The utility of 40 MHz periodontal ultrasonography in the assessment of gingival inflammation evolution following professional teeth cleaning

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Abstract

The aim of this study was to evaluate the usefulness of 40 MHz periodontal ultrasonography in the assessment of gingival inflammation, following professional teeth cleaning. **Material and methods:** The study was performed on 18 teeth without restorations having subgingival calculus (upper and lower premolars and frontal teeth). After the clinical exam the Gingival Index and the Sulcus Bleeding Index were calculated. Then a 40MHz transducer (ULTRASONIX SonoTouch device) was used to obtain longitudinal sections in the frontal plane. Three measurements were performed: alveolar crest – cementum-enamel junction distance (ACJ), gingival height (GH), and gingival width (GW). Professional cleaning was performed by ultrasound scaling (SatelecP5 booster, France) and airflow (NSK, Japan). Two and seven days after the first evaluation, ultrasonographic and clinical examinations were repeated. **Results:** Two days after the treatment the median value of the ACJ, was 2.70 (2.38; 2.95) mm, whereas 7 days after treatment it was 2.55 (2.45; 3.01) mm. The intraclass correlation coefficient for ACJ measurement was 98.8 ($p < 0.001$). The values obtained measuring GH [3.84(3.44; 4.27) mm vs. 3.52 (3.00; 3.76) mm] and GW [(1.81 (1.65; 1.95) mm vs. 1.62 (1.40; 1.95) mm) had statistically significant differences between the 2nd and 7th day. **Conclusions:** Periodontal ultrasonography is a highly precise and reproducible imagistic method, with which bone resorption, gingival inflammation as well as the presence or absence of subgingival calculus can be assessed.

Keywords: periodontal diagnosis, periodontal ultrasonography, gingivitis, scaling

Introduction

The major factors of gingival inflammation and periodontal disease are the presence of dental plaque and calculus at the gingival level. The follow-up of gingival inflammation evolution is usually made during clinical examinations by using the Gingival Index and the Sulcular Bleeding Index [1-4].

The dentist significantly influences the result of scaling and root planning, including the quantity of tissue removed during the clinical treatment [5-7]. Hung et al noticed, after analyzing several articles on this subject, that gingival attachment changes after scaling and root planning. In the case of small periodontal pockets, it

changes up to 1 mm while in the case of deep periodontal pockets, the gingival attachment changes up to 2 mm, shortly after scaling [8]. Thus scaling efficacy is highly important and is performed subgingivally based most of the time on tactile perception. Direct visualization of the remaining calculus in the sulcus is impossible in most of the cases. There are some new technologies such as perioscopy, optical spectrometry, autofluorescence-based technology, and ultrasonic devices that permit the detection of the residual calculus but those techniques are quite expensive and difficult to use [9,10]. Therefore, an investigation method which permits the assessment of whether any subgingival remaining calculus is present as well as monitoring the evolution of gingival inflammation after periodontal treatments is required.

Ultrasonography (US) was previously used to visualize periodontal tissue [11-13]. Also this imagistic technique was used previously to visualize the renal, ureteric and salivary calculus [14-16].

The aim of this study was to use 40 MHz periodontal US to assess the evolution of gingival inflammation fol-

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lowing professional tooth cleaning and to visualize any residual calculus after periodontal debridement.

Material and methods

The study was performed on 18 teeth with subgingival calculus. The informed consent was obtained from every patient and the study was approved by the Ethics Committee of the University. The examinations and treatments were performed on the upper and lower premolars and frontal teeth. The teeth were included in the study if they had subgingival calculus on the buccal surface and if neither reconstructions, nor lesions with missing substance were present at the crown or root level. In each case the initial US examination was performed, aiming to visualize the calculus deposits. Then the patient was clinically intraorally examined. Afterwards professional tooth cleaning was performed by ultrasound scaling (SatelecP5 booster, France) and airflow (NSK, Japan). In the second and seventh days after the first examination US and clinical examinations were repeated.

