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ORIGINAL RESEARCH

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Discomfort/pain due to periodontal and peri-implant probing with/without platform switching

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Abstract

Objective: To compare discomfort/pain following periodontal probing around teeth and peri-implant probing around implants with or without platform switching.

Methods: Two dentists recruited and examined 65 patients, each of them exhibiting a dental implant with a contralateral tooth. Only two types of implants were included: one with and one without platform switching. Periodontal and peri-implant probing depths (PPD) and probing attachment level (PAL) were assessed. Whether implant or tooth was measured first was randomly assigned. Immediately after probing, patients scored discomfort/pain using a visual analogue scale (VAS). The emergence profiles of implant crowns were assessed as angles between interproximal surfaces on radiographs.

Results: Sixty-five patients (age 69; 63/76 years [median; lower/upper quartile]; 38 females, 11 smokers) were examined. With the exception of mean PPD and PAL ($p < .05$) clinical parameters (PPD, PAL, bleeding on probing, suppuration) were well balanced between implants and teeth. Peri-implant probing (VAS: 10; 0.75/16.25) caused significantly ($p < .001$) more discomfort/pain than periodontal probing (4; 0/10). Logistic regression analysis identified a larger difference between discomfort/pain for peri-implant and periodontal probing in the maxilla than the mandible ($p = .003$). Comparing discomfort/pain between implants maxilla ($p = .006$) and emergence profile ($p = .015$) were associated with discomfort/pain. Type of implant (with/without platform switching) had no significant effect on discomfort/pain.

Conclusions: Peri-implant probing caused significantly more discomfort/pain than periodontal probing. Implant design with/without platform switching failed to have a significant effect on discomfort/pain.

KEYWORDS

dental implants, discomfort/pain, peri-implant probing, periodontal probing, platform switching

Parvini and Saminsky contributed equally to the study.

1 | INTRODUCTION

Assessment of probing parameters (i.e., probing pocket depths [PPD] and probing attachment levels [PAL]) provides basic information on periodontal and peri-implant health and disease. Thus, periodontal and peri-implant probing is integral part of routine examinations (Lang, Wilson, & Corbet, 2000; Rinke, Tsigaras, Huels, & Roediger, 2011). Bleeding on probing (BOP) is a significant clinical variable that is indicative for peri-implant mucositis and peri-implantitis (Heitz-Mayfield, 2008; Lindhe, Meyle, & Group D of European Workshop on Periodontology, 2008) and suppuration for peri-implant disease activity (Thierbach & Eger, 2013). Peri-implantitis may be detected by increasing PPD (Berglundh et al., 2018). Thus, peri-implant diagnosis is unthinkable without peri-implant probing using metal or plastic probes. Peri-implant probing is as harmless for peri-implant tissues as periodontal probing is harmless for periodontal tissues (Etter, Hakanson, Lang, Trejo, & Caffesse, 2002).

Previous studies report more discomfort/pain after peri-implant probing than periodontal probing (Ringeling et al., 2016; Stanner et al., 2017). Further, discomfort/pain after peri-implant and periodontal probing is influenced by age and the sequence of probing (implant or tooth first; Stanner et al., 2017). However, there may be several additional plausible factors to influence discomfort/pain after peri-implant/periodontal probing: for example platform switching or not and emergence profile. Thus, this study was designed to compare discomfort/pain after periodontal and peri-implant probing in two different implant types (one with and one without platform switching).

2 | MATERIAL AND METHODS

2.1 | Patients

All patients attending the Department of Periodontology or Oral Surgery and Implantology, Center for Dentistry and Oral Medicine (Carolinum), Johann Wolfgang Goethe-University Frankfurt for periodontal or peri-implant examinations and fulfilling the following inclusion criteria were asked to participate in this cross-sectional split-mouth study. Patients were included from 15 February 2016 until 7 May 2018.

The study was designed as multi-centre study with the Department of Periodontology of the Center for Dentistry and Oral Medicine (Carolinum), Johann Wolfgang Goethe-University Frankfurt as principal centre. The study design is a modification of previous studies. Thus, the report of examinations and analyses basically equals those of the previous articles of our group (Ringeling et al., 2016; Stanner et al., 2017). The study complied with the rules of the Declaration of Helsinki and was approved by the Institutional Review Board for Human Studies of the Medical Faculty of the Goethe-University Frankfurt/Main (Application# 482/15) and of the Dresden International University (DIU). All participating individuals were informed on risks and benefits as well as the procedures of the study and gave written informed consent.

