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Reliability of assessing interproximal bone loss

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Introduction

Objective
The aim of this study was to assess the reliability of linear measurements of interproximal bone loss on digitized radiographic images after the use of different filters.

Fig. 1 a, b, c: Radiograph of intrabony defect mesial of a right second premolar: if the CEJ (cemento-enamel junction) was destroyed by restorations the restoration margin was chosen as landmark. AC (alveolar crest); BD (most apical extension of bony defect)

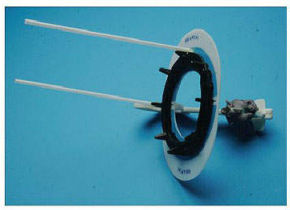

Fig. 2: Modified filmholder with aiming device

Material and Methods

Material and Methods I
Patients

- 50 patients (29 female) 22-65 years of age.
- untreated advanced periodontal disease.
- each exhibiting one interproximal intrabony defect.

Radiographic examinations

- standardized bitewing radio-graphs of teeth with intrabony defects using modified film holders (VIP 2 Film Positioning, UpRad Corp., Fort Lauderdale, FL, USA) (Fig. 1, 2). Two orthodontic wires were placed on the mandibular side of the filmholder at a specified position. Shadows of these wires were cast onto the radiographs (Fig. 1). From the distances between the images of these wires on a radiograph, the vertical and horizontal angulation difference between the central beam and the orthoradial projection could be calculated.
- intraoral dental films (Ultraspeed, Eastman Kodak Co., Rochester, NY, USA) size 2.
- x-ray source (Heliodent 70, 70 kV, 7 mA, Siemens, Bensheim, Germany).
- development unit (Periomat, Dürr Dental GmbH, Bietigheim-Bissingen, Germany).

Material and Methods II
Clinical examinations
At 6 sites per tooth:

- Gingival Index (GI) and Plaque Index (PlI).
- PD and PAL-V to the nearest 0.5 mm (PCPUNC 15).

After reflection of a full thickness flap:

- distance cemento-enamel junction (CEJ) to the most apical extension of the bony defect (BD).
- the height of the 3-wall as well as the 2- and 3-wall component of each interproximal lesion.
- all clinical measurements were performed by one examiner (PE) to the nearest 0.5 mm (PCPUNC 15).

Radiographic evaluation
Measurements using a loupe of 10 fold magnification and a 0.1 mm grid (Scale loupe 10, Peak,Tohkai Sangyo, Tokyo, Japan):

- distances between the projections of the orthodontic wires that had been fixed to the filmholders vertically (dv) and horizontally (dh) on every radiograph (Fig. 1).
- capturing of each radiograph with a flat bed scanner (Linotype Saphir, Friadent, Mannheim, Germany) with 600x1200 dpi resolution.
- all radiographs were analysed (CEJ-AC/ -BD) by 2 examiners blinded to the clinical and intrasurgical measurements: EvB, BW (Fig. 1).
- enlargement: 7x, 14x

- the length of the cast shadow of the wire placed on the maxillary side of the filmholder was marked (Fig. 1) and the length of the wire was entered into the program (Friacom, Friadent). All further measurements were adjusted according to the enlargement of each individual radiograph automatically.

Statistical analysis

- Kolmogorov-Smirnov/Lilliefors-Test for normal distribution.
- comparison of intrasurgical / radiographic measurements by paired t test.
- stepwise multiple linear regression analysis:
- dependent variable: □ intrasurgical / radio-graphic measurements
- explanatory variables: patient, angulation differences, analysing method, intrasurgical parameters

Results

Results I

- For the distance CEJ-AC the dentist had a lower measurement variability than the final year dental student (Tab. 2).
- For the distance CEJ-BD filters had significant influence on reproducibility in correlation with vertical angulation difference (Tab. 3).
- For the distance CEJ-AC "structure" resulted in less valid measurements than the other imaging modes (Tab. 5).

Results II

	clinical parameters				angulation difference/°	
	GI	PII	PPD/mm	PAL/mm	vertical	horizontal
mean ± SD	1.88 ± 0.44	0.32 ± 0.68	7.96 ± 1.73	8.82 ± 1.78	1.79 ± 1.41	0.99 ± 1.25
range	0.0 - 2.0	0.0 - 2.0	4.0 - 12.0	5.0 - 13.0	0.0 - 6.3	0.0 - 6.6

Table 1: Clinical parameters of 50 interproximal lesions and vertical as well as horizontal angulation difference of the central beam from the orthoradial projection of 50 radiographs (mean ± standard deviation [SD]; range [minimum - maximum]; Gingiva Index: GI; Plaque Index: PII; probing depth: PPD; attachment level: PAL).

source	SSQ	DF	MSQ	F-ratio	P	G-G	H-F
between subjects							
examiner	**6.85**	**1**	**6.85**	**6.83**	**0.010**		
height of 2wall component	**4.00**	**1**	**4.00**	**4.00**	**0.047**		
error	197.57	197	1.00				
within subjects							
filter	**4.03**	**2**	**2.02**	**2.67**	**0.071**	**0.090**	**0.089**
filter x examiner	1.06	2	0.53	0.70	0.497	0.450	0.452
filter x height of 2wall comp.	**8.68**	**2**	**4.24**	**5.74**	**0.003**	**0.009**	**0.009**
error	297.95	394	0.76				

