Tufts UNIVERSITY | School of Dental Medicine

Effect of implant-abutment emergence profile configuration on peri-implant bone remodeling: A radiographic study

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ABSTRACT

Aims & Hypotheses: The objective of this study was to assess the effect of different abutment and crown configurations on the peri-implant bone level. The hypothesis was that there is a positive association between implant-abutment angulation and marginal bone loss.

Materials & Methods: A total of 242 patients with 283 implants (mean follow-up 5.7 years) were evaluated. Radiographs of implants at baseline and follow-up of at least one year of prosthesis insertion were examined. Variables such as marginal bone loss, abutment angle, and abutment contour were obtained for each implant. Other patient and prosthetic characteristics were collected. Associations between marginal bone loss and abutment angle, abutment contour, and other characteristics were assessed using generalized estimating equations.

Results: Implants prosthesis with an abutment angle above 30^{o} showed significantly greater marginal bone loss than implants with an abutment angle below 30^{o} ($p<0.05$). Restorations with convex contour also showed significantly greater bone loss compared to concave and straight contour surfaces ($p<0.05$). Screw-retained implant prostheses showed significantly greater marginal bone loss compared to cemented retained implant prostheses ($p<0.05$).

Conclusions: Despite the limitations of this study, the results showed that an abutment angle of $>30^{o}$ was a significant risk indicator for marginal bone loss, and convex profile creates an additional risk.

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Introduction

Survival rate and success rates of dental implants are important components for evaluation of dental implant treatment outcome.[1,2] Osteointegration of the implants represent the survival of the implant, while peri-implant soft tissue and peri-implant hard tissue condition are critical for implant success. [3] Marginal bone loss around implant after implant placement and restoration insertion affect long-term implant success. It has been reported that mechanical factors including implant type, design, type of connection, type of abutment and implant surface have an impact on peri-implant bone remolding.[2,3,4,5]

The studies have studied the peri-implant biologic width and found its establishment occurs as the significant change in crestal bone reaction following implant placement.[6,7] It is considered as a physiological process whether one-piece or two-piece implant was placed. (non-submerged vs submerged).[5,8] Marginal bone loss around implants have been shown to be less around diameter-mismatched component (platform-switch) compared to those with butt-joint connection (platform-match).[9,10,11] However, there were also studies showing no significant differences in marginal bone loss regardless of platform-switched or platform-matched design.[12, 13]

Other systemic and local factors may also influence the amount of peri-implant bone loss. Risk factors includes poor oral hygiene, cigarette smoking and history of periodontal disease, systemic disease such as diabetes has also been reported as a risk factor.[4, 14] Excess cement was identified as another potential risk factor for peri-implant bone loss, which is likely due to the remaining cement in the sulcus.[15]

Furthermore, a recent preclinical study compared two different abutment designs on peri-implant bone remodeling after implant placement and with a transmucosal healing. It demonstrated that the implant healing abutment design influenced the establishment of the peri-implant biologic width and the wider and more divergent abutment design induced more bone remodeling.[16] Another recently published randomized prospective clinical trial[17] evaluated the peri-implant crestal bone loss during the osseointegration period, comparing submerged and non-submerged implants with healing abutments of different diameter close to the implant shoulder. The authors concluded that a transmucosal implant placement with a 3.52 mm[2]diameter presented superior results than a 4.5 mm abutment in terms of peri-implant bone remodeling. It was further concluded that there is a clear need for further research into different abutment macro-designs on non-submerged implants.

The restoration contour has been reported to affect periodontal health. Numerous studies have shown that over-contoured restoration is a greater risk factor of interfering with periodontal health on natural teeth compared to under-contoured restorations.[18, 19] Another study showed that natural teeth with straight contour allow the access for well-maintained gingival health whereas the contour with convexity tended to cause plaque-retention due to the inadequate effectiveness of oral hygiene procedures.[20, 21] Some studies have shown that lack of cleanability has an impact on maintaining peri-implant health. Two recent published studies have investigated the abutment angle and abutment contour of implant restorations. The results suggest a shallower abutment angle and the straight or concave abutment contour has minimize the risk for peri-implant bone loss. One of these studies also showed that the middle implant splinted with mesial and distal implants has higher

risk for peri-implant bone loss[22, 23]

Both two studies have studied for various prosthetic features on peri-implant bone remodeling on all the implants including anterior and posterior; single, splinted fixed implant supported prosthesis. However, the combining associations of abutment/crown configuration, or splinted prosthesis are still not clear. The objective of this retrospective study was to assess the effect of different abutment and/or crown configurations on the peri-implant bone level around implants focusing on single, tooth bound implants placed at the posterior side of the mouth.

