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The nanostructure of healthy and caries-affected human teeth

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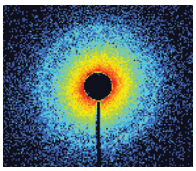
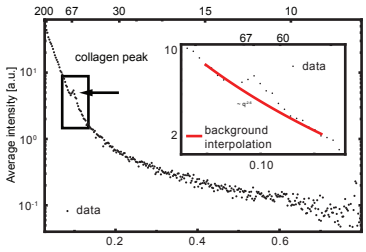
INTRODUCTION



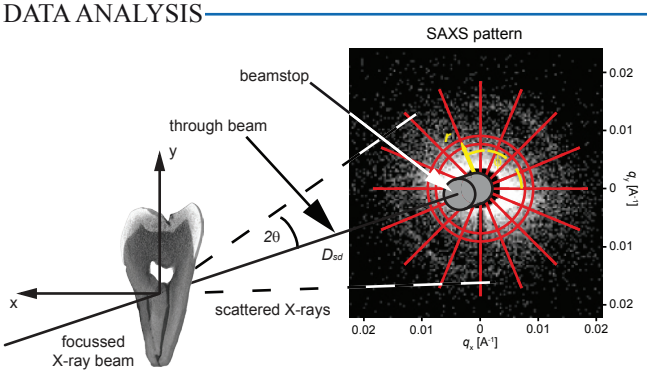
Human teeth are subject to high mechanical and chemical load during their lifetime. Even though only limited repair capacity, restricted to dentin, is present, the composite structure of human teeth guarantees function for decades. Caries is known to dissolve the ceramic components of teeth. The treatment of caries is based on the replacement of the affected regions by restoration materials, and is often accompanied by the amputation of healthy tissue. Most common restoration materials do not mimic the native morphology of the tooth, and posses limited lifespan. Therefore, the development of methods to regenerate carious lesions that recover and retain tooth structure is highly desired. It has been hypothesized that the collagen network is partially retained inside carious lesion [1] and can provide nucleation sites for tooth re-mineralization [2, 3].

COLLAGEN SIGNAL

The organic ingredients of dentin contain mainly collagen-I fibrils. The building blocks of collagen arrange themselves along the collagen fibril with a main periodicity of 67 nm and give raise to distinct peaks in the scattering signal. The base intensity below the peak can be approximated with a power-law with an exponent of -2.6. The intensity above the fitted curve is solely associated with the scattering signal from the collagen.

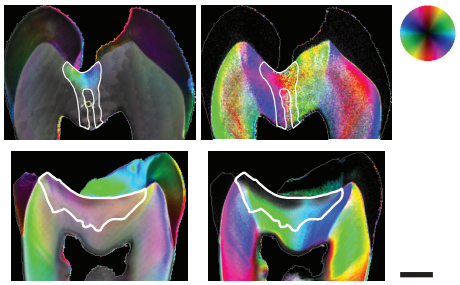


DATA ANALYSIS



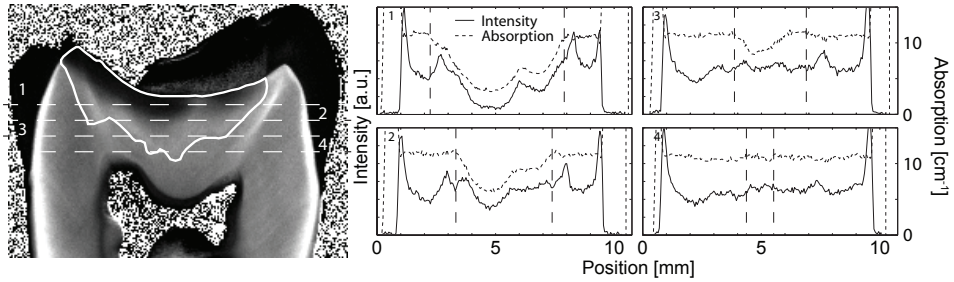
To process the high amount of information generated, automated analysis routines are needed. The first step in SAXS data analysis consists in a radial integration of the scattering patterns over sixteen radial segments in a specific q-range interval . The intensity in each circular segment is then plotted as function of its angular position ϕ. If the scattering pattern presents a moderate asymmetric intensity distribution, the plot is well approximated by a cosine curve. The mean scattered intensity, I_{sym} relates to the abbundance of scattering centers in the selected q-range, while the amplitude of the cosine I_{asym} relates to their orientation. The phase ϕ yields the mean orientation of the scattering signal.

COLLAGEN ORIENTATION



Above, the orientation of the scattering signal is shown (according to the colorwheel). The lesion is visible in the total signal (left) while it can be only partially identified in the collagen-related signal (right), indicating that collagen orientation is preserved. The scalebar corresponds to 2 mm.

COLLAGEN DENSITY



Above, the intensity of the collagen-related signal across one secimen is shown. White indicates strong intensity while black indicates no detectable collagen signal. The solid white line indicates the carious region in dentin, as identified from X-ray absorption measurements. The line plots according to the dashed lines in the image quantitatively show the changes in collagen scattering signal intensity (solid line) and specimen absorption (dotted line). If the X-ray absorption within the carious lesion is within 70% of that of healthy tissue, the collagen related signal does not differ from that of the healthy tooth.

CONCLUSION AND ACKNOWLEDGEMENT

Caries bacteria destroy the tooth and degenerate the dentin, but at least during the initial stages or only mild demineralization, a significant part of the collagen network is conserved in abundance and orientation. We hypothesize that dentin with mainly healthy collagen may be suitable for remineralization.

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[1] Deyhle, H., Bunk, O. and Müller, B., *Nanomed.* 2011. 7 694-701.
[2] Bertassoni, L.E., Habelitz, S., Pugach, M., Soares, P.C., Marshall, S.J., and Marshall, G.W., *Scanning* 2010. 32 312-319.
[3] Kurosaki, N. and Fusayama, T., *J Dent Res* 1973. 53 309-317.