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A mathematical model of fluid secretion and calcium dynamics in the salivary gland.

It is estimated that 20% of adults in the US will suffer xerostomia, a condition whereby a lack of saliva production causes issues with dental cavities, oral pain and infection. We construct a mathematical model of the parotid acinar cell with the aim of investigating how the distribution of K+ channels and Ca2+ wave speed affects saliva production. Secretion of fluid is initiated by Ca2+ signals acting the Ca2+ dependent K+ and Cl- channels. The opening of these channels facilitates the movement of Cl- ions into the lumen which water follows by osmosis. We use recent results into both the release of Ca2+ from internal stores via the inositol (1,4,5)-trisphosphate receptor (IP3R) and IP3 dynamics to create a physiologically realistic Ca2+ model which is able to recreate important experimentally observed behaviours seen in parotid acinar cells. We show that maximum saliva production occurs when a small amount of K+ conductance is located at the apical membrane, with the majority in the basal membrane. We simulate Ca2+ waves as periodic functions of time at both the apical and basal membranes. This enables us in investigate how the phase difference of apical and basal Ca2+ signals affects fluid flow. We find maximum fluid flow when Ca2+ signals are in-sync, predicting increased cell efficiency with faster Ca2+ waves.