Aim and Hypothesis

The aims of the present retrospective radiographic study were

(i) to evaluate the association between abutment design and the peri-implant radiographic parameters

(ii) to evaluate the association between other abutment parameters (retention and material) and the peri-implant radiographic parameters

Hypotheses:

- There is a positive association between implant-abutment angulation and marginal bone loss

Significance

This study will provide guidance for clinicians regarding the appropriate implant-abutment design that could potentially maintain peri-implant bone level in the long term. The study will also analyze other factors that could potentially affect the peri-implant bone level and as a consequence the long-term implant stability.

Materials and Methods

This study was designed to analyze retrospectively records of patients who had had implant supported crown in function for more than one year at Tufts University School of Dental Medicine. The study was approved by the Tufts Health Sciences Campus Institutional Review Board. Upon approval, a request was made to the Dental Clinical Services of Tufts Technology Service (TTS) to supply the data. Records of patients who had taken with ADA code with ANY of the CDT code D6058, D6059, D6060, D6061, D6062, D6063, D6064, D6094, D6065, D6066, D6067 and had at least one visit in any of the departments after one year of the treatment (one year after the date of those CDT codes were charged out). The search ranged within 10 years (from 8/29/2007 to 8/29/2017) and IT determined that a maximum patient count of 2560 could be provided. The patients were selected from the oldest to the newest records, in order to obtain a longer follow-up period. An example case is shown in Figure 1.

Inclusion Criteria

- Patients who had implant(s)' radiographs at baseline and at least one year after prosthesis insertion
- a posterior, single, and tooth-bound fixed implant-supported prosthesis; in the case of multiple radiographs from different time periods, the most recent was included.

Exclusion Criteria

- Insufficient clinical records
- Patients who presented teeth with active periodontal disease at the time of implant(s) placement, based on the patients' case note
- Heavy smokers (>10 cigarettes/day) at the time of implant placement

- Patients with conditions and/or current medications at the time of implant placement that could affect bone metabolism or with immunocompromised conditions
- Sites with implant-supported rehabilitations presenting poor marginal adaptation (>0.5 mm mismatch, confirmed through radiographic examination).
- Patients without intra-oral radiographs taken using paralleling technique at the baseline and at least one year of the prosthesis insertion

Data collection

Demographic parameters including age, gender, smoking status (never, past smoker or <10 cigarettes a day), and history of periodontal disease at the time of implant placement based on the case note were obtained. Information regarding the implant features was collected: implant connection (tri-channel or conical), diameter, length and time in function of the implant(s) placed, and tooth type (premolar or molar). Information about type of abutment connection (platform-switched or platform-matched), type of restoration material (PFM, metal and all ceramic) and type of retention (screw-retained or cement-retained) on patients' case notes was also collected. For patients with more than one implant, all of the implants were included. Distance from implant to adjacent teeth (mesial and distal), abutment angle (mesial and distal) and abutment contour (straight, concave and convex) of each implant were obtained.

Radiographic examination

The measurement of marginal bone loss (MBL) and prosthetic features was obtained from the resulting images. The radiographs that presented the best quality were included in the study. Only periapical radiographs were included. Patients presenting only poorly taken radiographs, including inappropriate angulation and/or missing anatomical structures, were not included in the study. The resulting images were analyzed using a computer software (Image J®, National Institutes of Health, Maryland, USA) and calibration for each implant was done based on already known measurements, such as implant length or width. All radiographic files were anonymously filed and measured by one blinded operator.

The amount of bone loss was measured as the difference in bone level between 2 radiographs (baseline and the most recent one after a year of prosthesis insertion) in marginal vertical bone level, marginal horizontal bone level and the area of possible bone loss, on the mesial and distal aspects subsequently, likewise the distance from implant to teeth and abutment angle. The mean value of the two measurements (mesial and distal) was obtained as the variable for each implant. The abutment contour was also obtained from the images.

