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Dimensional changes of peri-implant soft tissue over 2 years with single-implant crowns in the anterior maxilla

German O. Gallucci[1], Linda Grütter[2], Sung-Kiang Chuang[3] and Urs C. Belser[2]

[1]Department of Restorative Dentistry and Biomaterials Sciences, Harvard School of Dental Medicine, Harvard University, Boston, MA, USA; [2]Department of Fixed Prosthodontic and Occlusion, School of Dental Medicine, University of Geneva, Geneva, Switzerland; [3]Department of Oral and Maxillofacial Surgery, Massachusetts General Hospital, Harvard School of Dental Medicine, Harvard University, Boston, MA, USA

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Abstract

Objective: To compare the peri-implant soft tissue dimensions after insertion of single-implant crowns in the anterior maxilla.

Materials and Methods: Twenty patients were accepted according to well-defined inclusion criteria and randomized to porcelain-fused-to-metal (PFM) or all-ceramic groups. Follow-up was at: Baseline (B), Crown Insertion (CI), 1-year (1Y), and 2-year (2Y). The following parameters were statistically analysed: distance implant shoulder to marginal peri-implant mucosa (DIM), papilla height (PH), width of keratinized mucosa (KM), crestal bone level (CBL), full mouth plaque score (FMPS), full mouth bleeding score (FMBS), and probing pocket depth.

Results: Between groups measurements for DIM, PH, KM, CBL, FMPS, and FMBS showed no statistically significant differences except the distal CBLs to adjacent tooth. DIM (mid-facial) decreased from B to CI remaining stable at 1Y and 2Y (p-value 0.0014). DIM mesial and distal aspects significantly increased from B to CI showing signs of stability at the 2Y. PH between B and CI increased at the mesial site and at the distal site, thereafter, peri-implant soft tissues were stable at the 2Y.

Conclusion: The insertion of an implant crown affects the peri-implant mucosa morphology by an apical displacement at the mid-facial aspect and coronal at mesial and distal sites.

Key words: dental implants; DIM; emergence profile; interproximal papilla; peri-implant soft tissue; single-implant crown

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The anatomical composition of the peri-implant mucosa has been shown to be similar to the gingival tissue (Berglundh et al. 1991, Berglundh et al. 1992, Buser et al. 1992, Tonetti et al. 1994, Cochran et al. 1997a, b, Hermann et al. 1997, Weber & Cochran, 1998). After implant placement in a non-submerged approach or after a second stage abutment connection in a submerged placement protocol, the edentulous mucosa directly interacts with healing abutments and implant crowns. In this context, any changes in the dimensions or characteristics of the implant-prosthetic components would affect the final tri-dimensional morphology of the peri-implant soft tissue. Nisapakultorn et al. (2010) assessed the facial marginal mucosal and papilla level around anterior single-tooth implants. The authors concluded that the papilla level was influenced by the interproximal bone level at the adjacent teeth. The facial marginal mucosal level was affected by peri-implant biotype, facial bone level, implant angulations, interproximal bone level, depth of implant platform, and level of the first bone-to-implant contact. Conversely, in a narrative review assessing soft tissue management, Cairo et al. (2008) concluded that bone level, keratinized mucosa (KM), and implant features have not been associated factors with mucosal recession around anterior implants.

Scientific evidence about the influence of the transmucosal portion of the implant-prosthetic complex assessing aesthetic parameters of single-implant

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anterior rehabilitations is of good level (Andersson et al. 2003, Jung et al. 2008, Sailer et al. 2009). The underlying implant/prosthetic components have also been investigated as a stability factor for peri-implant soft tissue in the aesthetic zone. In a clinical study investigating the early inflammatory response to mucosa-penetrating abutments with different surface roughness, Wennerberg et al. (2003) found no relation between inflammatory response and abutment surface roughness after 4 weeks.

It is well-established that a harmonious integration between implant-prosthetic components and surrounding soft tissue is essential for achieving aesthetic integration. In this context, several methods to assess the aesthetic outcome of single-tooth implant rehabilitations in the anterior maxilla have been proposed (Furhauser et al. 2005, Meijer et al. 2005, Belser et al. 2009). However, limited data is still available regarding the dimensional changes of peri-implant soft tissue before and after delivering single implant crowns in the anterior maxilla and its effect on the long-term aesthetic outcome.

