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INTISARI

PENCITRAAN FOTOAKUSTIK UNTUK ANALISIS VARIASI KEDALAMAN LESI PADA MODEL KARIES GIGI

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Telah dilakukan penelitian untuk mengembangkan dan menganalisis kemampuan sistem *Photoacoustic Imaging* (PAI) berbasis laser dioda 808 nm dalam membedakan variasi kedalaman lesi pada model karies gigi buatan secara kuantitatif. Penelitian dilakukan melalui tahapan kalibrasi sistem, optimasi parameter operasi, optimasi konsentrasi pigmen *Brown Iron Oxide* (Fe_2O_3) sebagai penyerap optik, akuisisi citra fotoakustik, serta analisis citra menggunakan perangkat lunak ImageJ. Parameter operasi optimum diperoleh pada frekuensi modulasi 16 kHz dan *duty cycle* 10% berdasarkan evaluasi *Contrast-to-Noise Ratio* (CNR) dari citra fotoakustik pada variasi *duty cycle*. Sementara itu, konsentrasi optimum *Brown Iron Oxide* (Fe_2O_3) yang digunakan pada model lesi adalah 0,750 mg/mL. Kemampuan sistem dalam membedakan variasi kedalaman lesi dievaluasi menggunakan parameter rerata intensitas citra (*Mean Gray Value*), *plot profile*, serta analisis regresi linear terhadap logaritma natural rerata intensitas citra. Hasil penelitian menunjukkan bahwa rerata intensitas citra menurun secara konsisten dari (254 ± 1) a.u. pada kedalaman 0 mm menjadi (32 ± 3) a.u. pada kedalaman 4 mm, disertai perubahan distribusi intensitas yang tampak pada *plot profile*. Analisis regresi linear menghasilkan hubungan antara logaritma natural rerata intensitas citra dan kedalaman lesi dengan persamaan $ln\,(I_c) = -\,0{,}512d\,+\,5{,}453$ dan koefisien determinasi $R^2 = 0{,}990$. Hubungan tersebut menunjukkan bahwa penurunan rerata intensitas citra mengikuti kecenderungan peluruhan eksponensial yang dijelaskan oleh Hukum Beer–Lambert. Hasil penelitian menunjukkan bahwa sistem PAI yang dikembangkan mampu membedakan variasi kedalaman lesi pada model karies gigi buatan melalui analisis karakteristik citra secara kuantitatif, sehingga berpotensi menjadi alternatif metode pencitraan optik berbiaya rendah untuk evaluasi lesi karies.

Kata Kunci: *Photoacoustic imaging*, karies gigi, kedalaman lesi, laser diode 808 nm, model karies buatan, pigmen Fe_2O_3

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ABSTRACT

PHOTOACOUSTIC IMAGING FOR QUANTITATIVE ASSESSMENT OF LESION DEPTH IN AN ARTIFICIAL DENTAL CARIES MODEL

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This study was conducted to develop and evaluate the capability of an 808 nm diode laser-based Photoacoustic Imaging (PAI) system for quantitatively distinguishing variations in lesion depth using an artificial dental caries model. The study consisted of system calibration, optimization of operating parameters, optimization of Brown Iron Oxide (Fe_2O_3) pigment concentration as the optical absorber, photoacoustic image acquisition, and image analysis using ImageJ software. The optimum operating parameters were obtained at a modulation frequency of 16 kHz and a 10% duty cycle, determined based on the evaluation of the Contrast-to-Noise Ratio (CNR) of the photoacoustic images acquired under different duty cycle conditions. Meanwhile, the optimum concentration of Brown Iron Oxide (Fe_2O_3) used in the artificial lesion model was 0.750 mg/mL. The capability of the PAI system to distinguish lesion depth variations was evaluated using the mean image intensity (Mean Gray Value), plot profile analysis, and linear regression of the natural logarithm of the mean image intensity. The results showed that the mean image intensity decreased consistently from (254 ± 1) a.u. at a lesion depth of 0 mm to (32 ± 3) a.u. at 4 mm, accompanied by corresponding changes in the plot profile. Linear regression analysis yielded the relationship between the natural logarithm of the mean image intensity and lesion depth as $ln\ (I_c) = -0.512\ d + 5.453$ with a coefficient of determination of $R^2 = 0.990$. This relationship indicates that the decrease in mean image intensity follows the exponential attenuation trend described by the Beer–Lambert law. These findings demonstrate that the developed PAI system is capable of distinguishing lesion depth variations in an artificial dental caries model through quantitative image characterization, indicating its potential as a low-cost optical imaging technique for lesion depth assessment and as a foundation for further development toward biological tissue applications.

Keywords: *Photoacoustic imaging*, dental caries, lesion depth, 808 nm diode laser, artificial dental caries model, Fe_2O_3 pigment.