A volunteer examiner was recruited and calibrated to measure 30 randomly selected implants and showed a high level of intra-rater and inter-rater reliability. (Interclass correlation coefficient >0.8)

Radiographic measurements

1). *Marginal vertical bone level*

defined as the distance, in millimeters, from the implant shoulder to the first or most coronal bone-implant contact point

2). *Marginal horizontal bone level*

measured by the distance, in millimeters, from implant shoulder to the first contact with horizontal bone crest

3). *Distance from implant to teeth*

in millimeters, from the farther point of the implant shoulder to first contact with adjacent teeth

4). *Area of possible bone loss*

in square millimeters, measured by the distance between implant shoulder and bone margin first contacts (horizontal and vertical) and the bone margin extension underneath these two points

5). *Abutment angle*

measured in degrees, by the implant shoulder line and first contact with farther point of the prosthesis.

6). *Abutment contour*

categorized as convex, straight or concave

An example of the measurements is shown in Figure 1.

Statistical Analysis

Marginal bone loss was measured as change in marginal vertical bone level, change in marginal horizontal bone level and change in area of possible bone loss, with each of these variables adjusted by time in function. Specifically, for each of these variables, the amount of change in bone level for each implant was divided by the time in function (years). Therefore, time-adjusted marginal bone loss was collected as *change in marginal vertical bone level per year*, *change in marginal horizontal bone level per year*, and *change in area of possible bone loss per year*. Associations between these time-adjusted marginal bone loss variables and abutment angle and abutment contour were analyzed. Generalized estimating equations were used via the PROC GENMOD procedure in SAS® 9.4 (SAS Institute Inc., Cary, NC, USA) to account for clustering due to the presence of multiple implants for some subjects. Abutment angle was analyzed as a dichotomous variable ($<30^{o}$ vs. $\geq 30^{o}$). Abutment contour was divided into 2 groups: with convex contour on at least one interproximal side, or either concave or straight on at least one interproximal side. Multivariable analyses via generalized estimating equations were also conducted to adjust for potential confounding; the factors in these analyses included the aforementioned dichotomous variables for abutment angle and abutment contour, as well as smoking, history of periodontitis, implant connection, abutment connection, and prosthesis type. Descriptive statistics (frequencies and percentages for categorical variables; means and standard deviations for continuous variables) were also computed. The significance level was set at $\alpha = 0.05$.

Sample Size

A convenience sample was used. A total of 1100 records were reviewed. After excluding the ineligible samples, 242 patients with a total of 283 implants were included in the study.

A power calculation was conducted using the software nQuery Advisor (v. 7.0). The calculation determined the power of the study to detect a difference between the abutment angle groups ($<30^{o}$ vs. $\geq 30^{o}$) in terms of vertical bone level change. The assumed effect size was based on the results of Yi et al.[22] In particular, the assumed mean (SD) vertical bone level change values were 0.60 (0.68) mm and 1.16 (1.21) mm for the $<30^{o}$ group and the $\geq 30^{o}$ group, respectively. The calculation accounted for the clustering induced by the presence of multiple implants for some subjects based on the methodology of Killip et al.[23] Per Killip et al., the intracluster correlation coefficient (ICC) was assumed to be $\rho = 0.01$ or $\rho = 0.02$, with a separate power calculation performed for each value of ρ. Furthermore, as a sensitivity analysis, a third power calculation was conducted with the conservative assumption of a higher value of the ICC, namely, $\rho = 0.10$. Each of the three calculations determined that with the aforementioned sample size of 242 patients and 283 implants (with 178 implants in the $<30^{o}$ group and 105 implants in the $\geq 30^{o}$ group), the power to detect a difference between the groups was greater than 99% alongside a Type I error rate of $\alpha = 0.05$.

Results

Data from a total of 242 patients (131 females and 111 males; aged 32 to 87 years, mean age 62.9 years) were collected, in whom 283 implants were placed between December 2015 and September 2019. The mean follow-up time was 5.7 years, ranging from 1.4 to 14.3 years. All of the implants were placed in bone level with adjacent teeth on mesial and distal side at the posterior quadrant. Implants were supported by single, non-splinted fixed prostheses.

