Video Article

Long-term Culture of Human Breast Cancer Specimens and Their Analysis Using Optical Projection Tomography

Alexander D. Leeper1, Joanne Farrell2, J. Michael Dixon1, Sarah E. Wedden2, David J. Harrison1, Elad Katz1

1Breakthrough Breast Cancer Research Unit, Institute of Genetics and Molecular Medicine, University of Edinburgh
2MRC Technology

Correspondence to: Elad Katz at elad.katz@ed.ac.uk

URL: http://www.jove.com/details.php?id=3085
DOI: 10.3791/3085

Keywords: Medicine, Issue 53, Breast cancer, Optical Projection Tomography, Imaging, Three-dimensional, computer assisted, Tumour microenvironment,

Date Published: 29/7/2011

This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Citation: Leeper, A.D., Farrell, J., Dixon, J.M., Wedden, S.E., Harrison, D.J., Katz, E. Long-term Culture of Human Breast Cancer Specimens and Their Analysis Using Optical Projection Tomography. J. Vis. Exp. (53), e3085, DOI : 10.3791/3085 (2011).

Abstract

Breast cancer is a leading cause of mortality in the Western world. It is well established that the spread of breast cancer, first locally and later distally, is a major factor in patient prognosis. Experimental systems of breast cancer rely on cell lines usually derived from primary tumours or pleural effusions. Two major obstacles hinder this research: (i) some known sub-types of breast cancers (notably poor prognosis luminal B tumours) are not represented within current line collections; (ii) the influence of the tumour microenvironment is not usually taken into account.

We demonstrate a technique to culture primary breast cancer specimens of all sub-types. This is achieved by using three-dimensional (3D) culture system in which small pieces of tumour are embedded in soft rat collagen I cushions. Within 2-3 weeks, the tumour cells spread into the collagen and form various structures similar to those observed in human tumours1. Viable adipocytes, epithelial cells and fibroblasts within the original core were evident on histology. Malignant epithelial cells with squamoid morphology were demonstrated invading into the surrounding collagen. Nuclear pleomorphism was evident within these cells, along with mitotic figures and apoptotic bodies.

We have employed Optical Projection Tomography (OPT), a 3D imaging technology, in order to quantify the extent of tumour spread in culture. We have used OPT to measure the bulk volume of the tumour culture, a parameter routinely measured during the neo-adjuvant treatment of breast cancer patients to assess response to drug therapy.

Here, we present an opportunity to culture human breast tumours without sub-type bias and quantify the spread of those ex vivo. This method could be used in the future to quantify drug sensitivity in original tumour. This may provide a more predictive model than currently used cell lines.

Video Link

The video component of this article can be found at http://www.jove.com/details.php?id=3085

Protocol

1. Extracting Collagen from Rat Tails

1. Place frozen fresh rat tails in 70% ethanol.
2. Deglove the overlying skin with a scalpel exposing tendons.
3. Strip tendons away from tail and place in 70% ethanol to sterilise.
4. Weigh the collected tendons and transfer to acetic acid (1g tendon to 250ml 0.5M acetic acid). Mix for 48hr at 4°C.
5. Centrifuge the tendon/acetic acid mix at 10,000g for 30min and discard the pellet.
6. Add an equal volume of 10% (w/v) NaCl to the supernatant and allow the mix to stand overnight at 4°C.
7. Collect the collagen-rich, insoluble bottom layer and centrifugate for a further 30min at 10,000g.
8. Resuspend the collagen-rich material in 0.25M acetic acid at 4°C and dialyse against 1:1000 acetic acid at 4°C for 3 days, changing the dialysis buffer twice daily.
9. Further sterilise the collagen solution by centrifugation (20,000g for 2hr) and store at 4°C.
10. Dilute collagen as required with the addition of sterile 1:1000 acetic acid to a stock concentration of 1mg/ml.

2. 3D Assay Creation

The 3D assay is based on a cell line assay, published previously2.

1. Multiple core biopsies are harvested from consenting patients at the time of curative surgical resection for invasive breast cancer.
2. By eye, divide the cores using a scalpel into 1mm3 fragments. Trim and discard macroscopically distinct fat.
3. Antibody Staining of Assay in preparation for Optical Projection Tomography

We have adopted a previously published method for whole sample staining:\(^4\).

1. Wash formalin fixed specimens for 30min in PBS. Dehydrate the gels stepwise in methanol diluted in PBS containing 0.05% Tween 20 (0.05% PBST): 33%, 66%, and 100% for ≥15min at each step.
2. Incubate the tissue in freshly prepared MeOH: DMSO: 30%H\(_2\)O\(_2\) at a ratio of 2:1:3 (15% v/v H\(_2\)O\(_2\)) at room temperature for 24hr to quench the autofluorescence.
3. Wash samples twice for 30min in methanol. Freeze the samples to -80°C five times for at least 1hr each time and back to room temperature (RT) to ensure that antigens in the deeper parts of the tissue are rendered accessible.
4. Rehydrate the tissue back to 0.05% PBST with methanol as diluent (33%, 66% and 100% for 15min at each step).
5. Block the tissue in blocking solution (10% serum in 0.05% PBST) for 24hr.
6. Incubate the tissue with primary antibody to identify the epithelial content, using rabbit anti-cytokeratin at a concentration of 1:500 diluted in 1.5ml of blocking solution containing 5% DMSO for 48hr.
7. Wash samples four times with 0.05% PBST for 30min each.
8. Incubate the tissue with fluorescent secondary antibody (1:100 Goat anti-rabbit A\(_{555}\)), diluted in 1.5ml blocking solution containing 5% DMSO for 48hr.
9. Wash the samples again with 0.05% PBST four times for 30min each.