2.2 | Inclusion criteria

- At least 18 years of age.
- Dental implants of type Straumann Soft Tissue Level Implant (Institut Straumann AG; Figure 1a) or Ankylos (Dentsply Sirona Implants; Dentsply Sirona Deutschland GmbH; Figure 1b).
- One dental implant and one contralateral tooth. Contralateral meaning located in the same jaw (maxilla/mandible) and the same region (anterior/premolars/molars). In cases where more than one pair of implant and contralateral tooth were found the more anterior pair was included.
- Written informed consent.

2.3 | Exclusion criteria

- Requirement of systemic antibiotics for measures that may cause transitory bacteraemia (e.g., pocket probing).

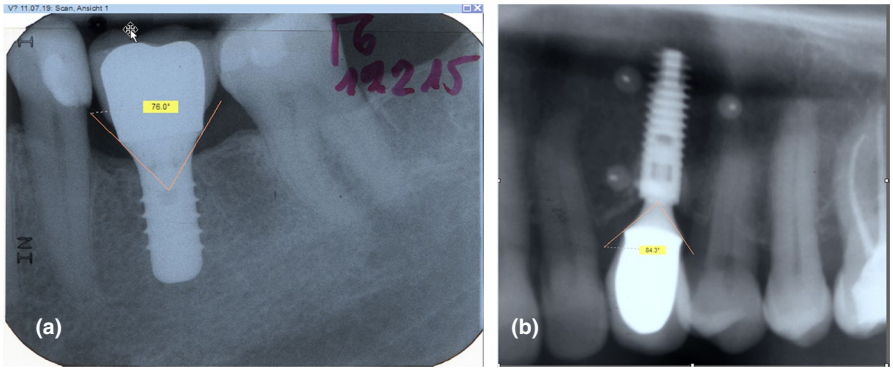

FIGURE 1 (a) Intraoral periapical radiograph of an Soft Tissue Level implant replacing a left mandibular first molar. The vertex of the angle is put in the centre of the silhouette of the apical plane of the intra-implant screw. The legs of the angle are positioned tangentially to the interproximal silhouette of the implant crown. The angle describing the emergence profile is 76°. (b) Part of a panoramic radiograph of an Ankylos implant replacing a left maxillary canine. The vertex of the angle is put in the centre of the silhouette of the platform plane. The legs of the angle were positioned tangentially to the interproximal silhouette of the implant crown and the angle used to describe the emergence profile. The angle describing the emergence profile is 84.3°

All patients were asked for current and former smoking status, diabetes mellitus, and degree of education (secondary modern school [9–10 years of school], college [Abitur: 12–13 years of school], university). Patients who reported smoking or had quit smoking for <5 years were classified as smokers (Lang & Tonetti, 2003). Further, patients were asked for intake of analgesics during the last 7 days.

2.4 | Examinations

Probing pocket depths and PAL were measured at six sites (mesiobuccal, buccal, distobuccal, mesiooral, oral, distooral) at each dental implant and the respective contralateral tooth using a rigid plastic probe with standardised probing force (0.23 N, Click-Probe®; Kerr) to the nearest 1 mm. A randomisation list determined whether the implant or the contralateral tooth was measured first. The information whether implant or tooth was measured first was provided in sealed envelopes that were numbered from 1 to 40 for each of two examiners (PE, PP). Immediately prior to the examination, the envelopes were opened according to the consecutive numbers starting with one for the first enroled participant. Probing parameters were measured at the implant or tooth and immediately thereafter the patients were asked to mark the intensity of discomfort/pain on a visual analogue scale (VAS) of 100 mm (Muller, Moene, Cancela, & Mombelli, 2014; Rollke et al., 2012). The value of 0 stands for no discomfort/pain and 100 mm standing for agonising pain. As measure of discomfort/pain intensity the distances between 0 and the patients' marks were assessed. Thirty seconds after probing BOP and suppuration were scored. Subsequently, probing and discomfort/pain measurements were performed at the contralateral side (implant or tooth) followed by PPD, PAL and BOP assessments at six sites of all the other teeth or implants. In addition, a full mouth plaque score (FMPS) was assessed (Ringeling et al., 2016; Stanner et al., 2017).

