Evaluation of Periodontal Tissues Using 40MHz Ultrasonography. Preliminary report.

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Abstract

Objectives: The aim of this study was to investigate the possibility to use high-frequency ultrasound imaging for the assessment of periodontal structures. **Material and methods:** A commercially available ultrasound scanner (Ultrasonix SonoTouch) with a linear 1.5 cm footprint, wideband 8 - 40MHz transducer was used, with external transcutaneous approach. A number of 4 patients with healthy periodontal tissue were evaluated. All 4 bicusps of the lower jaw were imaged from buccal incidence. A fixed landmark (no.20 gutta-percha point) was placed in the gingival sulcus, in order to measure the following dimensions: gingival sulcus depth (D1), free gingival thickness (D2), width of the periodontal space in the most coronal position, length of the supracrestal fiber (D3), height of the clinical crown (D4) and height of the anatomic crown (D5). **Results:** The 40MHz ultrasound image revealed the cortical bone, tooth crown, dental root, fixed mucosa and the gingival sulcus. The findings for D1 varied between 1.2-1.86 mm and for D2 between 0.65-1.34 mm. The smallest variation of the values was found for D3: 0.21-0.39. The mean value for the difference between D5 and D4 was 1.79 mm. No statistical differences were found between clinical and imagistic measurements in respect to sulcus depth (Wilcoxon Signed Rank test, $z = -1.221$ based on positive ranks). **Conclusions:** Ultrasonography provides a highly accurate and noninvasive technique for periodontal assessment. Future studies will be carried out in order to assess the correlation between clinical examination, radiology, and ultrasound measurements in patients with periodontal diseases.

Keywords: periodontal examination, periodontal tissue, ultrasonography

Introduction

The evaluation of periodontal tissues can be done through clinical examination (such as probing depth, assessment of gingival recession, tooth mobility) and complementary methods (radiological examination, blood tests and microbiological analysis) [1]. Clinical examinations are time-consuming, user dependent and of disputable reliability [2]. The X-ray examination (retroalveolar, bitewing, panoramic) is cost effective but the exposure to ionizing radiation and the lack of informa-

tion about bone resorption from the buccal and lingual surfaces of the teeth represent important drawbacks of the method [1].

Periodontal changes can be assessed more accurately using new imaging techniques like: cone-beam computed tomography; optical coherence tomography; optical spectroscopy and ultrasonography [3-5].

Very high-resolution ultrasonography has been used mainly for the exploration of the skin or the anterior chamber of the eye. With the advent of new, easy to use transducers, novel applications emerged such as the exploration of the oral cavity or small laboratory animals (mice) [6]. These complementary methods are attractive because they are noninvasive and comfortable for the patient.

Recent studies showed the validity and reliability of ultrasonography in the measurement not only of gingival thickness [7] but also of other periodontal structures which cannot be assessed through inspection and pal-

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pation [8]. Very high resolution (20 MHz) in vitro US studies of periodontal structures using a dermatology dedicated scanner further improved the knowledge on periodontal US appearance [9,10].

The aim of the present study is to assess the feasibility of in vivo transgenial assessment of the periodontal structures in humans with a very high resolution, 40 MHz transducer.

Material and methods

Four volunteers with clinical healthy periodontal tissues were included in the study. Ethical approval and written consent were obtained.

In all volunteers, the 4 lower bicuspid were first evaluated clinically, through inspection and probing. The examination of the periodontal structures showed no signs of inflammation, resorption, tooth mobility or bleeding on probing. The patients did not complain of any symptoms regarding the periodontal tissues. The gingival sulcus depth (C1) and the length of the clinical crown (C2) were measured with a periodontal probe.

After clinical assessment, the premolars were imaged ultrasonographically from the buccal incidence, with a percutaneous transgenial approach. A commercially available ultrasound scanner (Ultrasonix SonoTouch) with a linear 1.5 cm footprint, wideband 8 - 40 MHz transducer, operating at 40 MHz, was used (fig 1).

A fixed landmark (no.20 gutta-percha point) placed in the gingival sulcus, was used as reference (fig 2). The images were obtained by positioning the transducer in a coronal plane in the lateral area of mandible alveolar bone.

The 40 MHz image revealed the cortical bone, the buccal surface of the tooth, the gingival sulcus with the reference point and the periodontal space in its most coronal position (fig 3).

On the ultrasound image, the following micrometric level measurements were performed: (fig 4):

- D1 gingival sulcus depth;
- D2 free gingival thickness;
- D3 width of the periodontal space in the most coronal position;
- D4 distance between marginal gingiva and alveolar crest;
- D5 height of the clinical crown;
- D6 height of the anatomic crown.

Statistical differences between clinical and ultrasound measurements (sulcus depth and clinical crown) were evaluated using Wilcoxon Signed Rank test.