The aim of this clinical trial is to compare the peri-implant soft tissue morphology before and after insertion of screwed-retained single-implant crowns. The hypothesis of this investigation is that the delivery of different implant crowns affects the morphology and marginal location of the peri-implant soft tissue.

Materials and Methods

Twenty patients were invited to participate in this study and signed a consent form. This study was approved by the Ethical Committee of School of Dental Medicine – University of Geneva and was in accordance with ethical principles of the World Medical Association Declaration of Helsinki.

General inclusion criteria were age >21 years, absence of relevant medical conditions, absence of periodontal disease, and availability for 2 years follow-up. General exclusion criteria were heavy smokers (>10 cigarettes/day). Specific inclusion criteria were one missing tooth in the anterior maxilla (First bicuspid to first bicuspid), presence of two intact adjacent teeth, adequate native bone to achieve implant primary stability, facial keratinized mucosa width of at least 2 mm, Full Mouth Plaque Scores (FMPS) and Full Mouth Bleeding Scores (FMBS) $<25\%$. Specific exclusion criteria were adjacent implants, presence of periapical radiolucency at the adjacent teeth, missing adjacent teeth.

The participants were under investigation at: *Baseline (B)* – defined as 2 months after implant placement and before any soft-tissue conditioning or prosthodontic treatment was rendered; *Crown Insertion (CI)* – defined as 2 weeks after the delivery of the crown but no later than 1 month; *1-year follow-up (1Y)* – defined as within the 12th month follow-up after crown insertion; and *2-year follow-up (2Y)* – defined as within the 24th month follow-up after crown insertion.

All patients received soft tissue level implants (Straumann Co., Basel, Switzerland). The implants were placed on healed sites and the vertical location of the implant shoulder was established at 2 mm apical of a line connecting the cement–enamel junction of the adjacent teeth. Special attention was given to ensure the presence of adequate bone volume at the buccal aspect of the implant. A minimum healing period of 2 months was allowed before beginning the prosthetic phase. The implant crown fabrication was divided in two groups according to a randomization sequence: (1) screwed-retained all-ceramic crowns were fabricated using an in In-Ceram block (synOcta®-In-Ceram-blank, and synOcta® abutment, Straumann Co.) and (2) screwed-retained Porcelain-Fused-to-Metal (PFM) crowns was fabricated using a cast-on gold coping (synOcta®-gold coping crown and synOcta® abutment, Straumann Co.).

At each investigational appointment the following parameters were assessed:

Distance to the implant shoulder to the marginal peri-implant mucosa (DIM). After removing the screwed-retained implant crown, DIM measurements were clinically carried out at mid-facial, mesial, mid-lingual, and distal aspects to the nearest millimetre using a periodontal probe (Hu-Friedy, PCP, Chicago, IL, USA) (Fig. 1). Positive values corresponded to a submucosal position of the implant shoulder. Figure 2 shows the morphological change in peri-implant soft tissue at B and 2Y after crown insertion.

Papilla height (PH) was measured on study casts from the most apical point of the gingival line at the adjacent teeth to the most coronal point on the mesial and distal papilla at the implant site.

KM was clinically assessed with a periodontal probe at the mid-facial aspect of the implant site and adjacent teeth.

Crestal bone level (CBL) at adjacent teeth was measured on standardized radiographs taken at each investigational appointment. The digital peri-apical radiographs were measured using a