2.5 | Radiographs

Radiographs of implants were evaluated if they had been obtained within 6 months prior to or after the clinical measurements. Intraoral periapical and panoramic radiographs were eligible. All radiographs were digitalised using a computer program (SIDEXIS nextGeneration 1.51; Sirona) and a flatbed scanner (Epson Expression 1680pro; Seiko Epson Corp.) with 600 dpi resolution and eight bit grey values. The image files were stored as TIFF files and analysed using the computer program SIDEXIS and a 22' flat screen (NEC MultiSync E224Wi; NEC) in a particular room under exclusion of natural or artificial light except the screen.

Using the angle tool, the vertex of the angle was put in the centre of the silhouette of the apical plane of the intra-implant screw for the Soft Tissue Level implants. The legs of the angle were positioned tangentially to the interproximal silhouette of the implant crown and the angle used to describe the emergence profile (Figure 1a). With the Ankylos implants exhibiting a platform on or a little below bone level this platform was used as reference. Using the angle tool, the vertex of the angle was put in the centre of the silhouette of the platform plane for the Ankylos implants. The legs of the angle were positioned tangentially to the interproximal silhouette of the implant crown and the angle used to describe the emergence profile (Figure 1b). M.S. performed the evaluation of all radiographs. In five radiograph of each type of implants, replicate angle measurements were done.

2.6 | Statistical analysis

The individual patient was used as statistical unit. All analyses were performed on patient level. VAS was defined as the primary endpoint. All other parameters were control variables.

The analysis should focus on the primary endpoint, whereas, the control variables were investigated exploratively.

Both examiners were previously trained and calibrated for PPD and PAL measurements at teeth and implants. In all patients, PPD and PAL at contralateral implant and tooth were measured twice during a 20 min interval. In 50 patients, the second measurement was performed by each of the respective examiners himself (intra-examiner reproducibility). In additional 15 patients, the second measurement was performed by the respective other examiner (inter-examiner reproducibility). Intra- and inter-examiner reproducibility was assessed as standard deviation of single differences for intra-/inter-examiner repeated PPD and PAL measurements. Intra-examiner reproducibility of radiographic angle measurements was assessed as standard deviation of single differences for intra-examiner repeated angle measurements (Cohen & Ralls, 1988).

Sample size calculation was based on VAS means and standard deviations of a previous study (Ringeling et al., 2016; Stanner et al., 2017). To assess a difference of 10.8 mm on the VAS between probing at dental implants and contralateral teeth with a type 1 error $\alpha < .05$ and test power of 80% for an expected standard deviation of 15.5 mm, a minimal sample size of $n = 19$ is required (intra-individual comparison). To assess a difference of 12.0 mm on the VAS between two groups within dental implants (e.g., implant types) and contralateral teeth (e.g., sex) with a type 1 error $\alpha < .05$ and test power of 80% for an expected standard deviation of 13.4 mm, a minimal sample size of $n = 21$ is required (inter-individual comparison; http://biomath.info/power/prt.htm). After experiences with another study (Stanner et al., 2017) the actual sample size was set at $n = 65$.

For each implant and contralateral tooth, the PPD and PAL at the site with the deepest probing and the respective means per implant/tooth were compared. Further, each implant/tooth was characterised by the number of sites with BOP or suppuration. To characterise the periodontal condition of the participants the mean PPD and PAL per individual as well as full mouth bleeding score (FMBS) and FMPS were calculated. Additionally, the percentages of sites with PPD <4 mm, 4–5 mm, and ≥6 mm per participant were calculated.

Due to the fact that the data were not normally distributed with the exception of emergence profile angles they were expressed as