Associations between Time-Adjusted Marginal Bone Loss and Abutment Angle / Contour

Time-adjusted marginal bone loss was analyzed with 3 variables: *change in marginal vertical bone loss per year*, *change in marginal horizontal bone loss per year* and *change in area of possible bone loss per year*.

The mean ± SD abutment angle was 28.08 ± 9.97°. There were 178 implants with angle below 30° (62.9%) and 105 implants with angle above 30° (37.1%). 59.4% of implants had convex contour while 40.6% of implants had either concave or straight contours.

The mean ± SD of change in *marginal vertical bone level per year*, *change in marginal horizontal bone level per year* and *change in area of possible bone loss per year* was 0.28 ± 0.27mm, 0.21 ± 0.20mm and 0.35 ±0.48 mm^2, respectively (Table 1).

Change in Marginal Vertical bone level per year

There was significantly greater *change in marginal vertical bone level per year* in implants with an abutment angle above 30° (0.35 ± 0.30 mm) compared to implants with an abutment angle below 30° (0.24 ± 0.24 mm) ($p = 0.003$). There was also significantly greater *change in marginal vertical bone level per year* in the convex group (0.33 ± 0.29 mm) compared to the concave and straight group (0.23 ± 0.21mm) ($p = 0.001$).

Change in Marginal Horizontal bone level per year

There was significantly greater *change in marginal horizontal bone level per year* in implants with an abutment angle above 30° (0.27 ± 0.25mm) compared to implants with an abutment angle below 30° (0.18 ± 0.15mm) ($p < 0.001$). There was also significantly greater *change in marginal horizontal bone level per year* in the convex group (0.24 ± 0.22mm) compared to the concave and straight group (0.17 ± 0.14mm) ($p = 0.001$).

Change in Area of Possible Bone Loss per year

There was significantly greater *change in area of possible bone loss per year* in implants with an abutment angle above 30° (0.55 ± 0.66 mm^2) compared to implants with an abutment angle below 30° (0.24 ± 0.26mm^2) ($p < 0.001$).There was also significantly greater *change in area of possible bone loss per year* in the convex group (0.44 ± 0.57mm^2) compared to the concave and straight group (0.23 ± 0.24mm^2) ($p < 0.001$).

Patient Factors and Implant Characteristics

None of the marginal bone loss variables exhibited a significant association with gender, history of periodontal disease, smoking, implant connection, or abutment connection. However, with regard to prosthesis type, there was significantly greater bone loss with screw-retained compared to cement-retained in two bone level variables: *change in marginal vertical bone level per year* (screw-retained: 0.30 ±0.29mm; cement-retained: 0.25 ± 0.20mm) ($p = 0.046$) and *change in area of possible bone loss per year* (screw-retained: 0.38 ± 0.54; cement-retained: 0.29 ± 0.30mm) ($p = 0.032$). There was no significant association between any of the marginal bone loss variables and tooth type (premolar vs. molar). There was also no significant association between any marginal bone loss variable and the distance from implant to teeth.

Multivariable Analysis

Multivariable analyses were performed to adjust for potential confounding. Abutment angle ($<30^{o}$ vs. $\geq 30^{o}$) and abutment contour (convex vs. concave or straight) were still significantly associated with each of the three time-adjusted marginal bone loss variables when adjusting for smoking, history of periodontitis, implant connection, abutment connection, and prosthesis type. Additionally, prosthesis type was still significantly associated with *change in area of possible bone loss per year* when adjusting for the other factors.

Discussion

In the present study, prosthetic characteristics regarding abutment/crown configuration of implant supported prostheses were assessed to determine whether these characteristics (in particular, abutment angle and abutment contour) were associated with peri-implant bone loss.

Having an abutment angle ≥30° was significantly associated with greater time-adjusted marginal bone loss as quantified by three variables: *change in marginal vertical bone level per year*, *change in marginal horizontal bone level per year* and *change in area of possible bone loss per year* compared to restorations with abutment angle <30°. Additionally, significantly greater time-adjusted marginal bone loss (as quantified by each of the three aforementioned variables) was found in the group of at least one surface of convex contour compared to the group with either concave or straight contour.