Clinical exam

Manual periodontal probing was performed in the middle of the buccal surface, parallel with the long axis of the tooth for each site included in the study. The same type of periodontal probe was used in all patients. Gingival Index (Löe and Silness, 1963) and Sulcus Bleeding Index (SBI, Muhlemann and Son, 1971) were calculated.

For the Gingival Index, the degree of gingival inflammation was assessed in the examined area, by using the periodontal probe, as follow: grade 0= normal gingiva; grade 1= mild inflammation – slight change in color and slight edema but no bleeding on probing; grade 2= moderate inflammation – redness, edema and glazing, bleeding on probing; grade 3= severe inflammation – marked redness and edema, ulceration with a tendency to spontaneous bleeding [17].

For the Sulcus Bleeding Index, the following criteria were used: score 0 – health looking papillary and marginal gingiva, no bleeding on probing; score 1 – healthy looking gingiva, bleeding on probing; score 2 – bleeding on probing, change in color, no edema; score 3 – bleeding on probing, change in color, slight edema; score 4 – bleeding on probing, change in color, obvious edema; score 5 –spontaneous bleeding, change in color, marked edema [18].

Periodontal US

The ULTRASONIX SonoTouch (Chison Medical Imaging Co., China) device with 40MHz transducer was used. The transducer was placed parallel with the long axis of the tooth to be examined, in the middle of the buccal surface, similar to the periodontal probe during

Fig 1. Ultrasonix 40 MHz, ultrasound examination tooth 4.3 before scaling. The bone cortical (long white arrow), gingival connective tissue (long grey arrow), free gingival margin (long black arrow), root surface (short black arrow), subgingival calculus (short white arrow), tooth enamel (short grey arrow), gingival epithelium (GE) are evident.

Fig 2. Ultrasonix 40 MHz, ultrasound examination tooth 4.3 seven days after scaling. The alveolar crest (long white arrow), gingival connective tissue (long grey arrow), free gingival margin (long black arrow), root surface (short black arrow), cementum-enamel junction (short white arrow), dental enamel (short grey arrow), gingival epithelium (GE), distance between alveolar crest – cementum-enamel junction = ACJ (double grey arrow), the distance between alveolar crest – free gingival margin = GH (double white arrow), fixed gingiva thickness = GW (double black arrow) are all evident.

clinical exam. Longitudinal sections were obtained in the frontal and sagittal plane. The examinations were performed transdermally.

The keratinized gingival epithelium was identified as a continuous and hyperechogenic line. Gingival connective tissue was considered to be the hypoechoic area between gingival epithelium and the cortical bone or between gingival epithelium and the tooth. The cortical bone appeared as a continuous hyperechogenic line. The tooth can be visualized as a hyperechogenic well-contoured area, which is interrupted at the level of the cementum-enamel junction. Due to this interruption the crown and the tooth root can be identified (fig 1). The calculus appears as a hyperechogenic well-counteracted area which covers the root and the crown at the enamel-cementum junction level (fig 2).

Three dimensions were measured: the distance between the alveolar crest – cementum-enamel junction (ACJ), the distance between the alveolar crest – free gingival margin = gingival height (GH), and fixed gingiva thickness, measured between the root wall and the gingival epithelium at the coronary limit of the alveolar crest = gingival width (GW) (fig 2).

In order to appreciate the evolution of gingival inflammation the comparison was made only between the measurements from the 2nd day and 7th day after scaling. It was considered that the presence of subgingival calculus, before the professional cleaning can change the dimensions of the gingival tissue (GW and GH), due to mechanical pressure.

Statistical analysis

The SPSS 20 software was used for the statistical analysis. The continuous variables were tested for normal distribution by using the Kolmogorov-Smirnov test. The data were characterized by the median and by 25 and 75 percentiles. In order to analyze the difference between two measurements, Wilcoxon signed-rank test was employed. The reliability of method was tested by calculating the intraclass correlation coefficient (one-way random model), after logarithmic transformation. The level of statistical significance was set at $p < 0.05$.