TABLE 1 Patient characteristics in general and according to implant type

	All *N* = 65	Ankylos *N* = 35	Soft tissue level *N* = 30	*p*
Age (years)	69 (63/76)	72 (65.25/76)	66 (59/76)	.174
Female (*n*)	38/58%	23/66%	15/50%	.200
Education (*n*/%)				
8–9 years of school	25/38%	13/37%	12/40%	.016
10 years of school	0	0	0	
High school/college	14/22%	12/34%	2/ 7%	
University graduation	26/40%	10/29%	16/53%	
Number of teeth (*n*)	22 (19/24)	21 (19/24)	23 (21/24)	.211
Current smokers (*n*/%)	11/17%	2/ 6%	9/30%	.009
Pack years (*n*)	0 (0/21.75)	0 (0/31.13)	0.25 (0/8.44)	.477
Anterior teeth/implants (*n*/%)	16/25%	13/37%	3/10%	.011
Maxillary teeth/implants (*n*/%)	35/54%	23/66%	12/40%	.038
PPD/patient (mm)	2.35 (2.6/2.53)	2.33 (1.98/2.45)	2.4 (2.6/2.65)	.093
PAL/patient (mm)	2.77 (2.29/3.2)	2.5 (2.11/2.88)	2.95 (2.75/3.55)	.001
Full mouth plaque score (%)	29 (17.6/44)	19 (12.4/44.28)	35.5 (25/44)	.022
Full mouth bleeding score (%)	8.33 (0.93/17)	1.28 (0/6.93)	17 (12/24)	<.001
PPD <4 mm (%)	94 (90.51/97.23)	94.2 (92.13/97.6)	93.2 (82.6/97.2)	.219
PPD 4–5 mm (%)	4.8 (2.19/8)	3.6 (1.59/7.1)	5.1 (2.4/15.2)	.157
PPD ≥6 mm (%)	0 (0/2.2)	0 (0/1.63)	0.35 (0/2.2)	.553
Discomfort/pain (VAS/mm)	**10 (0.75/16.25)**	**10 (0/20)**	**6 (1/10)**	**.589**
	N = 63	*N* = 34	*N* = 29	
Emergence profile (°)	75.2 ± 15.8	84.3 ± 14.0	64.6 ± 10.3	<.001

Note: Number/frequency; median (lower/upper quartile; mean ± standard deviation).
Abbreviations: PAL, probing attachment level; PPD, probing pocket depths.

medians as well as lower and upper quartiles. Comparisons between implants and teeth were made for dichotomous parameters by McNemar's chi-squared test and for all other parameters by Wilcoxon signed-rank test. Further, clinical data at the implants were calculated for Ankylos and Soft Tissue Level implants separately. To explain the variation of the difference of VAS between teeth and implants, these differences were transformed into a dichotomous variable. The difference between both (implant/tooth) VAS scores was calculated. If the implant VAS was larger than the tooth VAS, this variable was 1 and if not 0. The variation of this variable was analysed using a stepwise backward logistic regression analysis with the following independent variables: whether the implant was measured prior to or after the tooth, gender, age, smoking, intake of analgesics, jaw (maxilla/mandible) and implant position (anterior/posterior). Additionally, implant VAS was also transformed into a dichotomous variable (VAS = 0:0; VAS > 0:1). Then, a backward stepwise logistic regression analysis was done for the dependent variable discomfort/pain (yes/no) and the independent variables examiner, platform switching (yes/no), jaw (maxilla/mandible), emergence profile (angle), sex, sum of BOP sites, and anterior location. For statistical analysis, a PC program was used (Systat™ for Windows version 13; Systat Inc.).

3 | RESULTS

A total of 71 patients were examined contributing 40 Ankylos and 31 Soft Tissue Level implants. Due to incomplete data, five patients contributing Ankylos implants were not included into analysis. Within the Soft Tissue Level implant group a patient contributing a bone level implant was examined. However, the Soft Tissue Level implant group should consist only of implants without platform switching (i.e., tissue level). Thus, this patient was excluded from analysis. Finally, a total of 65 patients (age 69; 63/76 years [median; lower/upper quartile]; 38 females, 11 smokers) were examined (Table 1). In one patient of the Soft Tissue Level group, the protocol was violated. She required antibiotic prophylaxis. However, she was kept in the study because she had to take antibiotics any way due to supportive periodontal treatment and not only due probing in course of this study. P.E. examined 26 patients (21 Soft Tissue Level, five Ankylos), and P.P. examined 39 patients (nine Soft Tissue Level, 30 Ankylos). Intra-individual reproducibility (standard deviation of single measurement: s) of PPD in teeth was 0.29 mm (P.P.), 0.54 mm (P.E.), s of PAL-V (teeth) was 0.38 mm (P.P.), 0.74 mm (P.E.). The respective numbers for implants were as follows: PPD 0.35 mm (P.P.), 0.52 mm (P.E.), PAL-V 0.33 mm (P.P.), 0.67 mm (P.E.). Inter-individual reproducibility

in teeth was 0.5 (PPD), 0.61 (PAL-V) and in implants 0.55 (PPD), 0.73 (PAL-V; Elez, Parvini, Stanner, Klum, & Eickholz, 2018). Radiographs were available for 34 Ankylos and 29 Soft Tissue Level implants. Intra-examiner reproducibility (standard deviation of single measurement: s) of radiographic angle measurements was 1.16° (mean 0.15°).