The results suggest that an over-contour implant restoration could be a risk factor for marginal bone loss and have a negative impact on peri-implant health, which supports our primary hypothesis and is in agreement with Katafuchi et al.[22] and Yi et al.'s studies.[23] Our study again provides evidence regarding prosthetic design and abutment/crown configuration in bone-level implants. The implant restoration contour is not only decided by restorative clinicians and lab technicians. The implant position, angulation and diameter also affect the abutment angle and abutment contour of the restorations.

In our study, all of the included 283 implants were placed at the bone level. We did not find any significant association between marginal bone loss and implant

connection or abutment connection. Results showed greater marginal bone loss in the conical connection type compared to tri-channel connection type; and greater marginal bone loss in platform-matched abutment connection compared to platform-switched group. The size of the abutment connection of the platform switching implant is smaller than the diameter of the implant. This concept appears to be beneficial in order to maintain the marginal bone level. [11, 12] However, the data need to be interpreted with caution due to the uneven distribution of the samples with 91.9% of implants having tri-channel connection and 90.1% having platform-matched connection. Further study should be done investigating these variables by having a more even sample distribution.

There was significantly greater marginal bone loss in screw-retained implant compared to cemented retained implant prostheses with regard to *change in vertical bone level per year* and *change in area of possible bone loss per year* (p=0.046, p=0.032, respectively). These findings are not in line with findings reported by Dalago, Schuldt Filho, Rodrigues, Renvert, and Bianchini [15] and Staubli, Walter, Schmidt, Weiger, & Zitzmann[25], but in agreement with studies conducted by Lemos *et al* [26] and Nissan et al. [27] Some studies reported[15] that cement-retained implant prosthesis is a risk factor for peri-implant periodontum and marginal bone loss due to plaque build-up and the gingival inflammation due to residual cement in sulcus. However, with the findings in the present study, a possible explanation for higher marginal bone loss in screw-retained design could be that occlusal loads were transferred in a non-axial manner from the position of access opening and therefore resulted in a higher change in marginal bone level. Furthermore, Lemons et al. [26] also suggested that cement may be better at filling discrepancies at the crown margin, which could absorb the stress and strain

caused by the mismatch at implant-abutment interface and therefore compensate and equalize the uneven distribution of the occlusal load.

With regard to patient factors in the current study, gender, smoking status, and history of periodontal disease had no significant association with marginal bone loss. In the multivariable GEE analysis, abutment angle and abutment contour exhibited significant associations with all three time-adjusted marginal bone loss variables, while prosthesis type was significantly associated with *change in area of possible bone loss per year* while adjusting for other potential confounding variables. These results again confirmed the important roles that abutment angle and abutment contour play in the marginal bone loss around implants.

A limitation of this study was the lack of clinical assessment of peri-implant health. The outcome parameter was the marginal bone loss around implant but not the clinical status of the implants. Therefore, the direct association between restoration contour and peri-implantitis remains unknown. Another limitation is that the amount of marginal bone loss and abutment angle was collected as a mean from the mesial and distal sides instead of using separate data. Abutment contour was also divided into 2 groups as convex surface on at least one interproximal side vs. either concave or straight contour. This might cause error resulting from discrepancies of data collected on different interproximal sides. Finally, some variables (such as implant connection and abutment connection) exhibited uneven distributions among the categories within those variables.

Conclusion

Within the limitations of this radiographic retrospective study, the following conclusions can be drawn:

(1) Implants with abutment angle ≥30° showed significantly greater bone loss compared to those with abutment angle <30°

(2) Restoration with convex contour showed significantly greater bone loss compared to concave and straight contour surfaces

(3) With and without adjustment for confounding factors, screw-retained implant prostheses showed significantly greater change in area of possible bone loss per year compared to cement-retained prostheses

APPENDICES

Appendix A: Tables

Appendix B: Figures

Appendix A: Tables

Table 1. Associations between time-adjusted marginal bone loss variables and abutment angle / contour

