Universität Rostock

Traditio et Innovatio

IT-based non X-ray human teeth investigation in dental practice

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Introduction

The common diagnostics in dental practice use X-rays for imaging processes. Over the decades X-ray technologies were developed from small sensors to large dimension imaging systems. Although the techniques were enhanced, patients were compromised over their life by X-ray exposure. Moreover, several diagnostic are still difficult. Especially prosthetic constructions can not be imaged by X-rays and margins as well as secondary caries below dental restorations are difficult to detect.

Aim

Ultrasonic detection and visualization are common methods in medicine, except in dental practice. Additionally to imaging, ultrasonic is used for material quality management in engineering sciences. Both fields should be combined in an IT-based non X-ray approach for dental practice. An ultrasonic array is constructed to generate data for imaging and mechanical as well as acoustic characterization. Moreover, a material database is used to match the measured values for an in vivo material evaluation. Finally, diagnostic advices are given to the dentist by an expert system based on fuzzy computing.

Ultrasonic visualization

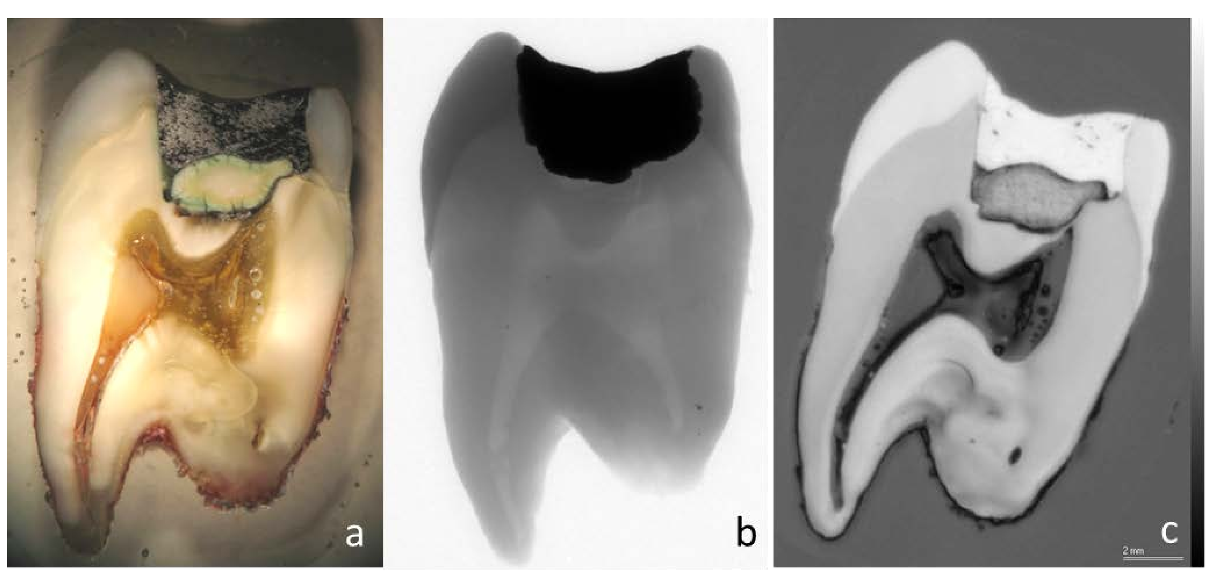


Fig. 1 a-c: Visualization of a polished tooth section by a) macrophotography, b) µCT and c) ultrasonic microscopy

A conventional X-ray image (Fig. 1 b) consist of gray shades resulting from the radiopacity of the different materials. Comparing a macroscopic image (Fig. 1 a) with a X-ray image , it was obvious that different restoration materials could not be divided.

Ultrasonic allows the imaging of the different materials similar to the macroscopic picture (Fig. 1 c). The imaging process is based on different reflection coefficients caused by the material densities. Moreover, air pockets, secondary caries and material fractures can be detected easily. Even metal based prosthetics as well as the interior abutment can be imaged without disturbing reflections which are known from X-ray techniques.