4. Optical Projection Tomography

Optical projection tomography is a microscopy technique previously developed to produce high-resolution 3D images of fluorescent biological specimens with a thickness of up to 15 millimeters:\(^5\).

1. Mount the stained gel in 1% low melting point agarose and dehydrate in 100% methanol for 24hr. Clear the specimen in BABB solution (1:2 Benzyl alcohol, Benzyl benzoate) for 48hr and scan using the OPT 3001M Scanner (Bioptics).
2. Both target and autofluorescence are captured using the Cy3 filter set (exciter 545nm/30 nm, emitter 610/75 nm) and GFP1 filter set (exciter 425nm/40 nm, emitter LP475 nm) respectively.

5. Reconstruction and 3D quantification

1. The set of angular projections acquired by OPT may be reconstructed using NRecon software (SkyScan) to create a series of cross section slices through the invasion assay. This software is available to download for free at http://www.skyscan.be/products/downloads.htm.
2. Analyse the reconstructed data using Velocity software (PerkinElmer). Free demonstration software is available to download at http://www.cellularimaging.com/products/Velcity/demo/.
3. In order to quantify epithelial volume by cytokeratin staining, set a minimum voxel intensity threshold to reduce interference from background fluorescence in the target channel. We defined this threshold empirically at 9000 a.u. Using a list of available parameters in the measurement application, we quantified the volume of epithelium in continuity with the original core (demarcated in the autofluorescent channel). This allowed us to quantify volumes of epithelial outgrowth between different tumour samples.

6. Representative Results:

During the development of the assay, a total of 52 breast cancer biopsy specimens with a wide range of histopathology have been used. Of these <10% (5/52) failed to provide at least one viable invasion assay. Assay failure was due to either bacterial supra-infection or insufficient tumour biopsy material. Therefore application of the assay is not restricted to a specific subtype of breast cancer.

Typical assays (figure 1) fixed after 20 days in collagen culture and subsequently stained for cytokeratin. Velocity software is able to recognise both the epithelial bulk continuous with the original core and detached groups of invading cells and quantify each volume separately.
**Collagen-based assays to study the behaviour of cancer cell lines are now widely used**. Nonetheless, these assays have not reflected in full the complexity of the tumour and its environment. In this study, we show that human breast cancer materials can be used in a similar manner, *ex vivo*. Furthermore, OPT is a useful tool to characterise the 3D expansion of breast cancer. We found that the main limitation of this technique is the availability of tumour materials (a single core biopsy is sufficient for 4-6 assays). Another limiting factor is that structural invasion occurs only in about 40% of assays. To overcome this, we regularly add any desired treatment around day 7 to all assays with visible growth. The usage of OPT could be extended in the future to also detect bulk changes, *ex vivo*, resulting from drug treatment. This in turn could facilitate more individualised cancer therapy, independent of animal models. We are currently exploring the response of ER+ tumours to tamoxifen *ex vivo*.

**Disclosures**

SEW and JF are employed by MRC Technology, which is commercialising Bioptonics OPT scanners. Other authors declare no conflict of interest.

**Acknowledgements**

We thank Lorna Renshaw (Edinburgh Breast Unit) for her invaluable assistance in obtaining clinical specimens.

Usage of tumour material was approved by the Lothian Research Ethics Committee (08/S1101/41) and obtained under the auspices of Experimental Cancer Medicine Centre programme (Edinburgh).

This work is supported by the Scottish Funding Council. A.D.L. is a Miss Margaret Butters Reekie Trust clinical fellow.

**References**

1. Lopez-Garcia, M.A., Geyer, F.C., Lacroix-Triki, M., Marchio, C., & Reis-Filho, J.S. Breast cancer precursors revisited: molecular features and progression pathways. *Histopathology*. 57, 171-192 (2010).
2. Sabeh, F., Shimizu-Hirota, R., & Weiss, S.J. Protease-dependent versus -independent cancer cell invasion programs: three-dimensional amoeboid movement revisited. *J Cell Biol*. 185, 11-19 (2009).
3. Dabrosin, C. Increased extracellular local levels of estradiol in normal breast *in vivo* during the luteal phase of the menstrual cycle. *J Endocrinol*. 187, 103-108 (2005).
4. Alenantalo, T., et al. Tomographic molecular imaging and 3D quantification within adult mouse organs. *Nat Methods*. 4, 31-33 (2007).
5. Sharpe, J., et al. Optical projection tomography as a tool for 3D microscopy and gene expression studies. *Science*. 296, 541-545 (2002).
6. Hidalgo-Carcedo, C., et al. Collective cell migration requires suppression of actomyosin at cell-cell contacts mediated by DDR1 and the cell polarity regulators Par3 and Par6. *Nat Cell Biol*. 13, 49-58, doi:ncb2133 [pii] 10.1038/ncb2133 (2011).
7. Katz, E., et al. A gene on the HER2 amplicon, C35, is an oncogene in breast cancer whose actions are prevented by inhibition of Syk. *Br J Cancer*. 103, 401-410, doi:6605763 [pii] 10.1038/sj.bjc.6605763 (2010).
8. Timpson, P., et al. Spatial Regulation of RhoA Activity during Pancreatic Cancer Cell Invasion Driven by Mutant p53. *Cancer Res*. 71, 747-757, doi:0008-5472.CAN-10-2267 [pii] 10.1158/0008-5472.CAN-10-2267 (2011).