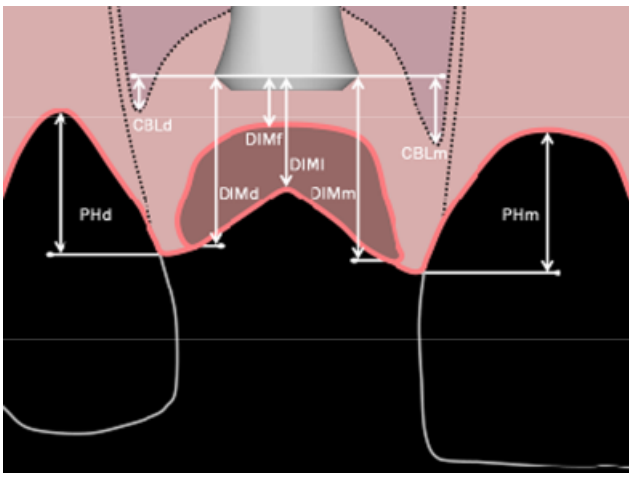

Fig. 1. Graphic representation of measurements at the implant site and adjacent teeth. DIMf, distance to the implant shoulder to the marginal peri-implant mucosa at mid-facial; DIMd, distance to the implant shoulder to the marginal peri-implant mucosa at distal; DIMl, distance to the implant shoulder to the marginal peri-implant mucosa at mid-lingual; DIMm, distance to the implant shoulder to the marginal peri-implant mucosa at mesial; PH, distance between the mesial (m) and distal (d) papilla and the zenith of the mid-facial gingival margin of the adjacent teeth; CBL, distance between the implant/abutment connection (micrograph) to the most coronal crestal bone detectable on the radiographs at the distal (d) and mesial (m) interproximal sites.

public domain Java imaging measuring software (ImageJ, National Institute of Health). CBL measurement was defined as the vertical distance from the implant /abutment connection (micrograph) to the most coronal crestal bone detectable on the radiographs at the interproximal aspect of the adjacent teeth. This measurement was considered positive when the CBL was located coronal to the implant/abutment connection.

FMPS and *FMBS* were assessed at each investigational appointment.

Probing pocket depth (PPD) was measured at mesial and distal aspects of teeth adjacent to the implant under investigation. Results were calculated in percentage of PPD values within the following groups: 1–3, 4–5, and >5 mm.

Statistical analysis

Descriptive statistics were computed for all of the study variables. Repeated longitudinal measurements using linear mixed effects models for continuous outcomes were computed using a statistical software (SAS Version 9.2 2008, SAS, Cary, NC, USA) accounting for correlated subject repeated measurements during the follow-up time with the command proc mixed with the option of exchangeable (compound symmetry) correlation matrix. The SAS statistical software was used to compare DIM, PH, KM, CBL, FMPS, and FMBS between the groups longitudinally at B, CI, 1Y, and 2Y time points. In addition, all parameters utilizing information for all groups were analysed to compare the difference between study time points accounting for the repeated measurements for the same subject. Statistically significant differences were indicated at a p-value <0.05.

Results

Twenty patients participated in the study and they were equally allocated to the all-ceramic crowns group and PFM group (Table 1). Three drop outs were recorded at the second year follow-up. No implant or prosthodontic failures occurred during the duration of the study and no unexpected events were recorded during the length of the study.

Between groups measurements for DIM, PH, KM, and CBL are presented in Table 2. No statistically significant differences at each time point were observed for DIM (all sites), PH, CBL, and KM except the distal CBL when comparing PFM and all-ceramic group mean values.

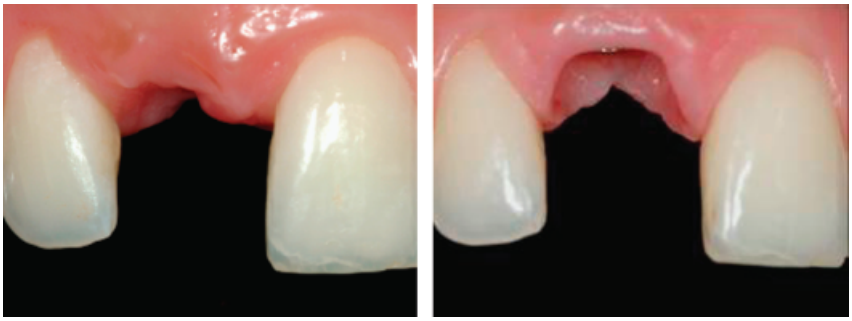

Fig. 2. (A) Peri-implant soft tissue before crown insertion. (B) Peri-implant soft tissue morphology after crown insertion.

Table 1. Patient allocation to all-ceramics and PFM groups by age, gender, and implant position

	Age	Gender		Implant position (anterior maxilla)			
		female	male	C. incisor	L. incisor	canine	premolar
PFM	37.0	7	3	5	3	1	1
All-ceramic	44.1	6	4	6	1	1	2
Overall	40.6	13	7	11	4	2	3

PFM, porcelain-fused-to-metal.