A total of four patients had diabetes (Soft Tissue Level: 1; Ankylos: 3). Two thirds of the Ankylos group were females whereas 50% of the Soft Tissue Level were female. There were only a few current smokers (17%) in the sample, more in the Soft Tissue Level than in the Ankylos group (p = .009). Periodontal conditions were generally healthy with median amount of PPD <4 mm of 94%. On average, there was more supragingival plaque and gingivitis in the Soft Tissue Level (FMPS 35.5%; FMBS 17%) than the Ankylos group (FMPS 19% [p < .05]; FMBS 1.28% [p < .001]). Median VAS after peri-implant probing at Soft Tissue Level was lower (6) than in the Ankylos group (10). The difference was not significant. The emergence profile measured as angles on radiographs was significantly narrower in Soft Tissue Level (64.6 ± 10.3°) than Ankylos implants (84.3 ± 14.0°; p < .001). Table 1 provides the demographical and general clinical data for all patients as well as for both implant types separately.

With the exception of PPD and PAL at the deepest site (p < .05), clinical parameters (PAL, BOP, suppuration) were well balanced between implants and teeth. None of the teeth exhibited any site with suppuration. Two of the implants showed one site each with suppuration. Peri-implant probing (VAS: 10; 0.75/16.25) caused significantly (p < .001) more discomfort/pain than periodontal probing (4; 0/10; Table 2).

Stepwise backward logistic regression identified a substantial (estimate 1.6) and significant association (p = .003) of discomfort/pain with higher differences between peri-implant and periodontal probing in the maxilla than the mandible (Table 3). None of the other considered factors (whether the implant was measured prior to or after the tooth, gender, age, smoking, intake of analgesics, and implant position [anterior/posterior]) exhibited any significant effect (Table 3). Only considering discomfort/pain (yes/no) after probing at implants stepwise backward logistic regression analysis found location in the maxilla (p = .006) and emergence profile (radiographic angle; p = .015) to significantly influence discomfort/pain (Table 4).

4 | DISCUSSION

Patients experience more discomfort/pain after peri-implant probing than after periodontal probing (Ringeling et al., 2016; Stanner et al., 2017). However, discomfort/pain may be modulated by additional factors. The examiner may play a role (Ringeling et al., 2016) as well as age or the fact whether implant or tooth are probed first (Stanner et al., 2017). The influence of different examiners may be reduced by use of a pressure-controlled probe (Stanner et al., 2017). Other plausible factors putatively influencing discomfort/pain as gender, smoking, intake of analgesics, implant position (anterior/posterior) and frequency of PPD 4–5 mm in the dentition could not be shown to additionally influence discomfort/pain after peri-implant/periodontal probing. Factors that were not investigated yet are platform switching and implant emergence profile. Thus, this study was designed to compare discomfort/pain after peri-implant and periodontal probing in two different implant types: one with and the other without platform switching. The observation that peri-implant probing causes significantly more discomfort/pain than periodontal probing was confirmed. Stepwise backward logistic regression identified a significant association (p = .003) of discomfort/pain with higher differences between peri-implant and periodontal probing in the maxilla than the mandible. The fact whether VAS was higher after peri-implant than periodontal probing was not significantly influenced by any other considered factor. Discomfort/pain (yes/no) between implants was associated with location in the maxilla and emergence profile.

