Vibrational structures of the nearly degenerate $\tilde{X}$ and $\tilde{A}$ states of all four positional isomers of the methylcyclohexoxy (MCHO) radicals were studied by jet-cooled dispersed fluorescence (DF) spectroscopy, which unravels the effect of methyl substitution at different positions on the six-membered ring. Experimentally observed vibronic transitions in the DF spectra were assigned based on vibrational frequencies from quantum chemical calculations and predicted Franck-Condon factors that take into account the Duschinsky rotation. DF spectra of 2-, 3-, and 4-MCHO radicals are dominated by CO-stretch progressions or the progressions of CO-stretch modes in combination with the excited vibrational modes. DF spectra of two lowest-energy conformers of the tertiary 1-MCHO radical, chair-axial and chair equatorial, are significantly different from each other and from those of the other three positional isomers. Strong C-CH$_3$ stretch progressions as well as progressions of its combination bands with the CO stretch modes or the excited modes were observed. Such differences between the isomers and the conformers can be explained by variation of geometry and symmetry of the electronic states of cyclohexoxy upon methyl substitution at different positions. DF study of MCHO provides direct measurement of the energy separation between the $\tilde{A}$ and $\tilde{X}$ states that are subject to the pseudo-Jahn-Teller effect.