The FMPS was of $13.73 \pm 8.10\%$ for the PFM group and $14.36 \pm 5.73\%$ for the all-ceramic goup at B. At CI, $13.09 \pm 6.92\%$ for the PFM group and $12.14 \pm 6.06\%$ for the all-ceramic group. At 1Y, $13.25 \pm 6.86\%$ and $12.55 \pm 5.97\%$ for the PFM and all-ceramic group, respectively. The FMPS was of $9.79 \pm 3.79\%$ for the PFM group and $11.90 \pm 4.34\%$ for the all-ceramic group at 2Y. FMPS was not statistically significant between groups (p-value, 0.97).

The FMBS was of $5.46 \pm 3.71\%$ for the PFM group and $7.94 \pm 5.02\%$ for the all-ceramic goup at B. At CI, $6.39 \pm 4.71\%$ for the PFM group and $5.12 \pm 2.63\%$ for the all-ceramic group. At 1Y, $10.81 \pm 6.51\%$ and $9.04 \pm 4.52\%$ for the PFM and all-ceramic group, respectively. The FMBS was of $9.80 \pm 5.24\%$ for the PFM group and $8.01 \pm 5.01\%$ for the all-ceramic group at 2Y. FMBS was not statistically significant between groups (p-value: 0.76).

The PPD values at the interproximal sites of the teeth adjacent to the investigational implants were as follows; 100% within 1–3 mm for both groups (mesial and distal tooth) at B and CI. At 1Y, 96.4% of the PFM and 90.6% of the all-ceramic group were within 1–3 mm and within 4–5 mm PPD values were 3.57% (PFM) and 9.38% (all-ceramic) for the mesial adjacent tooth. For the distal adjacent tooth at 1Y all measurements were 100% within 1–3 mm. At 2Y, the PPD values for the mesial adjacent tooth were 100% (PFM) and 95% (all-ceramic) within 1–3 mm and 5% within 4–5 mm for the all-ceramic group. Values at the distal adjacent tooth at 2Y were 93.7% (PFM) and 100% (all-ceramic) within 1–3 mm and 6.25% within 4–5 mm for the PFM group.

The mean difference for all groups combined comparing parameters between B to CI, CI to 1Y, 1Y to 2Y are presented in Table 3. Comparative outcome for DIM values at all time-points are presented in Fig. 3. The mean DIM at the mid-facial aspect decreased from B to CI remaining stable at 1Y and 2Y (p-value 0.0014). DIM values at the mesial aspect significantly increased from B to CI showing signs of stability at the 2Y (p-value <0.0001). The DIM at the lingual aspect failed to show any statistically significant differences at all time-points (p-value 0.542). At the distal aspect, the

Table 2. Comparison of DIM, PH, CBL, KM, between groups accounting for the overall follow-up time period including time points from B, CI, 1Y, to 2Y

