

**Data S1. Supplementary experimental methods: Immunohistochemistry and H&E staining protocols for patient pathological specimens.**

*Immunohistochemistry.* The tissue used in this experiment was fixed with 10% neutral formalin solution, with a concentration of 10% (volume fraction), the fixation temperature was room temperature (~25°C) and the fixation duration was 24 h. The tissue used in this experiment was paraffin-embedded, and the section thickness was 4 μm. For paraffin-embedded samples, the heating temperature for antigen retrieval was 95-98°C. The washing reagent used was PBS. After antigen retrieval, the sections were rehydrated by immersion in a descending alcohol series, starting from 100% alcohol, followed by 95% alcohol, 80% alcohol and 70% alcohol, and finally rinsed with distilled water. A quenching step was performed to block endogenous peroxidase activity. The reagent used was 3% hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) in methanol, with a concentration of 3%. Quenching was carried out at room temperature for 10 min. BSA (5%; Sigma-Aldrich; Merck KGaA) was used as the blocking reagent. Blocking was performed at room temperature (~25°C) for 30 min. For intracellular antigens or membrane proteins with an internal epitope, the permeabilization reagent used was 0.1% Triton X-100 in PBS, and the concentration of the permeabilization reagent was 0.1%. The permeabilization was carried out at room temperature for 10 min. The following primary antibodies were used:

Pan-cytokeratin [dilution, 1:200; cat. no. ab7753; Abcam; 4°C; overnight (~16 h)], vimentin (dilution, 1:150; cat. no. ab92547; Abcam; 37°C; 1 h), Ki-67 (dilution, 1:100; cat. no. ab16667; Abcam; 37°C; 45 min), S-100 [dilution, 1:300; cat. no. ab52642; Abcam; 4°C; overnight (~16 h)], Melan-A (dilution, 1:250; cat. no. ab238349; Abcam; 37°C; 1.5 h), HMB45 (dilution, 1:200; cat. no. ab125265; Abcam; 37°C; 1 h), P53 (dilution, 1:150; cat. no. ab26; Abcam; 37°C; 1 h) and SMA (dilution, 1:200; cat. no. ab5694; Abcam; 37°C; 1 h). The secondary antibody used was goat anti-rabbit IgG-HRP [dilution, 1:500; cat. no. ab6721; Abcam; room temperature (~25°C); 30 min]. As HRP was used, for chromogen detection, the detection reagent used was 3,3'-diaminobenzidine tetrahydrochloride. The Olympus BX43 light microscope (Olympus Corporation) was used.

*H&E staining.* The fixative used in this experiment was a 10% neutral formalin solution. The concentration was 10% (volume fraction), the fixation temperature was room temperature (~25°C) and the fixation duration was 24 h. The thickness of the tissue sections was 4 μm. H&E staining was mainly used for histopathological staining in the present study. The sections were placed in hematoxylin staining solution and stained at room temperature (~25°C) for 5-8 min. After hematoxylin staining, the sections were washed with PBS, and then placed in eosin staining solution and stained at room temperature (~25°C) for 3-5 min. The Olympus BX43 light microscope (Olympus Corporation) was used.