		Marginal bone loss (time-adjusted)					
	N (%)	*Change in marginal vertical bone level per year*	p	*Change in marginal horizontal bone level per year*	p	*Change in area of possible bone loss per year*	p
Mean (SD)		0.28 (0.27)		0.21 (0.20)		0.35 (0.48)	
Abutment angle	***283 (100%)***						
$< 30^o$	178 (62.9%)	0.24 (0.24)	***0.003***	0.18 (0.15)	***<0.001***	0.24 (0.26)	***<0.001***
$\geq 30^o$	105 (37.1%)	0.35 (0.30)		0.27 (0.25)		0.55 (0.66)	
Abutment contour	***283 (100%)***						
Convex	168 (59.4%)	0.33 (0.29)	***0.001***	0.24 (0.22)	***0.001***	0.44 (0.57)	***<0.001***
Concave or straight	115 (40.6%)	0.23 (0.21)		0.17 (0.14)		0.23 (0.24)	

* P-values obtained via generalized estimating equations (with separate analyses conducted for each factor)

Table 2. Associations between time-adjusted marginal bone loss variables and patient factors / implant characteristics*

		Marginal bone loss (time-adjusted)					
	N (%), mean	*Change in marginal vertical bone level per year*	p	*Change in marginal horizontal bone level per year*	p	*Change in area of possible bone loss per year*	p
Mean (SD)		0.28 (0.27)		0.21 (0.20)		0.35 (0.48)	
Gender	***242 (100)***						
Female	131 (54.1)	0.25 (0.22)	***0.072***		***0.267***		***0.102***
Male	111 (45.9)	0.32 (0.31)					
Age	***242 (100)***						
Mean (SD)	62.9 (12.3)						
Smoking	***242 (100)***						
Never	211 (87.2)	0.28 (0.26)		0.21 (0.20)		0.34 (0.46)	
Past smoker	11 (4.5)	0.37 (0.44)	***0.467***	0.20 (0.20)	***0.746***	0.54 (0.88)	***0.489***
< 10 cigarettes/day	20 (8.3)	0.33 (0.27)		0.24 (0.18)		0.43 (0.36)	
History of Periodontitis	***242 (100)***						
No	112 (46.3)	0.30 (0.28)	***0.585***	0.23 (0.22)	***0.164***	0.39 (0.50)	***0.398***
Yes	130 (53.7)	0.27 (0.257)		0.20 (0.18)		0.32 (0.45)	
Implant connection	***283 (100)***						
Tri-channel	260 (91.9)	0.28 (0.25)	***0.341***	0.21 (0.19)	***0.339***	0.34 (0.43)	***0.281***
Conical	23 (8.1)	0.37 (0.44)		0.26 (0.25)		0.55 (0.83)	
Abutment connection	***283(100)***						

Platform-match	255 (90.1)	0.28 (0.25)	*0.852*	0.21 (0.19)	*0.821*	0.34 (0.43)	*0.505*
Platform-switch	28 (9.9)	0.29 (0.40)		0.22 (0.24)		0.44 (0.77)	
Prosthesis type	***283(100)***						
Screw-retained	194 (68.6)	0.30 (0.29)	*0.046*	0.22 (0.22)	*0.101*	0.38 (0.54)	*0.032*
Cement-retained	89 (31.4)	0.25 (0.20)		0.19 (0.14)		0.29 (0.30)	
Location	***283(100)***						
Maxilla	133 (47)	0.29 (0.25)	*0.78*	0.18 (0.13)	*0.073*	0.29 (0.28)	*0.048*
Mandible	150 (53)	0.27 (0.27)		0.23 (0.24)		0.38 (0.56)	
Tooth type	***283(100)***						
Premolar	125 (44.2)	0.27 (0.24)	*0.442*	0.21 (0.16)	*0.702*	0.30 (0.31)	*0.060*
Molar	158 (55.8)	0.29 (0.28)		0.22 (0.22)		0.40 (0.57)	
Distance from implant to teeth	3.24 (1.21) (mean, SD)		*0.380*		*0.163*		*0.138*

* P-values obtained via generalized estimating equations (with separate analyses conducted for each factor)

Table 3. P-values of multivariable analyses examining associations between various factors and time-adjusted marginal bone loss variables, adjusting for potential confounding*

