Silver Diamine Fluoride Differentially Affects Dentin and Hypomineralized Enamel Permeabilities

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Introduction

- Permeability (the ability of a material to transmit fluids) of enamel and dentin relates to the 1) progression of caries, 2) hypersensitivity, and 3) outcome of treatment including the use of silver diamine fluoride (SDF).[1]
- In patients with molar-incisor hypomineralization, the severity of hypersensitivity varies but is frequently associated with the severity of hypomineralization (H).[2]
- **Purpose: To investigate the effect of SDF on the physiochemical properties of hypomineralized enamel and carious dentin.**

Method

Enamel and dentin from extracted carious primary teeth with(N=3;41 regions) and without(N=3;35 regions) SDF treatment *in-vivo*, and hypomineralized enamel from permanent molars with(N=3;41 regions) and without(N=7;43 regions) SDF treatment *in-vitro*

Specimens were scanned using high-resolution (65μm) X-ray micro computed tomography (microCT)

Spatial elemental maps of Zn^{2+} and Ca^{2+} were generated using X-ray fluorescence microprobe.

Physicochemical properties were computed and analyzed using Porous Microstructure Analysis, BoneJ, and RStudio software.

Results

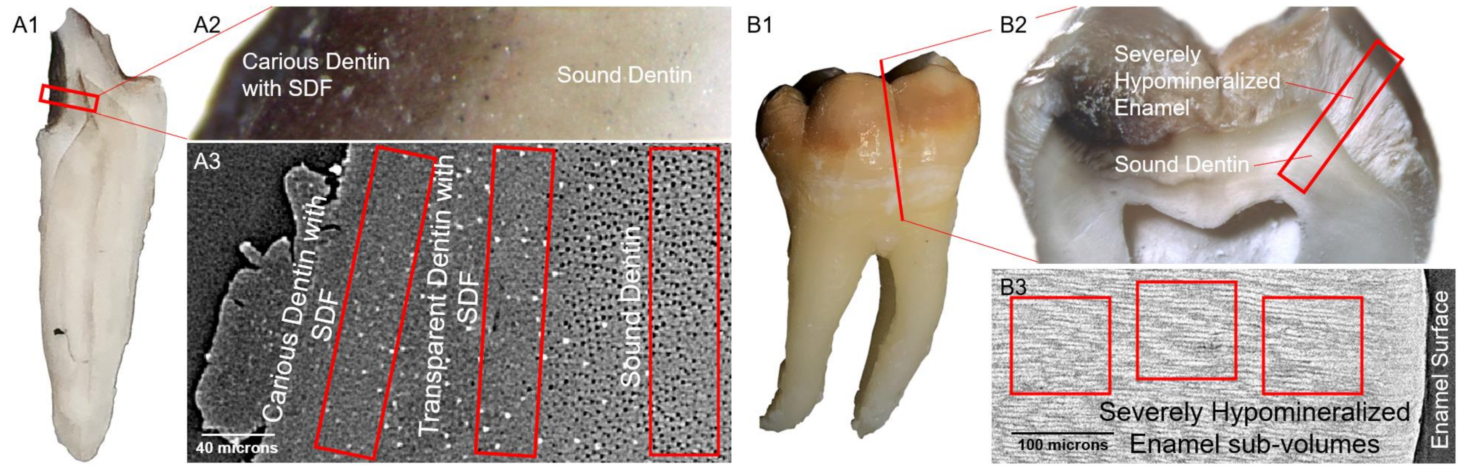


Figure 1: Sample processing and microCT. A1,B1: Photos of a carious primary tooth treated with SDF *in-vivo*, and permanent molar with severe hypomineralization without SDF. A2,B2: Light microscope image of specimen showing changes in the color and texture of tissues. A3,B3: **Tomographs from microCT revealing three dentin zones: carious, transparent, and sound dentin** of varying mineral density, diameter, tubule occlusions, and silver particles. **Hypomineralized enamel showed widened enamel sheaths between the rods.**