Table 2: Repeated measures analysis of variance: reproducibility of radiographic measurements; dependent variable: amount of the difference first minus second radiographic measurement (CEJ-AC)

source	SSQ	DF	MSQ	F-ratio	P	G-G	H-F
between subjects							
vertical angulation	0.21	1	0.28	0.19	0.664		
error	218.57	198	1.10				
within subjects							
filter	0.19	2	0.10	0.16	0.853	0.832	0.835
filter x vertical angulation	**10.27**	**2**	**5.13**	**8.42**	**0.000**	**0.000**	**0.000**
error	241.46	396	0.61				

Table 3: Repeated measures analysis of variance: reproducibility of radiographic measurements; dependent variable: amount of the difference first minus second radiographic measurement (CEJ-DB)

	CEJ-AC/mm		CEJ-BD/mm	
magnification	7fold	14fold	7fold	14fold
measurements	mean± SD	mean±SD	mean±SD	mean±SD
intrasurgical	3.81 ± 1.72		9.05 ± 1.68	

radiographic				
examiner BW				
without filter	4.55 ± 1.91	4.70 ± 1.93	9.12 ± 2.26	9.31 ± 2.25
D intra-without filter	-0.74 ± 1.67	-0.89 ± 1.65	-0.05 ± 1.65	-0.26 ± 1.71
spreading	4.81 ± 1.91	4.91 ± 1.96	9.24 ± 2.13	9.39 ± 2.21
D intra-spreading	-1.00 ± 1.76	-1.10 ± 1.71	-0.19 ± 1.59	-0.34 ± 1.64
structure	5.13 ± 1.99	5.28 ± 1.80	9.04 ± 2.28	9.26 ± 2.25
D intra-structure	-1.32 ± 1.78	-1.47 ± 1.58	0.00 ± 1.78	-0.21 ± 1.73
examiner EvB				
without filter	4.73 ± 1.89	4.75 ± 1.87	9.01 ± 2.19	9.21 ± 1.96
D intra-without filter	-0.92 ± 1.74	-0.94 ± 1.69	0.04 ± 1.84	-0.16 ± 1.68
spreading	4.93 ± 1.84	4.83 ± 1.81	9.44 ± 2.27	9.53 ± 1.95
D intra-spreading	-1.12 ± 1.72	-1.02 ± 1.68	-0.39 ± 1.88	-0.48 ± 1.59
structure	5.23 ± 1.91	5.21 ± 1.81	9.82 ± 2.12	9.43 ± 1.91
D intra-structure	-1.91 ± 1.83	-1.40 ± 1.76	-0.77 ± 1.85	-0.38 ± 1.61

Table 4: Intrasurgical measurements and radiographic parameters (mean± standard deviation [SD]) and differences between intrasurgical and radiographic related to magnification and examiner.

source	SSQ	DF	MSQ	F-ratio	P	G-G	H-F
between subjects							
intrasurgical CEJ-AC	**178.61**	**1**	**178.61**	**15.30**	**0.000**		
error	1397.84	198	7.06				
within subjects							
filter	**6.64**	**2**	**3.32**	**8.38**	**0.000**	**0.001**	**0.001**
filter x intrasurgical CEJ-AC	0.39	2	0.19	0.49	0.613	0.575	0.577
error	156.95	396	0.40				

Table 5: Repeated measures analysis of variance: validity of radiographic measurements (CEJ-AC); dependent variable: Difference between intrasurgical and radiographic measurement (CEJ-AC)

source	SSQ	DF	MSQ	F-ratio	P	G-G	H-F
between subjects							
examiner	5.09	1	5.09	0.67	0.415		
magnification	0.89	1	0.89	0.12	0.733		
examiner x magnification	1.90	1	1.90	0.25	0.619		
intrasurgical CEJ-BD	**73.13**	**1**	**73.13**	**9.57**	**0.002**		
horizontal angulation	**51.31**	**1**	**51.31**	**6.72**	**0.010**		
error	1482.09	194	7.64				
within subjects							
Filter	1.13	2	0.56	1.55	0.213	0.214	0.214
filter x magnification	**2.33**	**2**	**1.17**	**3.21**	**0.041**	**0.044**	**0.043**
filter x examiner	**8.05**	**2**	**4.02**	**11.09**	**0.000**	**0.000**	**0.000**
filter x examiner x magnification	**2.52**	**2**	**1.26**	**3.47**	**0.032**	**0.035**	**0.033**
filter x intrasurgical CEJ-BD	1.40	2	0.70	1.93	0.147	0.150	0.148
filter x horizontal angulation	0.22	2	0.11	0.30	0.738	0.725	0.732
Error	140.82	388	0.36				

Table 6: Repeated measures analysis of variance: validity of radiographic measurements (CEJ-BD); dependent variable: Difference between intrasurgical and radiographic measurement (CEJ-BD)

Discussion and Conclusions

Conclusions

- The chosen digital manipulations (filters: spreading, structure) of radiographic images failed to result in statistically significant more reproducible or valid measurements of interproximal bone loss within intrabony defects when compared to the digitized but unchanged images.

- Radiographic assessments, except for the use of enhancement of grey level differences (structure) came close to the intrasurgical gold standard.

Abbreviations

Definition of landmarks
BD was defined as most coronal point where the periodontal ligament space showed a continuous width. If no periodontal ligament space could be identified the point where the projection of the AC crossed the root surface was taken as landmark. If both structures could be identified at one defect, the point defined by the periodontal ligament was used as BD. If several bony contours could be identified the most apical that crossed the root was defined as the BD.

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