Peri-implant Bone Loss of Tissue-Level and Bone-Level Implants in the Esthetic Zone with Gingival Biotype Analysis

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Purpose: The esthetic outcome of dental implants can be compromised when some degree of bone loss occurs around the implant. This may particularly affect the tissue-level (TL) design. Therefore, bone-level (BL) design implants may be preferable if a natural emergence profile is important. Notwithstanding the implant design, the gingival biotype has been identified as a crucial factor in the stability of crestal bone. The objective of this study was to investigate bone loss in patients with different gingival biotypes at TL and BL implant sites in the esthetic zone. Materials and Methods: In 41 patients, 20 TL and 22 BL implant procedures were carried out. Intraoral radiographs of all of the 42 sites were taken immediately after implant insertion as well as during the follow-up examination. The analysis of bone height was conducted using a computerized technique. The TRAN method was used to determine the gingival biotype. Results: After a mean in situ period of 4.9 years in the TL group, 12 implants with a thick biotype had a mean bone loss of 0.21 mm (SD: 0.43 mm). The eight implants with a thin biotype had a loss of 0.05 mm (SD: 0.47 mm; P = .31). After a mean in situ period of 1.9 years, the 14 BL sites with a thick biotype showed a mean bone change of -0.03 mm (SD: 0.38 mm). In the eight implants with a thin biotype, a change of +0.09 mm (SD: 0.32 mm; P = .84) was noted. Conclusion: Analysis of the obtained results did not reveal a dependency of bone height on implant design or on gingival biotype. However, prior to choosing an implant design, it may nevertheless be beneficial to screen for transparent soft tissues, where the BL design offers a more natural emergence profile. For this purpose, the TRAN method is clearly the fastest and easiest. Int J Oral Maxillofac Implants 2018;33:1119–1125. doi: 10.11607/jomi.6641

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The quantity of marginal bone loss is commonly considered the main parameter of success in treatment with dental implants. Ongoing bone loss will decrease osseointegration and thus jeopardize the integrity of the implant. Therefore, the bone tissue in the area bordering the implant is a decisive factor in a long-term prognosis. After functioning for a year, an annual marginal bone loss of less than 0.2 mm around an implant has been observed and defined as a “steady state”. The recession of the alveolar bone has been attributed to various factors such as initial thickness of the buccal plate, vertical and orofacial implant position, and the presence of bacteria in the microgap, as the resulting inflammatory cells infiltrate into the surrounding tissues. In accordance with the idea of biologic width, the degree of inflammation will increase with declining distance between the alveolar bone crest and the microgap. The phenomenon of biologic width refers to the constant thickness of the gingiva surrounding a tooth and has also been observed at implant sites. Hence, the soft tissue around a tooth will inevitably adjust itself naturally to a width of approximately 2 mm to protect the bone from the contaminated oral cavity.
The distance from the gingival margin to the bone crest around implants, ie, the implantogingival unit, has been found to be a physiologically formed, stable structure, despite significantly differing (approximately 3 mm) from the corresponding dimensions around teeth. A restoration margin that has disregarded the biologic width and is too close to the alveolar crest may impair the periodontal health of restored teeth. As the mechanisms of protection in the peri-implant mucosa are similar to those in the gingiva surrounding a tooth, a certain width of the peri-implant mucosa may be required to avoid bone resorption and facilitate a stable soft tissue attachment. The traditional tissue-level (TL) implant with the microgap at a 2- to 3-mm distance to the alveolar bone may therefore respect the biologic width phenomenon.

A satisfying esthetic result, however, can be compromised by the restoration margin, which may become visible in situations with thin gingiva or beginning recession. In order to meet the esthetic expectations in the anterior maxilla, the bone-level (BL) implant design has been developed. In this implant type, a more severe bone loss might be expected due to the vertical proximity of the microgap to the bone. The abutment design, however, creates a horizontal distance to the microgap. In such implants (termed “platform-switching”), significantly less peri-implant bone loss has been observed compared with implants with a matching abutment diameter. Both TL implants and BL implants with platform switching adhere to the phenomenon of biologic width and therefore set the stage to minimize bone loss.

Nevertheless, it has still not been possible to clarify whether both types of implants affect the processes in the hard tissue around implants in a quantitatively different way. BL implants and TL implants place different demands on the surrounding tissues, as they differ in surgery protocol, position of restorative margin, and emergence profile. Therefore, the assumption that positioning of the implant-abutment junction above bone level exclusively can prevent apical migration of bone has been questioned. The initial thickness of the soft tissue as well as the general gingival biotype have been mentioned as crucial factors in the stability of crestal bone. However, the influence of implant design on the gingival condition is still a subject of some controversy due to an ambiguity of mucosal reactions on BL implants and TL implants being reported. These contradictory findings may have been obtained because of a lack of registration of initial mucosal thickness. The importance of the gingival biotype is still underestimated, although the clinical significance of the natural soft tissue biotype for the final esthetic treatment outcome is being emphasized. The preoperative identification of the gingival biotype has been repeatedly demanded, not least because different gingival biotypes have been reported to dictate different treatment modalities.