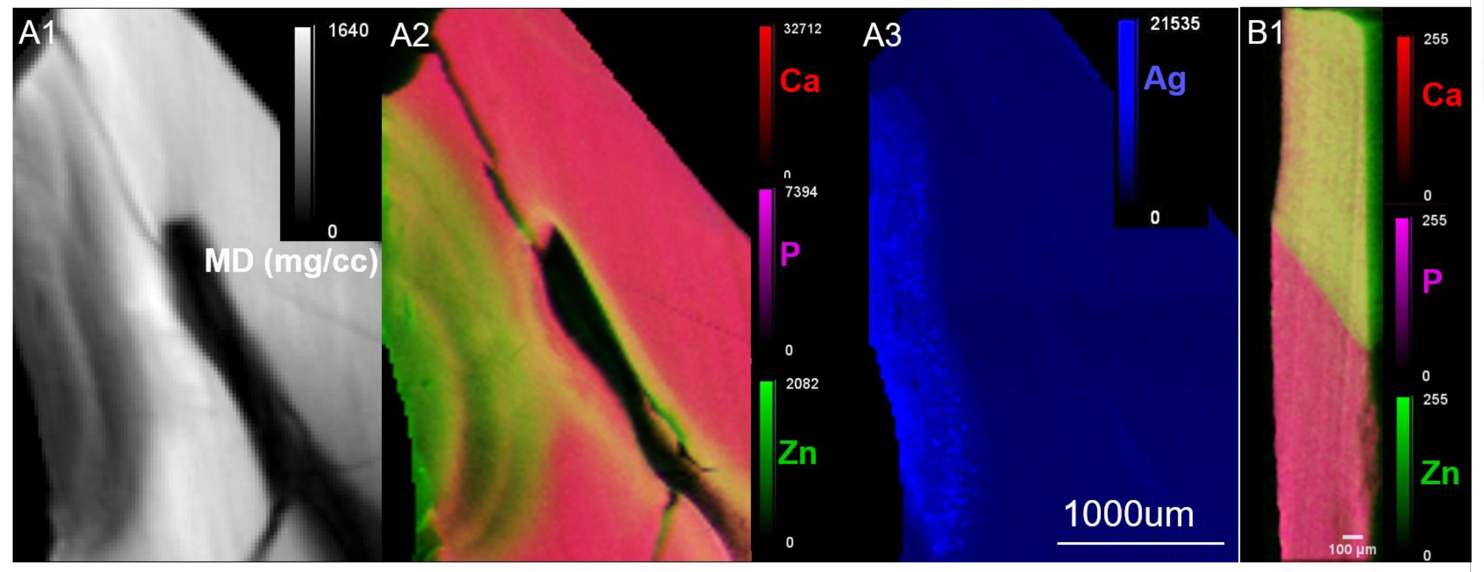


Figure 2: Mineral density (MD) and elemental composition maps. Heightened Zn level is found in pathologic enamel and dentin. A1: Calibrated MD (white) map from microCT in a carious primary tooth treated with SDF. A2-3: Elemental maps of Ca (red), P (pink), and Zn (green) in overlay, and Ag (blue) of the same specimen. B1: Elemental map of Ca (red), P (pink), and Zn (green) of a specimen with severe enamel hypomineralization.