	Baseline		Crown insertion		1-Year		2-Year		*p-value*
	PFM	all-ceramic	PFM	all-ceramic	PFM	all-ceramic	PFM	all-ceramic	
Distance from implant margin to marginal mucosa (mm)									
Buccal	2.60 ± 0.81	2.60 ± 0.97	1.90 ± 0.77	1.85 ± 0.75	1.75 ± 0.86	2.00 ± 0.82	1.64 ± 1.03	2.10 ± 0.88	0.72
Mesial	3.25 ± 0.42	3.25 ± 0.63	4.25 ± 1.09	4.70 ± 1.06	4.70 ± 0.82	5.30 ± 0.82	4.43 ± 0.98	5.30 ± 0.67	0.08
Lingual	2.25 ± 0.72	2.30 ± 0.86	1.85 ± 0.58	2.25 ± 0.86	1.95 ± 0.90	2.20 ± 0.79	1.79 ± 0.91	2.30 ± 0.82	0.36
Distal	2.50 ± 0.47	2.60 ± 0.97	3.50 ± 0.82	3.50 ± 0.94	3.60 ± 0.84	3.40 ± 0.84	4.00 ± 0.58	3.50 ± 0.97	0.82
Papilla height (mm)									
Mesial	2.48 ± 1.23	2.95 ± 0.89	2.86 ± 0.77	3.43 ± 1.08	3.22 ± 0.62	3.66 ± 1.00	3.71 ± 0.51	4.02 ± 1.03	0.18
Distal	2.25 ± 1.03	2.36 ± 0.74	2.94 ± 0.81	2.67 ± 0.69	3.26 ± 0.63	2.77 ± 0.69	3.04 ± 0.79	2.83 ± 0.67	0.48
Crestal bone level (mm)									
Mesial adjacent tooth	1.03 ± 0.90	0.86 ± 1.16	0.88 ± 0.83	1.01 ± 1.27	0.96 ± 0.78	1.01 ± 1.26	0.99 ± 0.89	0.83 ± 1.30	0.92
Distal adjacent tooth	−0.19 ± 0.37	−0.71 ± 0.46	−0.28 ± 0.36	−0.72 ± 0.53	−0.39 ± 0.49	−0.76 ± 0.40	−0.54 ± 0.54	−0.84 ± 0.41	0.03
Width keratinized mucosa (mm)									
Mesial adjacent tooth	4.30 ± 1.16	3.90 ± 1.37	4.25 ± 1.65	4.20 ± 1.14	4.00 ± 1.33	4.60 ± 1.78	4.29 ± 1.25	4.30 ± 1.06	0.98
Implant site	5.30 ± 1.16	4.50 ± 1.51	4.55 ± 1.74	4.50 ± 1.43	5.00 ± 0.94	4.60 ± 1.51	4.71 ± 0.95	4.80 ± 0.92	0.47
Distal adjacent tooth	4.20 ± 1.48	4.00 ± 0.94	3.90 ± 1.37	4.40 ± 1.07	4.90 ± 1.52	4.50 ± 1.27	4.86 ± 1.35	4.50 ± 0.97	0.81

All data are presented as mean ± SD.

p-value = 0.05.

CBL, crestal bone level; DIM, distance from implant margin to marginal mucosa; KM, keratinized mucosa; PFM, porcelain-fused-to-metal; PH, papilla height.

DIM value showed an increase from B to CI with no considerable changes thereafter (p-value <0.0001).

The mean PH between B and CI increased at the mesial site and at the distal site (p-value <0.0001). Thereafter, peri-implant soft tissue stability was observed at the 2Y.

Mean values for the CBL was only significant for the distal adjacent tooth (p-value <0.0461). Mean values for of KM and FMPS were not statistically significant among all compared time points with exception of FMBS (p-value 0.0027).

Discussion

Understanding the dimensional changes at the peri-implant mucosa level for single implant crowns in the anterior maxilla is of paramount importance to achieve aesthetic integration. In a similar study but including edentulous patients with immediate loading, Gallucci et al. (2007) demonstrated that the dimensional changes at the peri-implant mucosa level were significant after the insertion of an implant rehabilitation with anatomically correct emergence profile. The peri-implant soft tissue health has also been investigated by Giannopoulou et al. (2003). The authors assessed the DIM among other peri-implant/periodontal parameters in 61 implants after at least 1 year of receiving the final implant crowns. Similar to the results presented in this study, the authors showed that the DIM values for interproximal site were significantly higher that mid-facial site and this measurement was stable at long-term follow-up. The authors concluded that the intracrevicular position of the restoration margin does not appear to adversely affect peri-implant health and stability.

Results from the two crown types presented in this study may represent a limitation due to the clinical trial design. The submucosal margin of the PFM crowns presented a thin collar of gold alloy conversely to the all-ceramic group, which was made completely in ceramic. Nonetheless, most of the intracrevicular portion of the screwed retained crowns for both groups was composed of ceramic veneering. In this context, the crown type may not be an influential factor for the achievement of healthy peri-implant soft tissues. A similar comparison was proposed by Jung et al. (2008) to test the colour-change effect of all-ceramic restorations compared with PFM restorations on

Table 3. Comparison of DIM, PH, CBL, KM, for all groups accounting for the overall follow-up time period including time points from B, CI, 1Y, to 2Y

