Absence of ST7 Gene Alterations in Human Cancer

Seung Myung Dong and David Sidransky
Department of Otolaryngology-Head and Neck Surgery, Head and Neck Cancer Research Division, Johns Hopkins University School of Medicine, Baltimore, Maryland 21205-2196

ABSTRACT
The ST7 gene was cloned and mapped to chromosome 7q31.1-q31.2, a region suspected of containing a tumor suppressor gene involved in a variety of human cancers. Subsequent investigation described the presence of ST7 mutations in human cell lines derived from breast tumors and primary colon carcinoma. Introduction of the ST7 cDNA into a prostate cancer-derived cell line abrogated in vivo tumorigenicity in nude mice. To clarify the role of the ST7 gene in cancer, we scrutinized primary head and neck squamous cell carcinomas, invasive ductal carcinomas of the breast, and adenosccinomas of the colon. Loss of heterozygosity of D7S522/D7S677 was detected in 24% (4 of 17) of head and neck squamous cell carcinomas, invasive ductal carcinomas of the breast, and adenocarcinomas of the colon. Loss of heterozygosity of D7S522/D7S677 was detected in 24% (4 of 17) of head and neck squamous cell carcinomas, invasive ductal carcinomas of the breast, and adenocarcinomas of the colon, but no somatic mutations were found in any of these specimens. We then searched for mutations in breast cancer cell lines and found a complete wild-type sequence in all, including cell lines previously reported to harbor mutations. We believe that the ST7 gene is not a primary target of inactivation in most human cancers with loss of heterozygosity at 7q31.1-q31.2.

INTRODUCTION
Genetic alterations of the human chromosomal region 7q are common in human cancer (1). LOH of the 7q31-q32 region has been reported in breast, prostate, pancreatic, ovarian, gastric, colon, and head and neck cancer, as well as uterine leiomyomas and malignant myeloid disease (2–13). Furthermore, the introduction of an intact copy of human chromosome 7 into immortalized human fibroblasts cell lines with LOH/allelic imbalance at 7q31-q32 restore programmed senescence to the cells (14). In addition, transfer of human chromosome 7 into immortalized human fibroblasts, tumor cells, and malignant myeloid disease (2–13). Furthermore, the introduction of an intact copy of human chromosome 7 into immortalized human fibroblasts cell lines with LOH/allelic imbalance at 7q31-q32 restore programmed senescence to the cells (14). In addition, transfer of human chromosome 7 into immortalized human fibroblasts, tumor cells, and malignant myeloid disease (2–13). Furthermore, the introduction of an intact copy of human chromosome 7 into immortalized human fibroblasts cell lines with LOH/allelic imbalance at 7q31-q32 restore programmed senescence to the cells (14). In addition, transfer of human chromosome 7 into immortalized human fibroblasts, tumor cells, and malignant myeloid disease (2–13). Furthermore, the introduction of an intact copy of human chromosome 7 into immortalized human fibroblasts cell lines with LOH/allelic imbalance at 7q31-q32 restore programmed senescence to the cells (14). In addition, transfer of human chromosome 7 into immortalized human fibroblasts, tumor cells, and malignant myeloid disease (2–13). Furthermore, the introduction of an intact copy of human chromosome 7 into immortalized human fibroblasts cell lines with LOH/allelic imbalance at 7q31-q32 restore programmed senescence to the cells (14). In addition, transfer of human chromosome 7 into immortalized human fibroblasts, tumor cells, and malignant myeloid disease (2–13). Furthermore, the introduction of an intact copy of human chromosome 7 into immortalized human fibroblasts cell lines with LOH/allelic imbalance at 7q31-q32 restore programmed senescence to the cells (14). In addition, transfer of human chromosome 7 into immortalized human fibroblasts, tumor cells, and malignant myeloid disease (2–13). Furthermore, the introduction of an intact copy of human chromosome 7 into immortalized human fibroblasts cell lines with LOH/allelic imbalance at 7q31-q32 restore programmed senescence to the cells (14). In addition, transfer of human chromosome 7 into immortalized human fibroblasts, tumor cells, and malignant myeloid disease (2–13).

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1 To whom requests for reprints should be addressed, at Department of Otolaryngology-B Head and Neck Surgery, Division of Head and Neck Cancer Research, The Johns Hopkins University School of Medicine, 818 Ross Research Building, 720 Rutland Avenue, Baltimore, MD 21205-2196. E-mail: dsidrans@jhmi.edu.