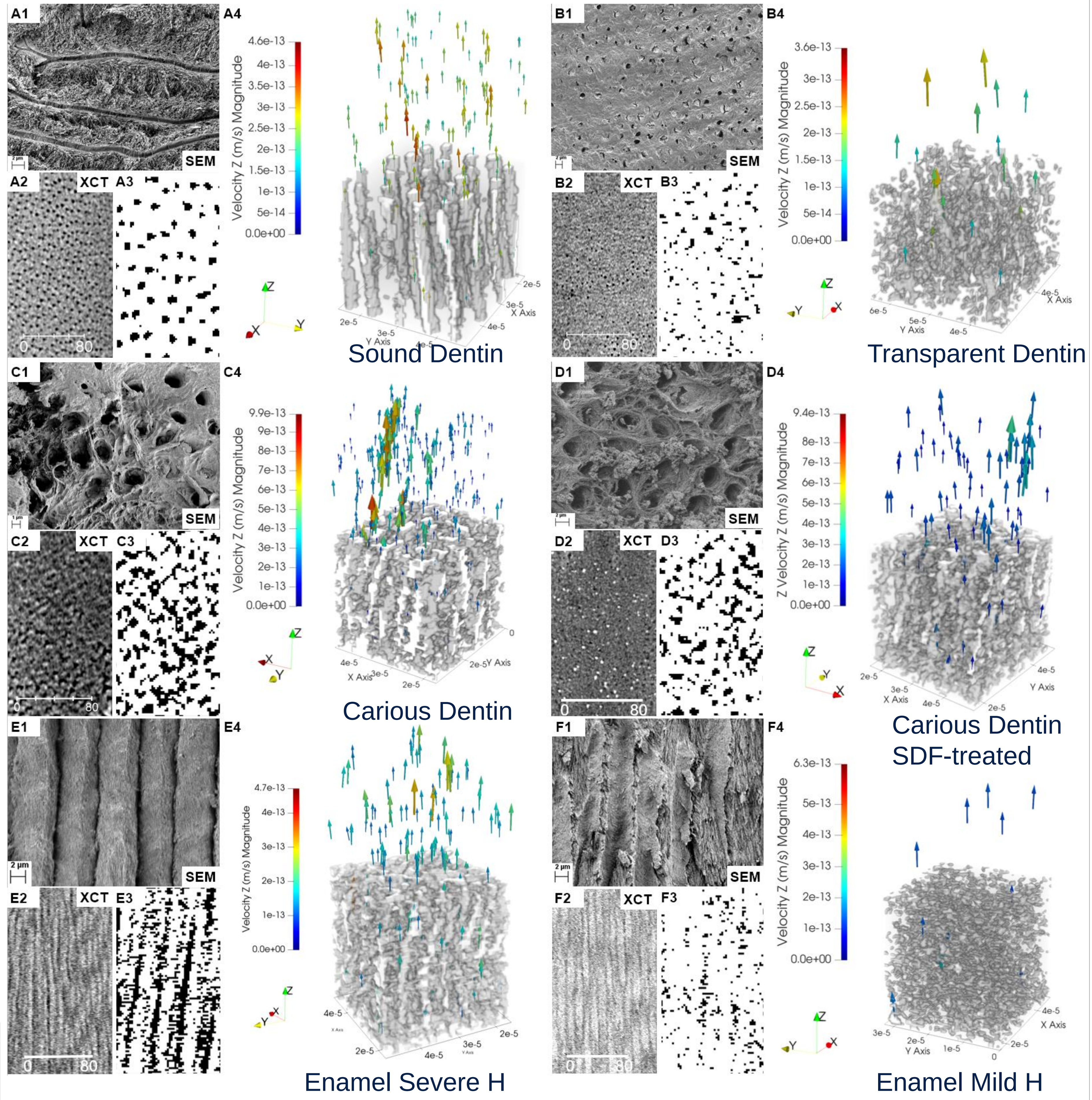


Figure 3: Micro-architecture and flow simulation. Pathologic changes in micro-architecture of dentin and enamel manifest in altered fluid flow. A1-C1: Scanning electron microscope (SEM) images showing the dynamic changes in the dentin tubules as a result of sclerosis, and carious progression. A2-C2: microCT image slices showing dentinal tubules, tubule occlusions, and tubule destructions, respectively. A4-C4: Fluid flow simulation through representative subvolumes of sound dentin, transparent dentin, and carious dentin, respectively. Vector arrows indicate magnitude (m/s) and location of fluid flow in Z-direction (along dentin tubules). White structures denote spaces. D1-D4: SEM, microCT, and flow simulation in SDF-treated carious dentin. **SDF-treated carious dentin showed increased tubule occlusion and reduced fluid flow compared to carious dentin without SDF.** E1-4,F1-4: SEM, microCT, and flow simulation in enamel with severe and mild hypomineralization, respectively. **Severely hypomineralized enamel exhibited gapping between enamel rods forming spaces for fluid flow.** Mild hypomineralized enamel displayed reduced spacing between enamel rods, leading to minimal permeability.

