Research of dental disease generates data with two levels of hierarchy: that of a tooth overall and that of the different surfaces of the tooth. The outcomes often exhibit spatial referencing among neighboring teeth and surfaces, i.e., the disease status of a tooth or surface might be influenced by the status of a group of neighboring teeth/surfaces. Assessments of dental caries (tooth decay) at the tooth level yield binary outcomes indicating the presence/absence of teeth, and trinary outcomes at the surface level indicating healthy, decayed, or filled surfaces. The presence of these mixed discrete responses complicates the data analysis under a unified framework. To mitigate complications, we developed a Bayesian hierarchical model under suitable (spatial) Markov random field assumptions that accommodates the natural hierarchy within the mixed responses. In the first stage, we use an autologistic model to estimate the spatial dependence between existing and missing teeth. In the second stage, conditioned on a tooth being non-missing, we use a Potts model to analyze the spatial referencing for the tooth. To tackle the computational difficulty in the Bayesian estimation scheme that is caused by the doubly-intractable normalizing constant, we use a double Metropolis-Hastings sampler. We illustrate the proposed methodology using dental caries data from a clinical study.