Ultrasonic assessment of osseointegration phenomena at the bone-implant interface using convolutional neural network

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Endosseous implants are widely used in the clinic. However, failures still occur and depend on the quality of osseointegration phenomena at the bone-implant interface (BII), which are given by bone ingrowth around the BII. The difficulty comes from the complex nature of this interphase related to the implant surface roughness and to the presence of a soft tissue layer (corresponding to non mineralized bone tissue) at the BII. The aim of the present study is to estimate the soft tissue thickness based on the analysis of ultrasonic response of the BII in reflection using 2D convolution neural network (CNN). The interaction between the BII and ultrasonic waves were modeled using a two-dimensional finite element method in the frequency domain. The surface profile was considered to be sinusoidal with a spatial frequency equal to 1.8 μm and an amplitude of h. The results were converted in the time domain and the effect of the soft tissue thickness on the reflected signal was determined. A time frequency analysis was carried out and the results were used as input data in the CNN. Training image data were generated by considering varying parameters of the surface roughness (between h = 310 and 410 μm) and soft tissue thickness (between 0 and 1.5*h). The proposed CNN method was verified for cases that were not included the training dataset in both microscopic and macroscopic scales. The results show a good agreement between the actual and inverted results (R^2=0.99).