2 The abbreviations used are: LOH, loss of heterozygosity; TSG, tumor suppressor gene; HNSCC, head and neck squamous cell carcinoma; DCB, ductal carcinoma(s) of the breast.

MATERIALS AND METHODS
Samples and DNA Extraction. A series of 17 primary HNSCCs, 12 invasive DCB, and 24 colon primary carcinomas were obtained for ST7 screening. Seventeen primary HNSCCs were selected that showed LOH of 7q22-q31 region from our previous study (18). Twelve primary breast carcinomas were obtained from the Department of Pathology, University campus BioMedico (Rome, Italy), and 24 primary colon carcinomas were obtained from Johns Hopkins Hospital (Baltimore, MD). We also tested three breast tumor-derived cell lines reported to harbor mutations of ST7 (MDA-MB435s, T-47-D, and MDA-MB231), purchased from American Type Culture Collection. Tumor tissue was selected from an area with greater than 75% malignancy. DNA was purified by phenol-chloroform extraction and ethanol precipitation and dissolved in 50 μl of distilled water, as described previously (22).

Microsatellite Analysis. DNA from tumor and normal control was examined for LOH by PCR-based microsatellite analysis. Markers D7S522 and D7S677 were used to identify alterations 7q31.1. PCR conditions and criteria for LOH and homozygous deletion were described previously (23).

Sequence Analysis. We carried out manual genomic sequencing. Basic primer sets included the intron/exon boundary for sequence analysis of the ST7 gene [GenBank accession no. AC009152 (cDNA), AC106873 (exon 1), AC002542 (exons 2–15), and AC003987 (exon 16); Table 1]. After detection of a PCR product, direct PCR sequencing reactions were performed using the Amplicycle Sequencing Kit (Perkin-Elmer, Branchburg, NJ) and sequenced on a Genomyx electrophoresis apparatus. We carried out both manual and fluorescent DNA sequencing for exons 3, 5, and 12 of ST7 in the three breast cancer cell lines. We further performed thermal cycling, followed by cloning of PCR products, with The Original TA Cloning Kit (Invitrogen, Carlsbad, CA). After purification of clones containing ST7 exons, they were analyzed by the Sequence Analysis Facility of The Johns Hopkins University to independently confirm our results in the cell lines.
RESULTS AND DISCUSSION

We first performed microsatellite analysis on all 53 primary tumors. LOH was found in 24% (4 of 17) of HNSCCs, 17% (2 of 12) of DCB, and 33% (8 of 24) of adenocarcinomas of the colon with markers D7SS522 and D7S677 that flank the ST7 gene. The frequency of LOH of DCB and HNSCCs was somewhat lower than previous reports (17).

In search of ST7 gene mutations, we sequenced all of the 53 primary tumors. None of the tumors displayed any changes in the coding regions or intron/exon boundaries. Any of these primary tumors were previously found to harbor point mutations in other TSGs (18, 24, 25). We then investigated the breast tumor cell lines MDA-MB435s, T-47-D, and MDA-MB231 to confirm previous reports of ST7 gene alterations (17). We did not find any mutations in these cell lines (Fig. 1) by manual sequencing or automated sequencing. We further cloned the PCR products and sequenced 10 clones containing the exons where mutations were previously reported. Again, the wild-type sequence was confirmed in all three cell lines.

The majority of previously reported mutations in the ST7 gene were identified as single base pair deletions or insertions predicted to form truncated proteins. Little is still known about ST7 function, but true truncation mutations would be expected to abrogate suppressor function. We have found that automated sequence analysis can both underestimate mutation frequency and also results in false positives, especially if not confirmed by sequence analysis in both directions (26). At this writing, two other recent reports support the absence of ST7 alterations in 128 human tumors (27, 28).

The complete absence of mutations in our series of primary tumors and absence of putative mutations in breast cell lines argue against a prominent role of ST7 in these tumor types. However, our work does not exclude a tumor suppressor role for ST7 based on the reported functional studies. Other mechanisms of inactivation such as promoter hypermethylation, homozygous deletion, or genomic rearrangements were not explored in our study but were not previously described as common mechanisms of ST7 inactivation. It is likely that other critical TSGs remain to be identified in the commonly deleted 7q31 region.

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