Apart from functional requirements, it is indispensable that dental implants in the anterior region of the maxilla fulfill the patient’s esthetic expectations. In this context, the soft tissue contour that depends on the support of the underlying alveolar bone is of paramount significance. The susceptibility to bone loss resulting from different gingival biotypes and implant designs is therefore of great interest. The objective of this study was to investigate the bone loss in patients with different gingival biotypes at TL and BL implant sites in the esthetic zone and outline clinical implications.

**MATERIALS AND METHODS**

**Patient Collective**

Patients with a failing maxillary central or lateral incisor were invited to take part in the study. One of the patients also had unilateral agenesis of a maxillary lateral incisor, while another patient had bilateral agenesis. Ultimately, 41 patients with a total of 42 implants were selected and scheduled for single implant treatment. The patients were informed about the treatment process and then signed informed consents. In the failing tooth situations, the natural incisor was removed atraumatically and replaced by an implant. From October 2001 to April 2008, 19 patients had 20 TL implants fitted with an insertion depth equal to the length of the rough surface (cylindrical full-body titanium screw Standard Plus with 1.8-mm polished neck; Fig 1 and Table 1). This group will be referred to as the TL group and consisted of 4 male and 15 female subjects (mean age: 39 years, range: 18 to 67 years at the time of insertion). From March 2009 to March 2011, the BL design was used in another 22 patients (9 male and 13 female subjects, mean age: 45 years, range: 18 to 76 years at the time of insertion). In the BL group, 22 BL implants (Straumann) were inserted (Fig 2 and Table 1) approximately level with the crestal bone.

Approximately 25% of the implants in this study were placed immediately after tooth removal. Another 25% were placed years after tooth loss and at sites of agenesis. Most of the implants were placed between 1 and 4 months after tooth removal (Table 2).

Since buccal bone had been resorbed or marginal defects had persisted in both groups of patients, bone augmentation measures were performed during surgery using Bio-Oss and Bio-Gide (Geistlich Biomaterials). Intraoral radiographs of all of the 42 implant sites were taken immediately after insertion (parallel technique; Phot-X II 303, USA; XIOS Plus, Dentsply Sirona;
women: 60 kV/4 mA/0.08 s; men: 60 kV/4 mA/0.1 s). In all 42 implant sites, definite single crown restorations were carried out from 1.5 to 13 months after implant insertion. All crowns were fabricated by the same dental laboratory. In the tissue-level group, 14 crowns (70%) were cemented and 6 crowns (30%) were screw-retained. In the bone-level group, 20 crowns (90%) were cemented and 2 crowns (10%) were screw-retained (Table 2). The follow-up examination of the TL implants took place after a usage period of a minimum of 11 months and a maximum of 7.8 years. At the time of examination, the BL implants were 2 months in situ.

**Table 1**  Length and Diameter of Implants

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Length</th>
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<tbody>
<tr>
<td>Bone-level implants (n = 22)</td>
<td></td>
</tr>
<tr>
<td>3.3 mm</td>
<td>1 × 10 mm; 6 × 12 mm</td>
</tr>
<tr>
<td>4.1 mm</td>
<td>1 × 10 mm; 11 × 12 mm; 1 × 14 mm</td>
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<tr>
<td>4.8 mm</td>
<td>1 × 12 mm; 1 × 14 mm</td>
</tr>
<tr>
<td>Tissue-level implants (n = 20)</td>
<td></td>
</tr>
<tr>
<td>3.3 mm</td>
<td>1 × 10 mm; 5 × 12 mm; 1 × 14 mm</td>
</tr>
<tr>
<td>4.1 mm</td>
<td>5 × 10 mm; 8 × 12 mm</td>
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**Table 2**  Time of Insertion and Type of Retention

<table>
<thead>
<tr>
<th>Time of insertion (No.)</th>
<th>Type of retention (No. [%])</th>
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<tbody>
<tr>
<td></td>
<td>Cement-retained</td>
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<tr>
<td>Bone-level implants</td>
<td>4</td>
</tr>
<tr>
<td>Tissue-level implants</td>
<td>5</td>
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</table>

Fig 1  (a) Clinical view of a tissue-level (TL) implant in the esthetic zone after restoration and (b) the corresponding radiograph of this implant in the maxillary right central incisor region.