VAS median after peri-implant probing at Soft Tissue Level implants was lower (6) than in the Ankylos group (10). However, the difference failed to be statistically significant. It is plausible that in platform switch implants it may be that the probe gets stuck at the platform instead of being halted between the implant surface and the surrounding tissue due to tissue pressure. Hitting the platform may exert less pain/discomfort than being halted between implant

TABLE 2 Periodontal and peri-implant variables of implants and respective teeth

	Teeth N = 65	Implants N = 65	p
Bleeding on probing sum of six sites (n)	0 (0/1)	0 (0/2)	.150
Suppuration on probing sum of six sites (n)	0 (0/0)	0 (0/0)	.317
PPD deepest site (mm)	3 (3/4)	3 (3/4)	.417
PPD mean of six sites (mm)	2.5 (2.16/2.67)	2.5 (2.17/3)	.048
PAL deepest site (mm)	3 (3/4)	3 (3/4)	.157
PAL mean of six sites (mm)	2.83 (2.32/3.23)	2.5 (2.16/2.87)	.004
Discomfort/pain (VAS/mm)	**4 (0/10)**	**10 (0.75/16.25)**	**<.001**

Note: Median (lower/upper quartile); Wilcoxon signed-rank test.
Abbreviations: PAL: probing attachment level; PPD, probing pocket depths.

TABLE 3 Stepwise backward logistic regression analysis of discomfort/pain (VAS) after periodontal and peri-implant probing

	Estimate	*SE*	*p*
Constant	−0.693	0.387	.074
Maxilla	1.609	0.539	.003

Note: $n = 65$; $\chi^2 = 9.654$; $p = .002$.

TABLE 4 Stepwise backward logistic regression analysis of discomfort/pain (yes/no) after peri-implant probing

	Estimate	*SE*	*p*
Constant	−8.259	2.794	.003
Maxilla	2.538	0.931	.006
Emergence profile (radiographic angle)	0.070	0.029	.015

Note: $n = 63$; $\chi^2 = 14.414$; $p = .001$.

surface and soft tissue. However, this idea is not supported by the data of the present study.

There are different methods to assess intensity of discomfort/pain in general: for example VAS, the Numerical Rating Scale (NRS), Verbal Rating Scale (VRS), and Faces Pain Scale-Revised (FPS-R) (Thong, Jensen, Miro, & Tan, 2018). The VAS is most similar to the NRS and less influenced by non-pain intensity factors than the VRS or FPS-R. Although the VRS and FPS-R ratings both reflect pain intensity, they also contain additional information about pain interference and pain unpleasantness, respectively (Thong et al., 2018). Thus, as other groups (Canakci & Canakci, 2007; Hassan et al., 2005; Rollke et al., 2012), we used a VAS of 100 mm in our recent studies (Ringeling et al., 2016; Stanner et al., 2017). Higher pain sensitivity was scored in anterior teeth than in molars (Heins, Karpinia, Maruniak, Moorhead, & Gibbs, 1998). More Ankylos implants were placed in women, in the anterior region and in the maxilla. These differences may have influenced the comparison between the implant types. However, stepwise backward logistic regression analysis only identified location in the maxilla ($p = .006$) and emergence profile (radiographic angle; $p = .015$) to significantly influence discomfort/pain. By use of a split-mouth design comparing peri-implant probing in each patient to probing around a contralateral (same jaw, same type of tooth) tooth, patient characteristics as, sex and age as well as location of implant/tooth was the same for each comparison. Thus, these factors could not contribute to intra-individual differences between peri-implant and periodontal probing.

Younger individuals have been reported to show higher pain sensitivity than older people (Canakci & Canakci, 2007). A recent study confirmed these results by identifying age as a factor to influence the difference of VAS between implant and tooth. After separating the cohort into two subgroups (<57/≥57 years of age), the difference between VAS in implants and teeth was significantly larger in individuals younger than 57 years ($p = .036$) with younger individuals reporting more discomfort/pain when compared to older patients (Stanner et al., 2017). This observation is not confirmed by this study. Stanner et al. report lower and upper quartiles for age of 47.5/65.5 (Stanner et al., 2017) whereas the present study reports 63/76. The patients of this study are older on average and the dispersion of age is smaller. This may have obscured the effect of age.