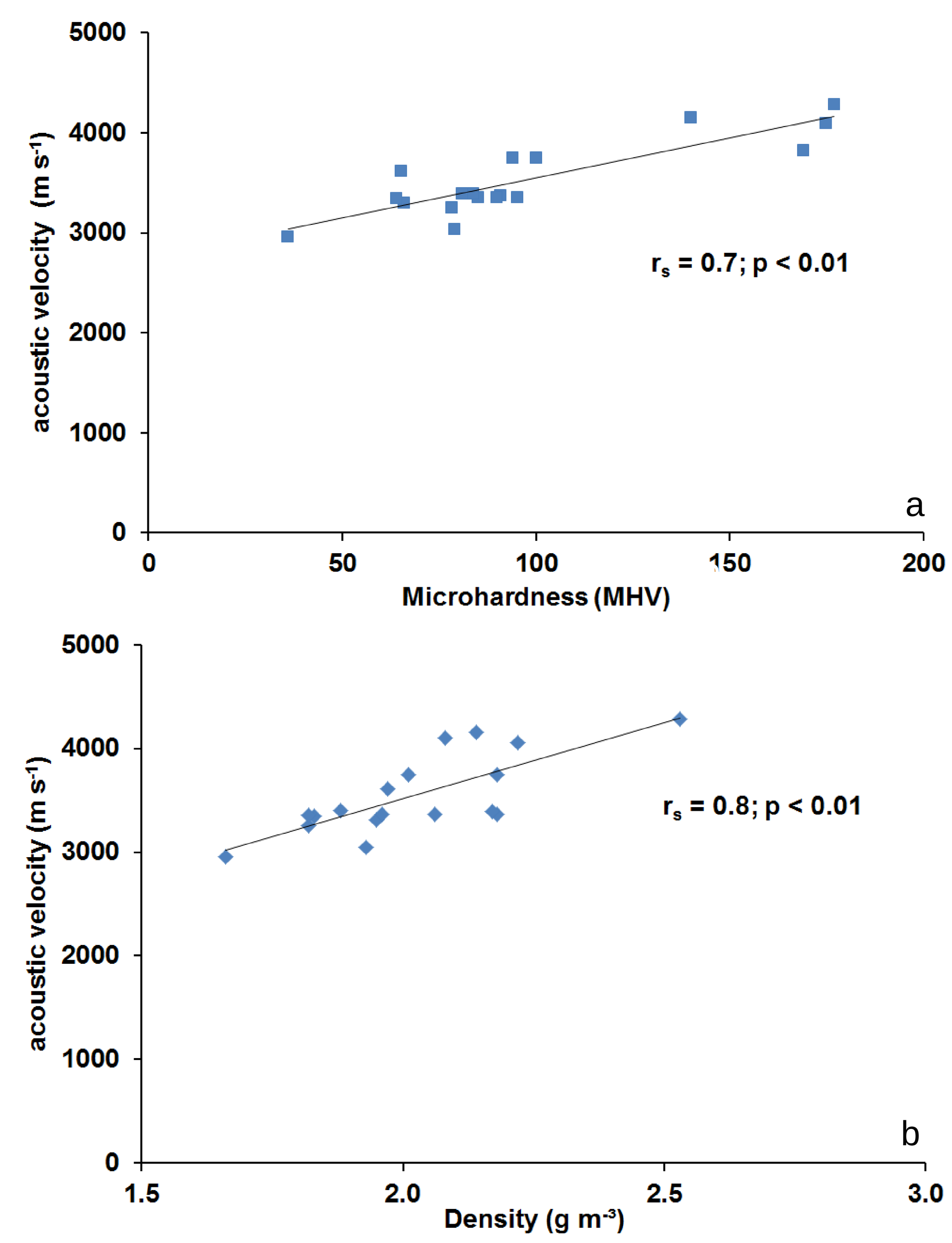
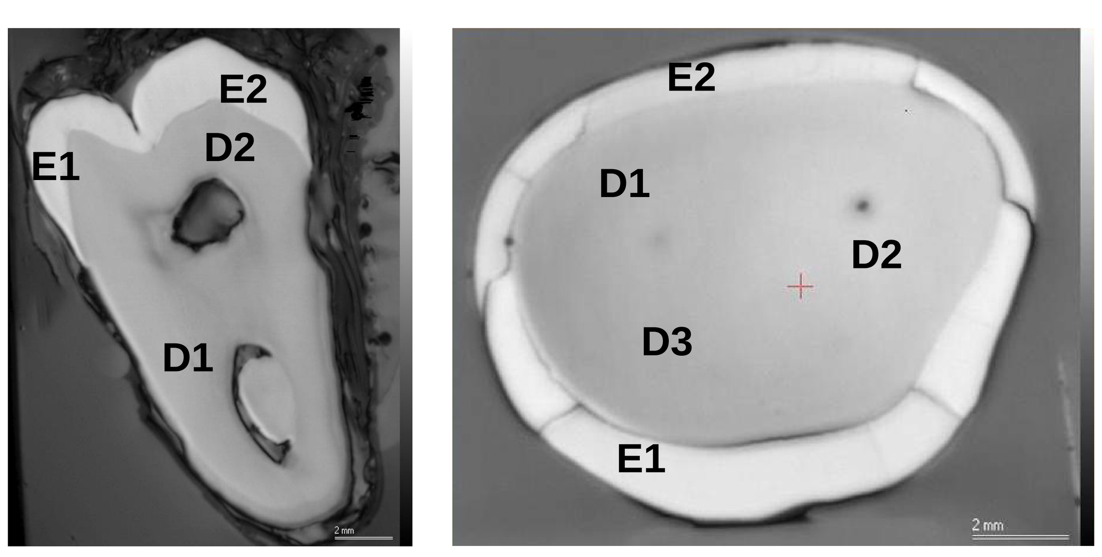