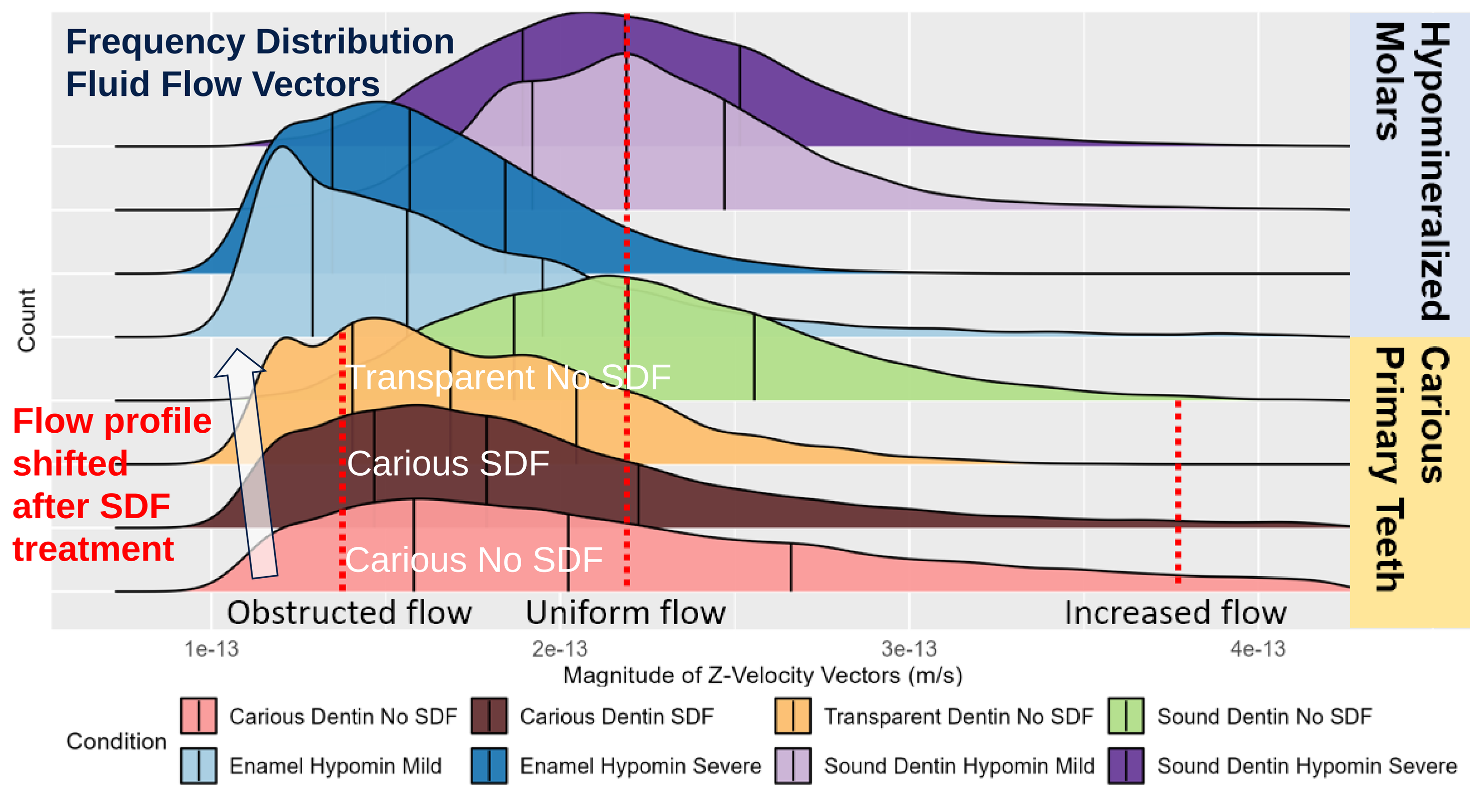


Figure 4: Fluid flow profiles in health and disease. Carious dentin, transparent dentin, and hypomineralized enamel (mild or severe) showed skewed, non-uniform flow. Heavy right-sided tail in carious dentin drives fluid flow. **SDF-treated carious dentin demonstrated a flow profile between those of carious untreated and transparent dentin.**