	Marginal bone loss (time-adjusted)		
	Change in marginal vertical bone level per year: p-values	Change in marginal horizontal bone level per year: p-values	Change in area of possible bone loss per year: p-values
Smoking	0.680	0.965	0.678
History of periodontal disease	0.339	0.062	0.131
Implant connection	0.184	0.473	0.511
Abutment connection	0.459	0.918	0.646
Prosthesis type	0.072	0.161	0.030
Abutment angle	0.039	0.003	<0.001
Abutment contour	0.018	0.010	0.004

* Multivariable analyses conducted via generalized estimating equations

Appendix B: Figures

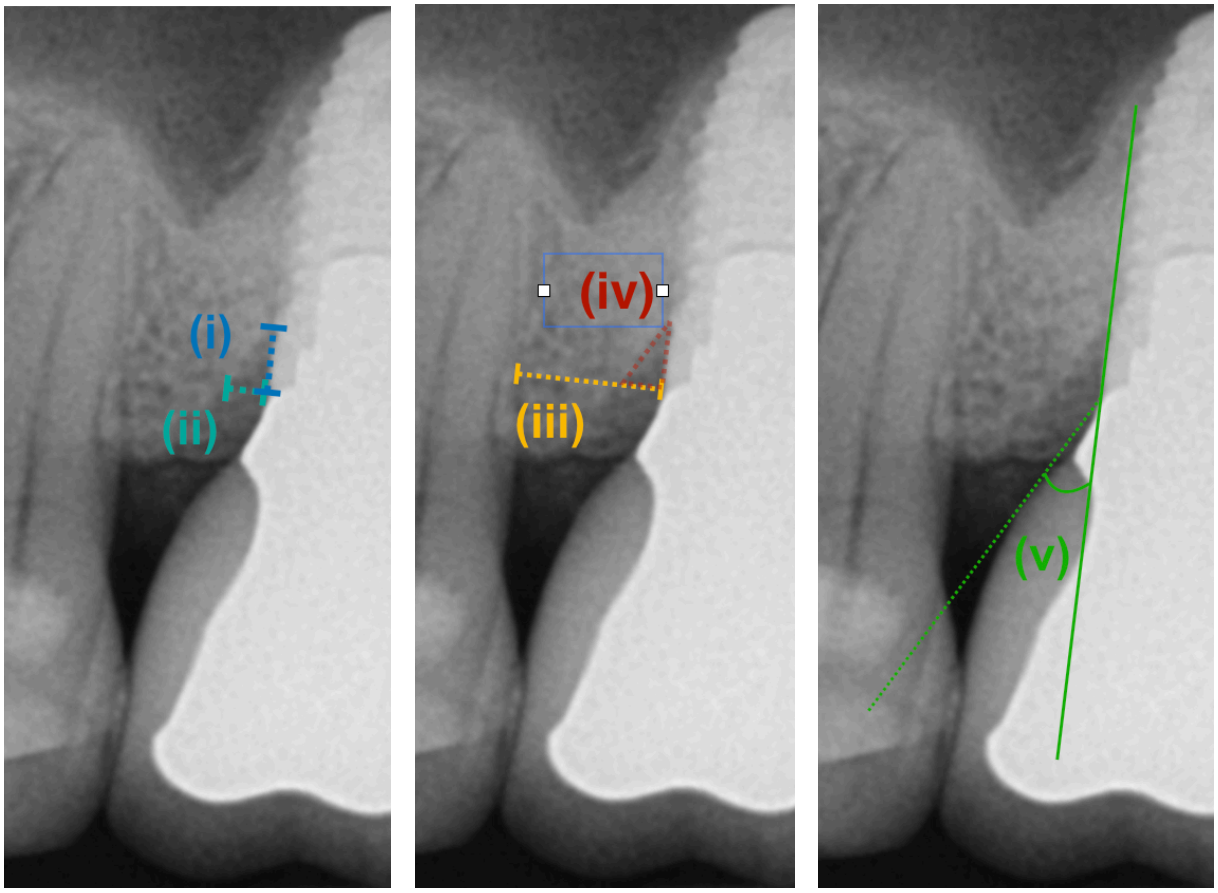

Figure 1. Example of the radiographic measurements of (i) marginal vertical bone level (ii) marginal horizontal bone level (iii) distance from implant to teeth (iv) area of possible bone loss (v) abutment angle