Fig. 3 a-b: Correlation of acoustic velocity with mechanical and physical properties of dental composites

Imaging and material database



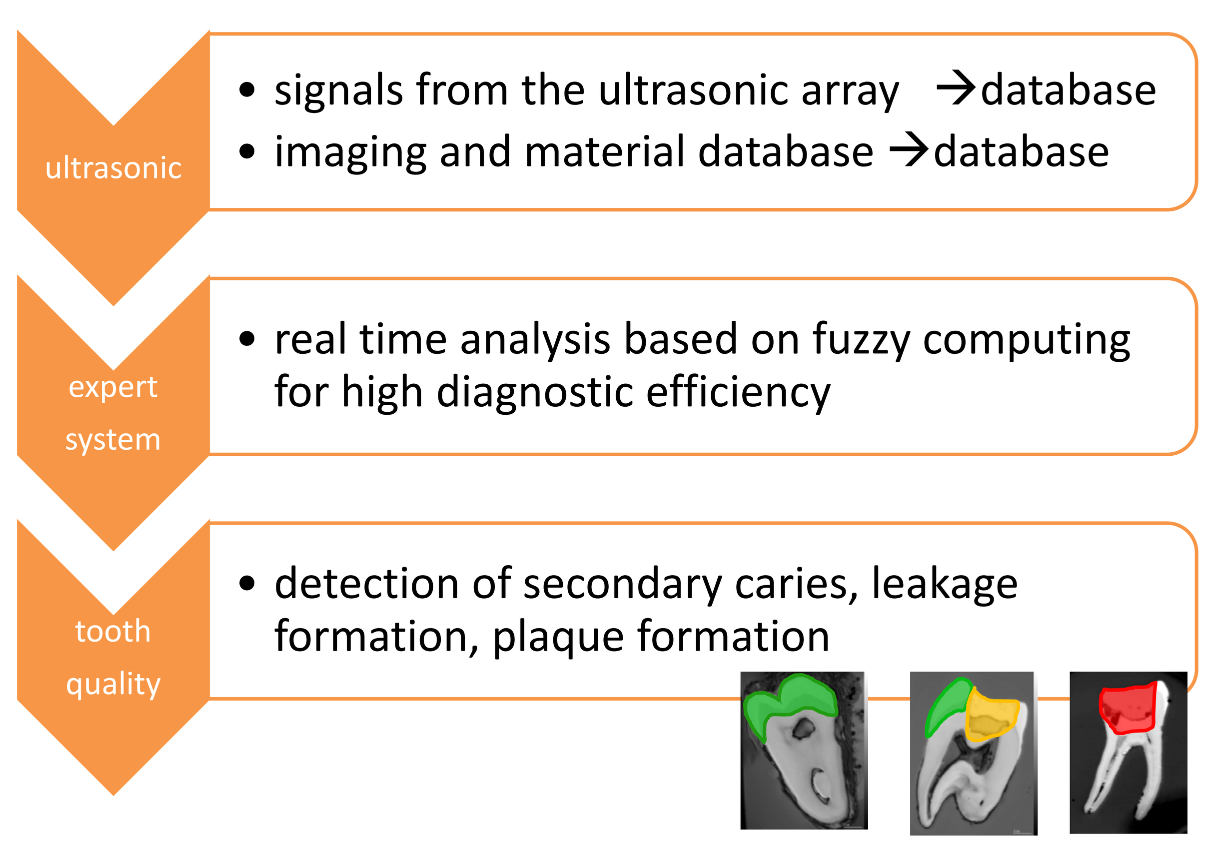
E = 5642 - 7665 m s^{-1}
D = 3985 - 4380 m s^{-1}

Fig. 2 a-b: Spatial and directional acoustic pattern of the tooth materials enamel (E) and dentin (D)

Ultrasonic scanning of tooth material showed spatial and directional distribution patterns of different acoustic velocities as well as material densities (Fig. 2 a-b). This was also tested with different composite based restoration materials. Significantly correlations were found between acoustic parameters and mechanical as well physical parameters (Fig. 3 a-b).

Hence, ultrasonic images and parameters can be converted to material quality statements.

Diagnostics



The combination of ultrasonic imaging with the corresponding material properties from a database allows the evaluation of tooth quality. This diagnostic step is managed by a fuzzy based expert system.

Conclusion

Our system manages several disadvantages known from X-ray techniques. Hence, imaging can be often repeated since the patients risk is eliminated. Moreover, diagnostics are improved by additional material quality data combined with diagnostic advices which supports the dentist's appraisal.

This project is granted by the European Regional Development Fond (EFRE).

Europäische Fonds EFRE, ESF und ELER in Mecklenburg-Vorpommern

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