Fig 2  (a) Clinical view of a bone-level (BL) implant in the esthetic zone and (b) the corresponding radiograph in the maxillary right central incisor region.
at the minimum and 3.6 years at the maximum. The mean age of the patients in the TL group was now 51 years (range: 27 to 78 years) and in the BL group 50 years (range: 23 to 81 years). The follow-up status of all implant sites was captured by another intraoral radiograph with the same technique as the first one.

**Analysis of Bone Height**

The analysis of peri-implant bone loss was carried out using a computerized technique (SIDEXIS XG 2.53 Sirona Dental Systems). As TL implants and BL implants differ in their geometric configuration, the standard parameter Distance Implant Bone23 could not be used. Instead, a modified procedure was applied.24 The x-ray films were enlarged, and the most coronal point of peri-implant bone-to-implant contact was marked as BIC (Figs 3 and 4).

The mesial and distal implant shoulders of TL implants were defined as RTm and RTd. In BL implants, the respective reference points were RBm and RBd. For calibration purposes, an implant Shoulder Connecting line SC-T (Tissue level) or SC-B (Bone level) was drawn through the reference points.2 Furthermore, a line A was drawn as a tangential line of the implant apex and parallel to SC-T or SC-B. The bisecting line of the angle between the implant walls from SC-T or SC-B to A was measured in Sidexis as distorted Roentgenological Length (RL-T or RL-B; Fig 4). With the known real implant length, the software delivered a calibration factor and automatically computed all measured distances in real values, thus eliminating a distortion factor. A line L-T or L-B was drawn from SC-T or SC-B on the mesial and distal aspects of the implant (Fig 4). In order to determine bone loss over time, the value of the first radiograph measurement was subtracted from the second (follow-up) radiograph. The measurement of each site was repeated three times on the mesial and distal aspects, and the results obtained were averaged to achieve one final value. The entire analysis was carried out by the same researcher (G.W.).

**Analysis of Gingival Biotype**

In order to determine the gingival biotype of each implant patient, the TRAN method was applied.21 At the follow-up session, a periodontal probe (Colorvue Periodontometer, Hu-Friedy) was inserted midfacially in the sulcus of the implant (Fig 5) and documented photographically (digital camera Nikon D 90, Lens: Sigma 105 mm F 2.8 Ex DG Makro; photographic device after Weinländer).25

The images were adjusted for brightness (Adobe Photoshop) and printed on DIN A4 glossy paper. After randomization, five examiners were requested to evaluate the visibility of the periodontal probe through the gingival tissue. The biotype was categorized as thin if
at least three of the examiners termed the tissue transparent, and as thick if at least three opted for opacity. For statistical purposes, the Wilcoxon rank-sum test was applied in order to reveal the correlation between implant design and gingival biotype.

**RESULTS**

After a mean in situ period of 4.9 years, the TL group presented a mean bone loss of 0.15 mm (SD: 0.53 mm) for every site and every implant. In the BL group, after a mean in situ period of 1.9 years, a mean bone change of +0.02 mm (SD: 0.35 mm) for every site and every implant was observed (Fig 6). In the TL group, 12 implants with a thick biotype had a mean bone loss of 0.21 mm (SD: 0.43 mm). The eight implants with a thin biotype had a bone loss of 0.05 mm (SD: 0.47 mm; \( P = .31 \)). The 14 BL sites with thick biotypes showed a mean bone change of –0.03 mm (SD: 0.38 mm). In the eight implants with a thin biotype, a change of +0.09 mm (SD: 0.32 mm; \( P = .83 \)) was found.

**DISCUSSION**

In the study as presented, the peri-implant bone height in dental implant sites with TL design and BL design was measured, and the respective gingival biotype was determined. In the TL group, 12 implants with a thick biotype showed a mean bone loss of –0.21 mm. The eight implants with the thin biotype had a value of –0.05 mm. The 14 BL sites with the thick biotype showed a mean bone change of –0.03 mm. In the eight implants with the thin biotype, a change of +0.09 mm was found. For both groups, there was no marked statistical significance between the thick and thin biotypes (\( P = .31 \) and \( P = .83 \), respectively). The BL implants at thin biotype sites even reached values above 0 mm. Most of the examined implants presented only slightly negative bone height values.