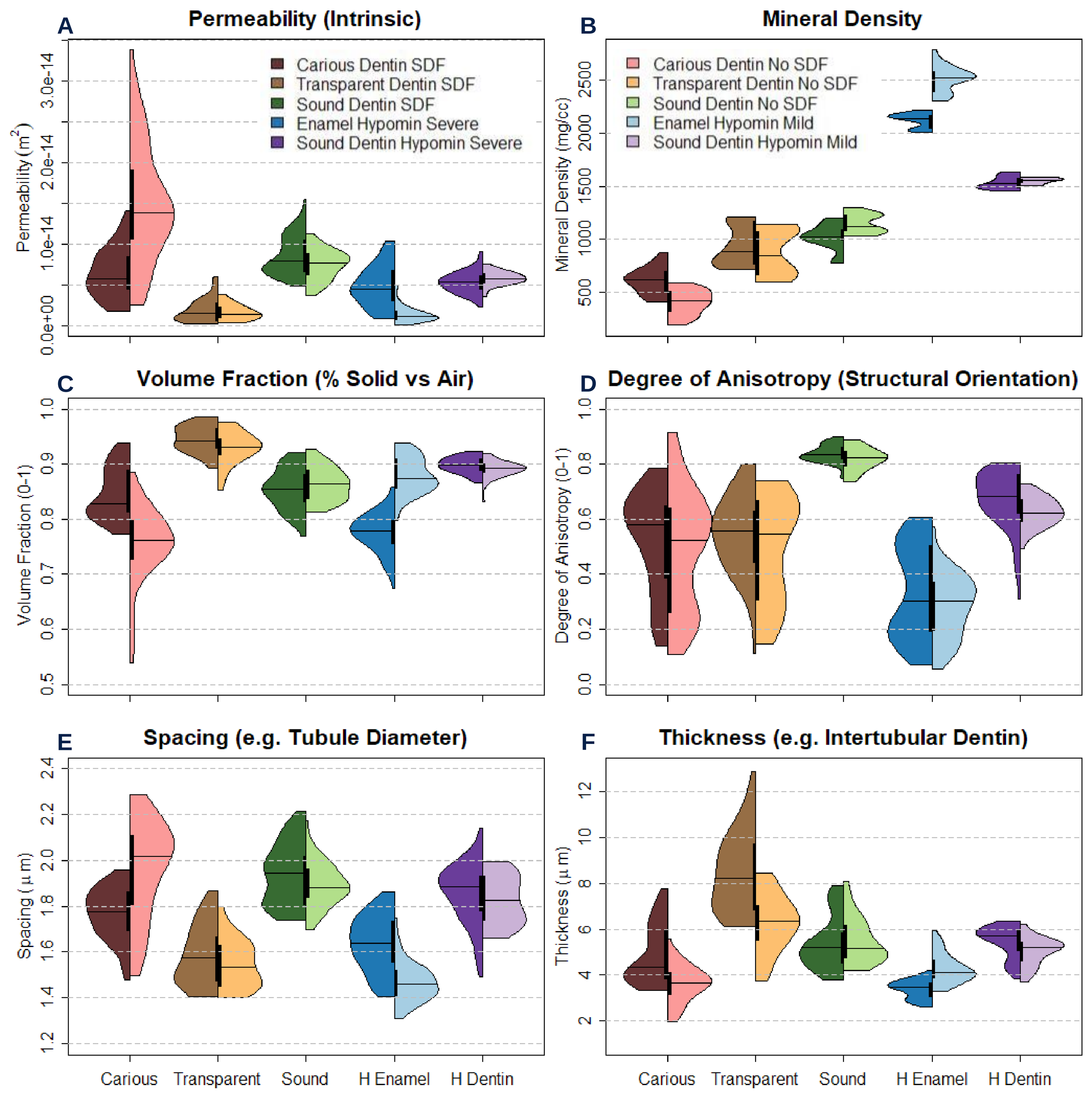
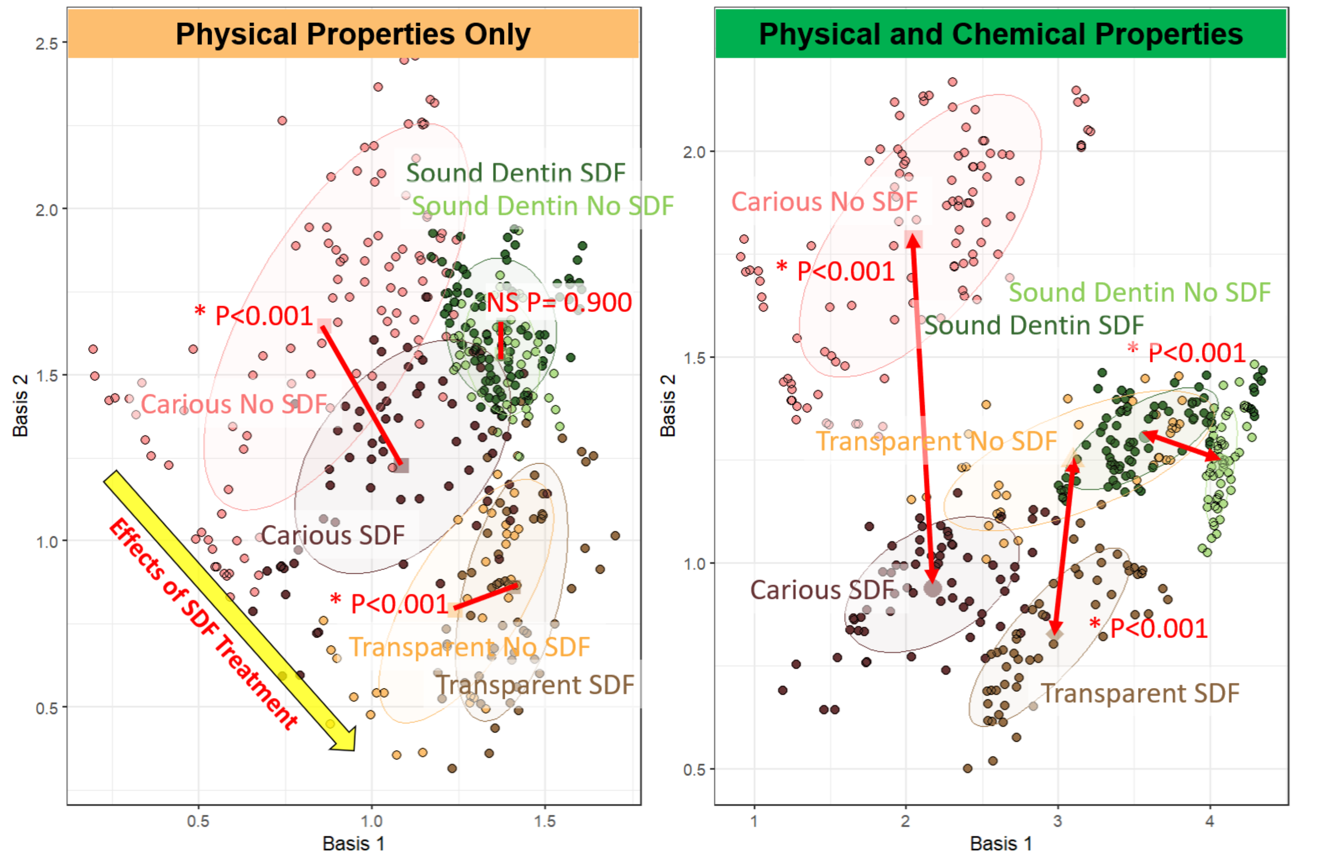


