al., *Measurement of the mechanical characteristics of benign prostatic tissue: a novel method for assessing benign prostatic disease*. Urology, 2005. **65**(5): p. 1024-8.