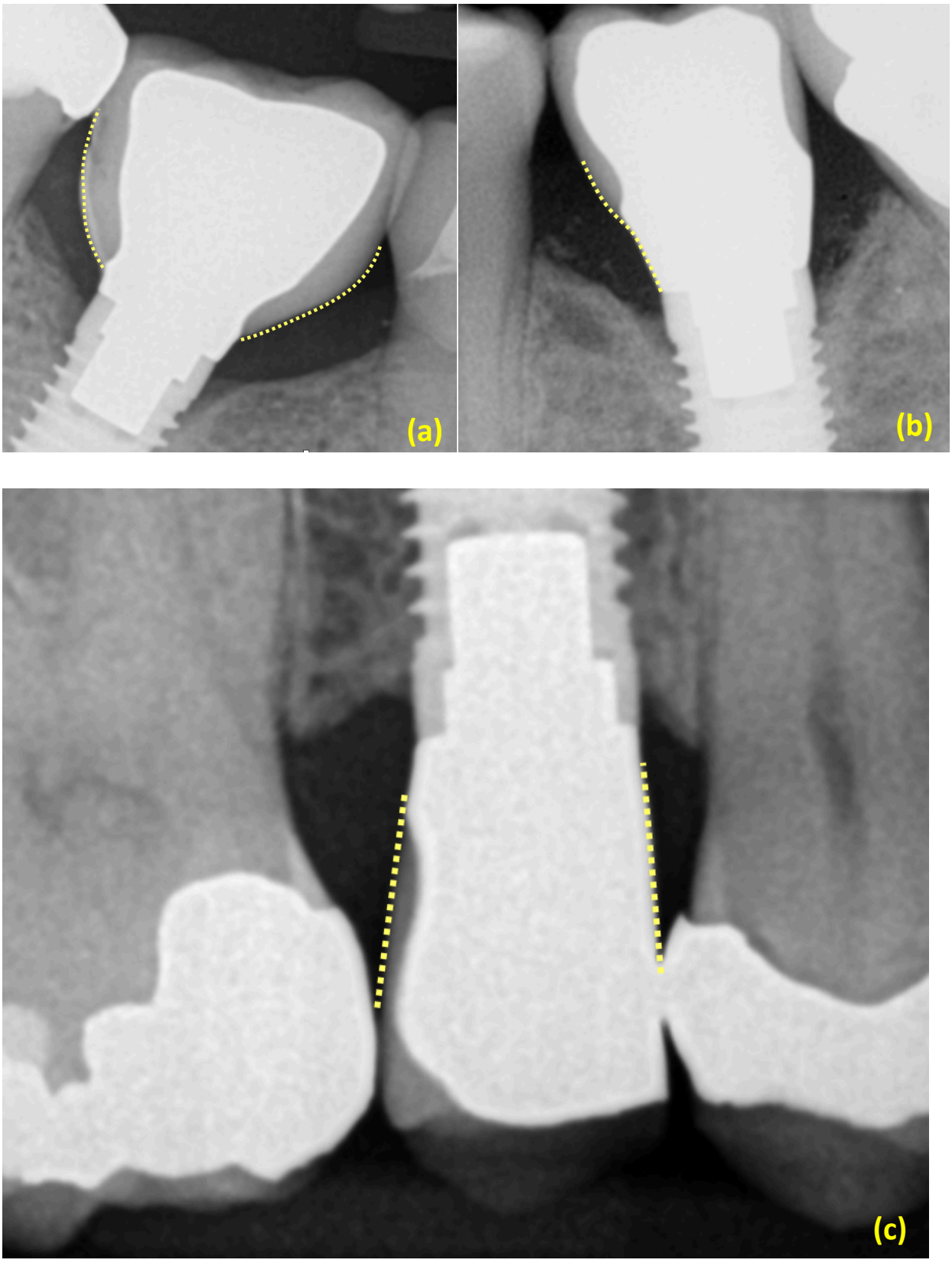

Figure 2. Example of assessment of abutment contour (a) convex (b) concave (c)straight

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