Fig 1. Coronal US image of the dento-periodontal structures at 40 MHz. Tick marks on the left side of the image indicate 2 mm.

Fig 2. The gutta-percha marker (arrow) placed in the gingival sulcus.

Fig 3. Dental and periodontal US anatomy - 40 MHz image (top) and anatomic sketch (bottom – inspired after ref. [11]): 1 – dentin; 2 – enamel; 3 – cementum; 4 – cemento-enamel junction; 5 – supra crestal fibers; 6 – gingival epithelium; 7 – periodontal ligament; 8 – crest of alveolar bone; 9 – gingival sulcus.

Fig 4. Measurements performed on the US image. Details in the text.

Results

The 40MHz ultrasound image revealed the cortical bone, the anatomical and clinical crown and root, attached mucosa and the gingival sulcus.

The findings for D1 varied between 1.2-1.86 mm and for D2 between 0.65-1.34mm. The smallest variation of the values was found for D3: 0.21-0.39. The results of the measurements are presented in table I.

No statistical differences were found between clinical and imagistic measurements in respect to sulcus depth (Wilcoxon Signed Rank test, $z = -1.221$ based on positive ranks).

Discussions

The possibility to assess periodontal tissues with a dedicated 20 MHz dermatology scanner (Dermascan) was well documented by Chifor and coworkers, in an in vitro study [9]. The results demonstrated a high correlation between ultrasonography, Cone Beam computed tomography and direct microscopic section measurements as a reference standard, therefore eliciting the possibility to use 20 MHz ultrasonography in monitoring periodontal tissue [9].

The same authors showed, in another paper [10], that measurements using 20 MHz ultrasonography are highly accurate and suggest the possibility of using this method as a reliable alternative for X-ray examinations in patients with periodontal disease, if a miniaturized transducer for endooral approach would be available.

To the best of our knowledge this is the first report on the use of very high resolution ultrasound (40 MHz) in the assessment of the periodontal structures. The aim of this pilot study was to demonstrate the possibility to use ultrasonography in vivo, for periodontal evaluation. Us-

Table I. Ultrasonographic measurements (d1-d6) and clinical measurements (c1-c2) (details in text)

	d1	d2	d3	d4	d5	d6	c1	c2	d1-c1
p1 34	1.98	1.29	0.43	2.98	4.78	6.45	1.5	5	0.48
p1 35	1.02	2.03	0.33	5.28	5.8	7.26	1	6	0.02
p1 44	2.02	0.81	0.22	2.48	5.5	6.29	2	6	0.02
p1 45	1.58	0.65	0.34	2.17	4	5	1.5	5	0.08
p2 34	1.26	0.88	0.39	0.88	5.67	6.24	1	6.5	0.26
p2 35	1.86	0.99	1.3	0.21	4.92	5.78	2	5	-0.14
p2 44	1.4	0.67	0.28	1.89	5.24	6.65	1	5.5	0.4
p2 45	1.48	0.84	0.36	1.33	5	6.09	1.5	5	-0.02
p3 34	1.52	1.18	0.31	1.34	5.07	6.29	1.5	5	0.02
p3 35	1.79	0.71	0.17	0.62	4.31	5.46	2	5	-0.21
p3 44	1.2	0.85	0.26	0.78	7	8.36	1	6.5	0.2
p3 45	1.43	1.02	0.22	0.71	5.93	6.39	1.5	6	-0.07
p4 34	1.87	1.12	0.39	1.2	5.75	6.21	1.5	6	0.37
p4 35	1.79	0.82	0.35	1.54	5.36	6.02	1.5	5.5	0.29
p4 44	1.25	1.46	0.18	0.92	5.22	6.44	1	6	0.25
p4 45	1.47	0.88	0.28	0.75	4.97	6.5	1.5	6.5	-0.03

ing the gutta-percha point as a landmark in the gingival sulcus of the buccal surface of the tooth, it was possible to determine the clinical and anatomical crown, the root with the periodontal space, the width of the free gingival margin and the distance between the alveolar crest and free gingiva.

The ultrasound method has two main advantages: the absence of exposure to ionizing radiation, and a wider range of information.

The present study confirmed the feasibility of external, transgenial approach for very high resolution US assessment of the periodontal structures. Further, in vitro and in vivo research is required and being performed, for the complete understanding of the US appearance of normal and diseased periodontal structures.

Conclusions

To the best of our knowledge this the first report of the use of very high resolution (40 MHz) ultrasound in the assessment of periodontal structures. Data regarding gingival sulcus depth, free gingival thickness, width of periodontal space, distance between marginal gingiva and alveolar crest, height of clinical and anatomical crown were obtained. No statistical differences between clinical and imagistic US measurements were obtained, in respect to probing depth. Ultrasonography provides a noninvasive technique for periodontal assessment but further studies are mandatory to define a potential clinical role of the method.

Conflict of interest: none

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