	All groups				*p-value*
	baseline	crown insertion	1-year	2-year	
Distance from implant margin to marginal mucosa (mm)					
Buccal	2.60 ± 0.87	1.88 ± 0.74	1.88 ± 0.83	1.91 ± 0.94	0.0014
Mesial	3.25 ± 0.53	4.48 ± 1.07	5.00 ± 0.86	4.94 ± 0.90	<0.0001
Lingual	2.28 ± 0.77	2.05 ± 0.74	2.08 ± 0.83	2.09 ± 0.87	0.542
Distal	2.55 ± 0.74	3.50 ± 0.86	3.50 ± 0.83	3.71 ± 0.85	<0.0001
Papilla height (mm)					
Mesial	2.72 ± 1.07	3.14 0.96	3.44 ± 0.84	3.90 ± 0.84	<0.0001
Distal	2.30 ± 0.88	2.80 0.74	3.01 ± 0.69	2.92 ± 0.71	<0.0001
Crestal bone level (mm)					
Mesial adjacent tooth	0.94 ± 1.02	0.94 ± 1.05	0.98 ± 1.02	0.89 ± 1.12	0.918
Distal adjacent tooth	− 0.45 ± 0.49	− 0.50 ± 0.50	− 0.58 ± 0.48	− 0.72 ± 0.48	0.0461
Width keratinized mucosa (mm)					
Mesial adjacent tooth	4.10 ± 1.25	4.23 ± 1.38	4.30 ± 1.56	4.29 ± 1.10	0.738
Implant site	4.90 ± 1.37	4.53 ± 1.55	4.80 ± 1.24	4.76 ± 0.90	0.580
Distal adjacent tooth	4.10 ± 1.21	4.15 ± 1.23	4.70 ± 1.38	4.65 ± 1.11	0.050

All data are presented as mean ± SD.

p-values = 0.05.

CBL, crestal bone level; DIM, distance from implant margin to marginal mucosa; KM, keratinized mucosa; PFM, porcelain-fused-to-metal; PFM, porcelain-fused-to-metal; PH, papilla height.

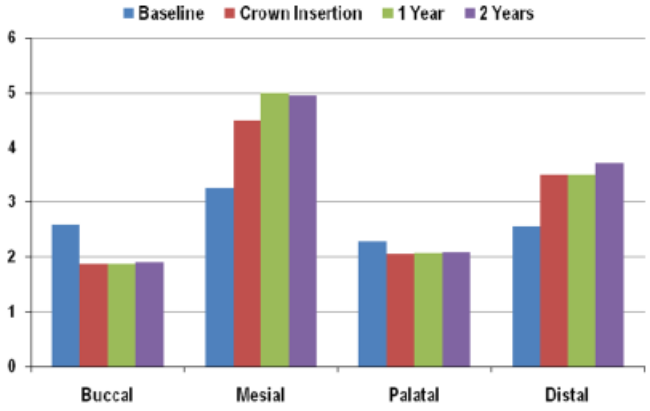

Fig. 3. DIM dimensional dhanges at buccal, mesial, palatal, and distal sites for each time point (in mm).

marginal peri-implant soft tissue. The authors failed to show significant differences between the two groups but the all-ceramic group was found to better match the natural dentition.

Data assessed in this present study yielded significant results when comparing the peri-implant soft tissue dimensions before and after the insertion of an implant-crown for both groups. As shown in Fig. 2, the peri-implant soft tissue reacted to the insertion of an anatomically correct implant crown by adopting the morphology of the crown transmucosal portion so-called emergence profile. DIM dimensional changes were significant for all sites from B to CI with the exception of the Palatal aspect. Thus, the mid-facial margin of the peri-implant mucosa was apically displaced from B to CI and no further significant changes were observed at later follow-up appointments. At the interproximal sites, DIM values increased in a coronal direction showing significant changes from B to CI. From CI to 2Y the DIM values were unchanged at all four sites. Clinically, it was observed that at the crown insertion the peri-implant soft tissue presented a transitory ischaemia and generally opened interproximal spaces. Later, these interproximal spaces were filled with peri-implant soft tissue. These changes could be explained by the pressure exerted by the implant crown emergence profile causing a displacement of the peri-implant soft issue into the interproximal areas. This could also have been induced by an inflammatory reaction of the mucosa around the implants but the monitoring of periodontal parameters such as PPD, FMPS, FMPS, and KM, showed signs healthy peri-implant soft tissue throughout the length of this study. In consequence, this morphological change is attributed to the insertion of an implant crown, which will determine the final location of the peri-implant mucosal margin. This clinical condition has also been observed in different clinical situations by Jemt, (1997), Chang et al. (1999), Kinsel et al. (2000), Furhauser et al. (2005), Meijer et al. (2005), Gallucci et al. (2007), Belser et al. (2009). Similarly, to the results obtained in this clinical trial Jemt (1997), concluded that the soft tissue contour adjacent to single-implant restorations changed in a systematic manner during the time period between insertion of the crowns and follow-up examinations 1–3 years later. However, limited data exist in documenting the morphological changes of peri-implant soft tissue before and after the insertion of different types of implant crowns.