Peri-implant and periodontal inflammatory as well as general inflammatory status may also influence discomfort/pain intensity: the higher the degree of periodontal inflammation the more discomfort/pain is elicited by periodontal probing (Heft, Perelmuter, Cooper, Magnusson, & Clark, 1991). However, in the recent (Ringeling et al., 2016; Stanner et al., 2017) and the present study implant- and tooth-based inflammation variables (BOP, mean PPD) were quite balanced between implants and teeth. Thus, it is unlikely that higher VAS after peri-implant than after periodontal probing is due to different levels of peri-implant or periodontal inflammation. General degree of inflammation as assessed as FMBS was significantly higher in the Soft Tissue Level than in the Ankylos group. This is explained by higher levels of supragingival plaque (FMPS) in the Soft Tissue Level than the Ankylos group. There was a difference between VAS median after peri-implant probing at Soft Tissue Level (6) and at Ankylos implants (10). However, VAS was lower in Soft Tissue Level with more inflamed peri-implant tissues and this difference failed to be statistically significant.

The present study introduced an estimate for emergence profile of implant crowns. On radiographs the angle between tangents to the interproximal silhouettes of the implant crowns were used to describe the emergence profile. This profile may have an effect on discomfort/pain elicited by peri-implant probing. The more angulated to the implant axis the periodontal probe is the less deep the probe may enter the peri-implant tissue due to friction with the implant. This may cause less discomfort/pain. On the other hand, a large angle may result in more flexion to the tissue while probing. This may cause more discomfort/pain. This analysis identified emergence profile described by angulation to have a significant and substantial influence on peri-implant discomfort/pain (yes/no): the bigger the angle the more likely was discomfort/pain. The estimate for this correlation was only .07. However, this estimate applies for each additional degree of angulation. A limitation of our method is that it assessed only the interproximal emergence profile of the implants. Buccal or oral emergence was not considered. However, buccally overhanging implant crowns may impair probing and may influence discomfort/pain.

The implant types are not only different with regard to platform switching. They are from different manufactures, they have different shapes, different screws, and different surfaces. Possibly the use of one or the other implant type may have had a certain reason. All these differences may have contributed to different levels of discomfort/pain. The ideal comparison to the Straumann Soft Tissue Level implant would have been the Straumann Bone Level implant. However, Ankylos implants (all with platform switching) and Soft Tissue Level implants were the most prevalent types in the Center for Dentistry and Oral Medicine. Thus, they were chosen for this comparison. Anyway, this analysis failed to find any difference

between implants with or without platform switch regarding VAS indicating minor significance of the above considered differences.

One group has reported gender to influence discomfort/pain elicited by periodontal probing (Canakci & Canakci, 2007). This was not confirmed for periodontal as well as peri-implant probing by another group (Ringeling et al., 2016). In this study, backward stepwise logistic regression also failed to identify an influence of gender on discomfort/pain elicited by probing around implants and teeth. Interestingly, intake of analgesics also failed to have an effect on inter-individual comparisons regarding discomfort/pain.

Three studies including a wide range of implant types show more discomfort/pain after peri-implant than after periodontal probing. This difference is unlikely to be explained by higher degrees of inflammation around implants (BOP, suppuration, PPD) than around teeth. Regarding BOP, suppuration, and PPD test (implants) and control (teeth) were well balanced in all three studies. Structural discrepancies between periodontal and peri-implant tissues may be the reason for the different levels of discomfort/pain after peri-implant and after periodontal probing. Supracrestal periodontal fibres in teeth make a difference between periodontal and peri-implant tissues and may stop the periodontal probe prior to reaching nerve endings.

In the recent (Ringeling et al., 2016; Stanner et al., 2017) as well as the present study clinical parameters (PPD, PAL-V, BOP and suppuration) represent predominantly healthy tissues. The level of discomfort/pain was low, lower than in a previous study (Ringeling et al., 2016) and in the same range as in the other study (Stanner et al., 2017). Although Ringeling et al. (Ringeling et al., 2016) used a simple hand probe, Stanner et al., 2017 (Stanner et al., 2017) and the present study used the pressure calibrated Click-Probe®. The simple hand probe may have been used with more than 0.23 N force in some cases and, thus, resulted in more discomfort/pain. However, discomfort/pain after peri-implant and periodontal probing may be higher in more severely diseased/inflamed tissues.

Within the limits of this study, we may conclude the following.

- Peri-implant probing causes significantly more discomfort/pain than periodontal probing.
- Future studies are required to address the putative influence of peri-implant/periodontal inflammation.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHORS' CONTRIBUTION

P.E. conceived the ideas; P.P., P.E. and M.S. collected the data; P.E. and K.N. analysed the data; and P.E. led the writing; all authors contributed to the writing.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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