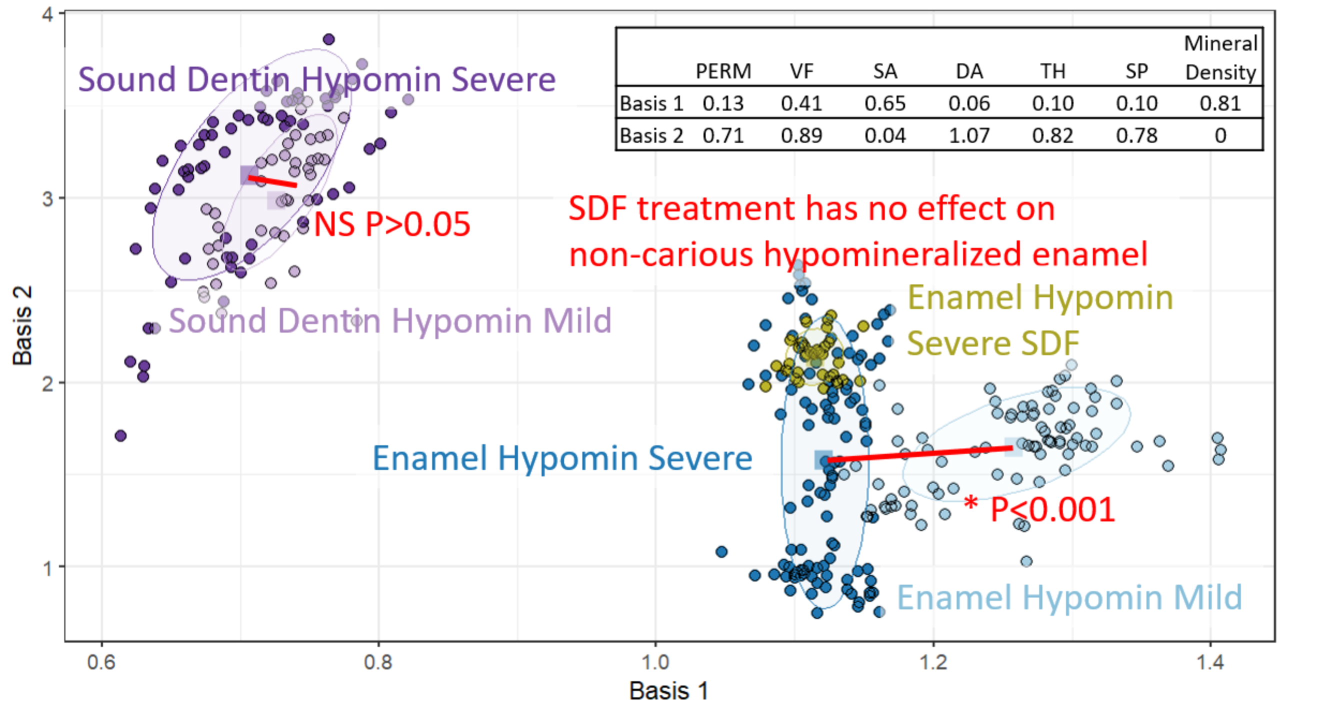
Figure 5: Permeability and associated physical and chemical properties.
Permeability of SDF-treated carious dentin (P<.0001), but not transparent dentin (P=0.9293), was significantly lower than those untreated. Permeability of severely hypomineralized enamel was comparable to sound dentin (P=0.2043), and was significantly higher than mildly hypomineralized enamel (P<.0001).