One interesting finding, was the differential in the coronal increase when comparing DIM *versus* PH. Figure 2a shows the status of the peri-implant soft tissues before crown insertion. Here, it can be observed that the mesial and distal papillae are in a more coronal plane than the peri-implant mucosa.

From B to CI the DIM value at interproximal sites increased of 1.23 mm for the mesial and 0.95 mm for the distal site, whereas the PH increased only of 0.42 and 0.50 mm for the mesial and distal site, respectively (Fig. 2b). This clinical situation would indicate that the changes observed post-insertion of an implant–crown in the anterior maxilla are mainly attributed to the relocation of the peri-implant mucosa into the interproximal embrasures. Thus, the interproximal papillae would also benefit from this volume of peri-implant mucosa being relocated into the interproximal space by a smaller increase in height than DIM.

The vertical distance from the CBL (teeth and implants) to the height of the mesial and distal papillae have been proven to be correlated (Choquet et al. 2001, Kan et al. 2003, Tarnow et al. 2003, Kourkouta et al. 2009). In this context, major changes on the CBL at the proximal aspects of teeth adjacent to an implant would be reflected in the papilla height. In this clinical study, no changes were observed on CBL at any study time point at the mesial adjacent tooth and minor changes at the distal one. A similar result was observed with KM at mid-facial aspect of the implant site. Stable CBL and KM values are also suggesting that vertical changes observed in the peri-implant soft tissue at the interproximal sites resulted from the insertion of an implant crown.

Based on the result presented in this clinical study it would appear of paramount importance to reproduce anatomical characteristics of the of transmucosal portion of the abutment/crown complex to achieve a natural looking implant/peri-implant mucosa integration.

Conclusions

1. The insertion of a single-implant crown (PFM or all-ceramic) influenced the morphology of the peri-implant soft tissue by an apical displacement at the mid-facial aspect and a coronal displacement at mesial and distal sites.
2. Major dimensional changes of peri-implant soft tissue occurred from B to CI.
3. Papilla height increased at each study time-point, with the mesial papilla being more important than the distal one.
4. The uses of both PFM or all-ceramic screw retained implant crowns are compatible with the maintenance of peri-implant soft tissue and periodontal parameters and both equally influenced the morphology of the peri-implant mucosa.
5. The hypothesis of this investigation that the delivery of an implant crown influenced the morphology and marginal location of the peri-implant soft tissue was confirmed.

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Address:
German O. Gallucci
Department of Restorative Dentistry and Biomaterials Science
Harvard School of Dental Medicine
Harvard University
188, Longwood Avenue
02115 Boston, MA
USA
E-mail: german_gallucci@hsdm.harvard.edu

Clinical Relevance

Scientific rationale for study: Understanding how an implant crown affects the morphology and outline of the peri-implant mucosa is essential for achieving aesthetic integration.

Principal findings: The insertion a single implant crown with an emergence profile of correct anatomical dimensions displaces apically the peri-implant mucosa margin at midfacial. Interproximal sites changes in a coronal direction. Mesial and distal papilla heights show also an increase and are influenced by CBL at teeth adjacent to the implant site.

Practical implications: Characteristics of the of transmucosal portion of the abutment/crown complex requires careful attention to achieve a natural looking implant/peri-implant mucosa integration.