Passive and Iontophoretic Transport of Fluoride in Bovine Enamel In Vitro
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Purpose
Fluoride ion from dentifrice can replace the hydroxyl groups in hydroxyapatite and convert the hydroxyapatite into fluorapatite, which is more resistant to acids and helps prevent dental cavities. However, enamel has low permeability to fluoride ion. In this study, the transport properties of ions in enamel were investigated and the possibility of iontophoretically enhanced transport of fluoride to enhance its delivery into the enamel was explored.

Methods
Side-by-side diffusion cells were used to determine the flux and permeability coefficients of fluoride through bovine enamel under passive and iontophoretic conditions. Electrical conductances of bovine enamel in different concentrations of NaCl, KCl, MgSO4 and the phosphate buffered saline (PBS) at different pH were measured and used to analyze the barrier properties of the enamel.

Results
The effective diffusion coefficient of fluoride in bovine enamel was estimated to be 9.5 x 10^-9 cm^2/s. The fluxes of fluoride across enamel increased 27 to 218 fold under 0.1 mA constant direct current iontophoresis compared with those under passive diffusion. These experimental flux enhancement factors are consistent with the values predicted by the Nernst-Planck equation. Moreover, iontophoresis decreased the lag time of fluoride ion transport across the enamel specimen from 6.6 hours to 1.4 hours. In the enamel conductance study, the conductance of enamel in pH 7.4 PBS was essentially the same over 72 days, suggesting that the enamel specimens are very stable over time. The conductance of enamel was not significantly affected by pH (from pH 5.0 to 9.0). Enamel conductance was proportional to solution conductance in 0.01 M, 0.04 M and 0.15 M NaCl, KCl, or MgSO4 and the conductances of enamel in KCl and NaCl were higher than those of MgSO4.

Conclusion
The amount of fluoride delivered through enamel can be significantly enhanced by iontophoresis without altering the barrier properties of the enamel. There is no significant effect due to electroosmosis; the enamel specimens are not highly charged. Electrophoresis is the dominant flux enhancing mechanism of iontophoretic transport of fluoride ion through enamel.