Fig 3. Patient M.T. 26 years, tooth 4.3: a) subgingival calculus, purple gingival margin, inflammation, bleeding on probing; b) 7 days after subgingival scaling.

Fig 4. Ultrasonix 40 MHz, ultrasound examination tooth 3.2 a) before scaling; b) 2nd day after professional teeth cleaning c) 7th day after professional teeth cleaning.

Results

For all the examined teeth it was noticed that clinically (fig 3) and ultrasonographically (fig 4) in the second and in the seventh day after the professional cleaning there was no restant calculus neither at the crown nor at the root level.

The US measurements and the gingival indices calculated in the 2nd and 7th day after professional teeth cleaning are detailed in table I.

There is a slight difference of 0.15 mm between the median values of the ACJ in the 2nd day and in the 7th day. The intraclass correlation coefficient was 98.8 ($p < 0.001$). The median dimension of GH decreased in the 7th day comparing with the 2nd day with 0.32 mm ($p = 0.001$). The median values of the two variables width/thickness of the gingival tissue (GW) at 2 days and GW at 7 days are different with a decrease of 0.19 mm ($p = 0.001$) (table II).

As shown in Table III, there were statistically significant differences between the median and the 25 and 75 percentiles for GI and SBI in the 2nd, respectively on the 7th day ($p < 0.05$).

Discussions

The insignificant changes between the 2 sets of ACJ values (in the 2nd and 7th days after treatment) and the intraclass correlation coefficient which was 98.8 ($p < 0.001$) shows that 40 MHz periodontal ultrasonography is a very reproducible intraobserver investigation method.

ACJ is used to evaluate and quantify the evolution of the horizontal bone atrophy. Previous studies showed that this variable needs months or years to change significantly. Even at a very fast evolution rate for periodontal disease, the annual changes are up to 1 mm [19].

The decrease of the gingival dimensions, which indicates a decrease of the inflammation, is shown by the changes of the GH in the 2nd and 7th days after treatment. Also the decrease of GW 2 days after the treatment, compared to the results obtained 7 days after the treatment, shows that the volume of the gum is significantly smaller. This proves that the gingival inflammation significantly decreases following professional cleaning. Seshan et al in a study performed on 20 volunteers, proved by using data collected on photographs that the gums change their dimensions one month after the scaling [20].

The significant decrease of GI and SBI confirm the decrease of the gingival inflammation, even though these indices are quite subjective, depending on the instrument chosen for examination and on the pressure exerted by the clinician. On the contrary, the measurements performed on the periodontal ultrasonography images are

Table I. Ultrasonographic measurements and gingival indices calculated in the 2nd and 7th day after professional teeth cleaning.

Tooth	Examination in the 2nd day					Examination in the 7th day				
	ACJ	GH	GW	GI	SBI	ACJ	GH	GW	GI	SBI
2.3	3.36	3.46	1.91	2	3	3.18	3.97	1.48	1	0
1.3	3.39	4.39	2.09	2	3	3.51	3.82	1.69	0	0
2.2	2.53	3.53	1.94	1	2	2.55	3.15	1.84	0	0
4.3	3.06	3.38	1.97	3	5	2.52	2.85	1.19	1	2
3.1	2.23	2.58	1.68	2	2	2.45	2.51	1.43	1	0
2.5	2.88	4.59	1.88	2	3	2.54	3.75	1.77	1	0
2.4	2.92	4.17	1.72	3	4	3.24	3.6	1.66	1	0
4.1	2.63	3.67	1.78	2	3	2.6	3.08	1.32	0	0
1.3	2.78	4.25	1.62	3	4	2.45	3.68	1.73	1	0
1.2	2.9	4.36	1.95	1	2	2.96	3.58	1.64	1	0
4.2	2.28	2.88	1.44	2	3	2.15	2.31	1.27	0	0
3.3	2.61	3.95	1.62	3	3	2.56	3.05	1.49	0	0
2.3	2.57	4.07	1.79	1	2	2.67	3.82	1.48	0	0
3.2	2.4	2.65	1.76	2	3	2.55	2.81	1.61	1	0
2.1	2.1	3.87	1.92	0	0	2.07	3.39	1.7	0	0
1.1	2.35	3.82	1.89	0	0	2.28	3.56	1.87	0	0
2.3	2.85	3.64	1.19	1	2	2.94	3.48	1.23	0	0
4.3	10.94	11.02	1.84	3	4	10.34	10.82	1.76	2	3

