

**Title:** Accuracy and reliability of assessing periodontal parameters on intraoral ultrasound images

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**Background and Objective:** Intraoral ultrasonography (iUS) is emerging as a promising imaging modality in dentistry, valued for its non-invasiveness and non-ionizing radiation. However, the efficacy of iUS has not been fully examined. This study evaluated the accuracy and reliability of intraoral ultrasound (US) imaging.

**Methods:** A customized 20-MHz ultrasound system was used to scan teeth on cadavers and orthodontic patients. Two parameters were evaluated for accuracy: the alveolar bone level (ABL) between the cementum-enamel junction and the alveolar bone crest (ABC), and the thickness of the alveolar crestal bone (ABT). The measurements were performed on 50 pairs of US and micro-computed tomography ( $\mu$ CT) images from 50 cadaver teeth by 2 trained raters. The mean absolute difference (MAD) and its standard deviation (SD), the Student's paired t-test, and Bland-Altman (BA) plots were used for quantitative and qualitative analyses. For reliability study, 134 teeth from 19 adolescents (age  $13.8 \pm 1.8$  years) were scanned by US with ethics approval and patient consent. Three raters measured four parameters on 134 images twice with 2 weeks apart: ABL, ABT, the gingiva thickness close to the ABC (GT1), and the gingiva thickness at 2 mm away from the gingival margin (GT2). The intra- and inter-rater reliabilities were evaluated using the intraclass correlation coefficient [ICC].

**Results and Discussion:** For accuracy analysis, the average measured US-ABL vs  $\mu$ CT-ABL by R1 and R2 were  $4.38 \pm 1.15$  vs  $4.39 \pm 1.11$  mm, and  $4.47 \pm 1.16$  vs  $4.44 \pm 1.14$  mm, respectively. For US-ABT vs  $\mu$ CT-ABT, the measurements from R1 and R2 were  $0.34 \pm 0.13$  vs  $0.30 \pm 0.14$  mm, and  $0.33 \pm 0.13$  vs  $0.30 \pm 0.14$  mm, respectively. Overall, the maximum MADs for ABL and ABT were  $0.22 \pm 0.24$  mm and  $0.07 \pm 0.07$  mm. There were no statistically significant differences between the measurements from iUS and  $\mu$ CT ( $p > 0.2$ ). The BA analysis showed almost no bias (0.03 mm max) for both ABL and ABT, and 46/50 measurements were within the 2SD. The intra-rater reliability for the measured ABL, GT1, and GT2 was excellent with  $ICC_{[2,1]} \geq 0.93$ . For ABT, it showed good to excellent with the  $ICC_{[2,1]}$  ranging from 0.84 to 0.90. For the inter-rater (R1vsR2vsR3) reliability, the GT1 showed excellent  $ICC_{[2,1]}$  of 0.96, and good for ABL, ABT and GT2 with  $ICC_{[2,1]} \geq 0.82$ .

**Conclusion:** The accuracy analysis on the cadavers showed no statistically significant difference in measurements between iUS and  $\mu$ CT. The reliability analysis on clinical data demonstrated high intra- and inter-rater reliabilities for the periodontal measurements.