TL implants, as opposed to BL implants, are more prone to being inserted too deeply. The peri-implant bone coronally of the rough surface recedes naturally. This is interpreted as bone loss when comparing postoperative and follow-up radiographs.\(^{24}\)

Generally, the thin biotype showed somewhat better results than the thick biotype, an observation not noted in previous studies.\(^{19}\) However, it must be kept in mind that all data are recorded on a scale of hundredths of millimeters, which has an attenuating effect on the results. In the study, the thin biotype was found in approximately one-third of the whole sample, as noted in previous reports.\(^{26}\) However, in the literature, there is no clear consensus about the distribution of the thin and thick biotypes among patient collectives. A ratio of 43% thin to 57% thick biotype has been noted elsewhere,\(^{27}\) and splitting the sample into anterior and posterior sites revealed the thin biotype in 70% to 76% of the central incisors and 29% to 45% of the posterior sites.\(^{28}\) The entities that were defined in the present study as thick or thin biotype may be different from what others conceived as such.\(^{29}\) This discrepancy leads inevitably to different results.

In a study sample of 1,178 implants comprising 86% TL implants at the outset, French et al observed a mean bone loss of 0.21 mm (SD: 0.45 mm) after 4 to 5 years.\(^{24}\) BL implants have been reported to show a slightly stronger vertical bone loss of 0.36 mm (SD: 0.15 mm) within the first year of service\(^{30}\) or similar results.\(^{31}\) In keeping with the present findings, however, BL implants with platform switching have been reported to exceed TL implants.\(^{32}\)

As the BL design, and particularly that involving platform switching, was only launched in recent years, there is still a lack of long-term study evidence about its clinical outcome. The mean follow-up interval of 1.9 years for the BL group as in the present study is longer than in the majority of studies currently available.\(^{29,31}\) In terms of clinical behavior, the thick biotype is considered to be more resistant to inflammation and trauma than the thin biotype, which might be due to the difference in the amount of blood supply to the underlying bone.\(^{33}\) Predictability and control of the esthetic outcome of dental treatments in the maxillary front zone requires an adjusted soft tissue guidance, which indispensably implies the understanding of the variance of gingival physiognomy.\(^{33}\) The surgical trauma of an implantation creates challenges in terms of revascularization, healing potential, and remodeling of the soft tissue. These demands provoke vicarious reactions from the soft tissues, even though the treatment procedure and all other circumstances might be exactly the same.\(^{22}\)
This experience has led to the hypothesis of different gingival biotypes, which is currently under intense discussion in the literature. In 1969, Ochsenbein and Ross described two biotypes: the scalloped thin type and the flat thick type. In later years, the term “periodontal biotype” was introduced, resulting finally in the concept of “gingival biotype”. As the identification is not unambiguous, a third group with mixed features has been proposed.

A genotypical origin of the different characteristics of the gingival types seems rather unlikely, as variance of biotype even exists locally at the subject level. Of much greater significance is the fact that the soft tissue dimensions obviously depend on anatomical conditions such as underlying bone morphology and contact point position. Accordingly, the gingival biotypes seem more likely to be an expression of functional adaptation than a question of genetic constitution. Apart from anatomical and endocrinial conditions, secondary functional factors have to be considered that may promote the leaning toward a particular biotype. Eating, brushing, parafunctions, and the tonicity of tongue and buccal muscles vary on a wide scale among individuals and can result in different tissue morphologies.

Limitations of the Study

The accuracy of the peri-implant bone height determination in this investigation is naturally limited. The radiographs were not free of distortion, as the surrounding tissues inevitably create a certain distance between the film and implant body. Based on the real dimensions of the implants, the measured distances on the radiographs were then mathematically extrapolated. Ensuring that the same dental staff took the radiographs as well as using an identical method of data analysis helped to minimize the influence of confounding factors.

In general, the measurement method in the study involved the risk of personal bias, as it was based on the examiners’ impartiality when determining bone height values and gingival biotype. With three repeated measurements at each site of the radiographic images and five examiners for the TRAN method, the appearance of errors has been kept to a minimum. Using the TRAN method as demonstrated at least serves as a makeshift and permits one possible way of classifying the different types, although further basic research is required to identify the physiologic substructures of gingival biotype. Therefore, the present results may only be reluctantly compared with other biotype studies since the categories of thick and thin gingival biotype have still not been scientifically defined.

The comparability of the bone height data in the two implant designs is limited, as the in situ times differ noticeably: from October 2001 to April 2008, tissue-level implants were placed, and from March 2009 until March 2011, the bone-level design was chosen. Long-term studies show the impact of the examination intervals on the outcome of bone values. In this case, the longer in situ times of the TL implants might be responsible for the somewhat higher bone loss values in this group. On the other hand, it has been reported that once the steady state has been reached after the initial remodeling phase, only a negligible bone loss will occur over the years.

CONCLUSIONS

The analysis of TL and BL implant sites revealed that peri-implant bone height did not depend on implant design or gingival biotype. Prior to choosing an implant design, however, the TRAN method can be helpful to screen for transparent soft tissues where the BL design may reach a more favorable esthetic result.

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REFERENCES