ACJ – alveolar crest – cementum-enamel junction distance, in mm; GH – gingival height, in mm; GW – gingival width in mm; GI – Gingival Index; SBI- Sulcus Bleeding Index.

Table II. Differences between the ultrasonographic measurements performed on the 2nd and 7th day after professional teeth cleaning.

Periodontium variables	2 nd day – median (25; 75 percentile) (mm)	7 nd day – median (25; 75 percentile) (mm)	P
ACJ	2.70 (2.38; 2.95)	2.55 (2.45; 3.01)	<0.001
GH	3.84 (3.44; 4.27)	3.52 (3.00; 3.76)	0.001
GW	1.81 (1.65; 1.95)	1.62 (1.40; 1.95)	0.001

ACJ – alveolar crest – cementum-enamel junction distance; GH – gingival height; GW – gingival width.

Table III. Differences between the gingival indices calculated on the 2nd and 7th day after professional teeth cleaning.

Periodontium variables	2 nd day - median (25; 75 percentile)	7 nd day - median (25; 75 percentile)	P
GI	2 (1; 3)	0.5 (0; 1)	<0.001
SBI	2 (2; 3.25)	0 (0; 0)	<0.001

GI – Gingival Index; SBI – Sulcus Bleeding Index.

objective and bring supplementary information regarding the degree of the gum edema.

Ultrasonographic visualization of periodontal tissues permits a non-invasive examination and may be used in assessing the periodontal disease evolution whenever needed. Using ultrasonography the outline of both the hard and soft tissues, can be visualized, unlike the radiographic examination. This brings important information in monitoring the gingival inflammation, but also in monitoring the horizontal and vertical bone atrophy.

Zimbran et al demonstrated that periodontal 40 MHz ultrasonography is a feasible method which returns reliable results, which can be interpreted relatively easy [11]

The above mentioned issues are actually a suggestion for creating a new method for evaluating the gingival inflammation: recording the thickness of the gingival

mucosa and of the length of the gingival margin, on ultrasound images in order to monitor the gingival inflammation.

The presence or the absence of the subgingival calculus is directly and significantly influencing the evolution of periodontal disease and may be assessed by different methods. The palpatory method is the most frequently used nowadays. Sometimes periapical X-rays may identify the subgingival calculus but this method cannot be used to control the treatment efficacy. There are also modern methods to verify the presence or the absence of calculus following professional cleaning, such as the multiphoton autofluorescence imaging method [21]. The advantage of periodontal ultrasonography compared to such a method is that it brings information regarding the size and the position of the calculus deposit before

treatment and it can confirm the absence of calculus after treatment, thus assessing the quality of the treatment performed. Besides that, the dimensions of the gingiva can be measured; therefore the level of inflammation can be quantified, as well as the dimensions of bone atrophies. Being a non-invasive and cost effective method, it can be used as often as needed without side effects on patients or medical staff.

Further studies are required to develop an appropriate transducer for all the areas to be examined. With an Ultrasonix device it is very difficult or even impossible to examine the lingual and the approximal surfaces of the teeth, due to the size and the shape of the transducer. Further studies should include more teeth divided into several study groups, according to the stage of the periodontal disease.

Conclusions

Periodontal ultrasonography is a highly precise and reproducible imagistic method, with which both bone resorption, gingival inflammation as well as the presence or absence of subgingival calculus, can be assessed.

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Conflict of interest: none

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