	Permeability (PERM)	Volume Fraction (VF)	Specific Area (SA)	Degree of Anisotropy (DA)	Thickness (TH)	Spacing (SP)
Basis 1	0	0.86	0.02	0.59	0.45	0.13
Basis 2	0.61	0.25	0.71	0.59	0	1

	PERM	VF	SA	DA	TH	SP	Mineral Density	Ca Level	P Level	Zn Level
Basis 1	0.09	1.09	0.11	0.99	0.57	0.46	1.05	0.63	0.59	0.09
Basis 2	0.40	0.29	0.50	0.27	0.03	0.53	0	0.05	0.17	0.79

Figure 6: Principal Component Analysis - Carious Primary Teeth



	PERM	VF	SA	DA	TH	SP	Mineral Density
Basis 1	0.13	0.41	0.65	0.06	0.10	0.10	0.81
Basis 2	0.71	0.89	0.04	1.07	0.82	0.78	0

Figure 7: Principal Component Analysis - Molars with H Enamel

Conclusions

1. **Progression of caries is spatially and chemically dynamic**
2. **The physicochemical properties of SDF-treated carious dentin are likened to transparent dentin**
3. **Zn^{2+} localization can alter dentin permeability**
4. **Permeability of severely hypomineralized enamel is comparable to sound dentin**
5. **Permeability of non-carious hypomineralized enamel is unaffected by SDF treatment**

Reference

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