Biologic width around titanium implants. A physiologically formed and stable dimension over time


Research in implant dentistry has mainly focused on hard tissue integration with much less data available with regards to soft tissue integration involving epithelium and connective tissue. In the present study, the implantogingival junction of unloaded and loaded non-submerged titanium implants has been analyzed histometrically in the canine mandible. In 6 foxhounds, 69 implants were placed. Dogs in the unloaded group were sacrificed 3 months after implant placement. Loaded implants were restored with gold crowns and those dogs were sacrificed after 3 months and 12 months of loading. Non-decalcified histologic sections were analyzed histometrically measuring the dimensions of the Sulcus Depth (SD), the Junctional Epithelium (JE), and the Connective Tissue Contact (CTC). Histometric evaluation revealed that significant changes within tissue compartments (SD, JE, CTC) occurred over time (P<0.05). Sulcus Depth had a mean of 0.49 mm and 0.50 mm after 3 months and 6 months of healing, but after 15 months was 0.16 mm which was significantly different. Similarly, the length of the Junctional Epithelium after 3 months and 6 months of healing was 1.16 mm and 1.44 mm, respectively, and these values were significantly different from measurements taken after 15 months (1.88 mm). The area of Connective Tissue Contact showed a different pattern of change in that after 3 months of healing (1.36 mm) it was significantly different from the same area after 6 months and 15 months which were 1.01 mm and 1.05 mm, respectively. Interestingly, the sum of SD, JE, and CTC, forming the Biologic Width, did not change over the observation period (P>0.05). These data indicate that the Biologic Width is a physiologically formed and stable structure over time in the case of non-submerged, one-piece titanium implants as evaluated histometrically under unloaded and loaded conditions. Dynamic changes did occur, however, within the overall Biologic Width dimension. Thus, the use of non-submerged, one-piece implants allow for stable overall peri-implant soft tissues as evaluated under loaded conditions for up to 12 months.

Many clinical studies on various clinical indications have documented high success rates of endosseous dental implant therapy (Bränemark et al. 1977; Adell et al. 1981; Babbush et al. 1986; Cox & Zarb 1987; Adell et al. 1990; Buser et al. 1990; ten Bruggenkate et al. 1990; Buser et al. 1991; Behnke et al. 1992; Schmitt & Zarb 1993; Mericske-Stern et al. 1994; Jemt & Lekholm 1995; Henry et al. 1996; Buser et al. 1997). When success has been evaluated in these studies, specific criteria have been met. Generally, these criteria include lack of mobility, absence of persistent infection or discomfort, lack of pain, and absence of continuous periapical radiolucency (Albrektsson et al. 1986; Smith & Zarb 1989; Buser et al. 1990). Most of these criteria are designed to evaluate the integrity
of the bony integration of the implant and provide little information related to the soft tissue integration of the implant. Historically, this has occurred due to the popularity of the submerged approach to the placement of implants. Schroeder et al. in the later 1970s and early 1980s reported on a non-submerged approach to dental implant placement and described the soft tissue attachment/contact to the transgingival portion of the implant (Schroeder et al. 1976; Schroeder et al. 1978; Schroeder et al. 1981). It is now recognized that the non-submerged technique is as predictable as the submerged approach (Babbush et al. 1986; Buser et al. 1991; Gottfredsen et al. 1991; Behneke et al. 1992; Mericske-Stern et al. 1994; Buser et al. 1997; Buser et al. 1999), and in fact has advantages over the submerged approach to implant placement including: 1) the lack of an interface/microgap between the implant and abutment at or below the alveolar crest level, 2) lack of a second surgical procedure to connect a transgingival component to the top of the implant, 3) a more mature soft tissue healing due to the lack of a second-stage surgery, and, 4) a smaller crown-to-implant ratio for one-piece designed non-submerged implants. Recognizing these advantages, clinicians utilizing typically submerged implants began connecting an abutment to the implant at the time of implant placement. This technique avoids a “second stage” surgery, but results in a two-piece, but non-submerged implant (Ericsson et al. 1994; Bernard et al. 1995; Ericsson et al. 1996; Becker et al. 1997; Collaert et al. 1998).

The placement of submerged implants in a non-submerged approach has direct implications for crestal bone levels around implants and subsequently may influence the overlying soft tissues.

Hermann et al. (1997) demonstrated that radiographic bone levels around non-submerged, one-piece implants do not significantly change over 6 months in the canine mandible. However, if a submerged implant with attached abutment (with an interface) is placed in either a non-submerged approach or in a submerged approach (with an abutment placed after a 3-month healing period) similar amounts of bone loss occur. This data, combined with the fact that bone loss decreased as the interface was moved coronally and the bone loss increased with the more apical placement of the interface, indicates that there is a physiologic reaction to the presence of an interface. The reason for this reaction to the interface is unknown, but may be related to the presence of microbial contamination (Quirynen & van Steenberghe 1993; Persson et al. 1996; Jansen et al. 1997) or micromovement of the interface between the implant and the abutment or secondary implant components.

Cochran et al. (1997) documented the soft tissue dimensions and described the Biologic Width around non-submerged, one-piece dental implants. This study supported previous reports on soft tissues around non-submerged, one-piece dental implants (Buser et al. 1989; Buser et al. 1992; Listgarten et al. 1992; Romanos et al. 1995; Tonetti et al. 1995; Abrahamsson et al. 1996; Hämmerrele et al. 1996; Weber et al. 1996; Piattelli et al. 1997) and showed that an area of epithelial attachment with the implant surface occurs similar in morphology to that which is found around natural teeth. In addition, an area of Connective Tissue Contact was found between the apical extension of the Junctional Epithelium and the alveolar bone comprising the first bone-to-implant contact. The dimensions of these tissues, the Biologic Width, for non-submerged, one-piece implants were demonstrated to be similar to the dimensions for the same tissues described for natural teeth (Gargiulo et al. 1961; Vacek et al. 1994).

The aim of the present study was to describe the changes in the dimensions of the Sulcus Depth, length of the Junctional Epithelium, and the area of Connective Tissue Contact over a healing period of 3 to 15 months. Significantly, for implants followed from 6 to 15 months, the implants had been restored with gold crowns. Thus, loaded implants were evaluated histologically after 3 and 12 months of function.

Materials and methods

Study animals and implants

In this study, 6 male, lab-bred American foxhounds were used. These animals were, at the be-
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Fig. 2. Study design outlining three different groups of animals, A, B and C. Only animals in group B and C had restorations placed. Animals in group C had implants in place for 15 months with restorations for 12 months.

After a healing period of 3 months, non-submerged titanium implants were placed under the same conditions as the tooth extractions (Fig. 2). A crestal incision was made maximizing keratinized gingiva on each side of the incision. Full-thickness flaps were gently reflected on the lingual and buccal aspect. The edentulous osseous ridge was carefully flattened using an acrylic burr and copious irrigation with chilled sterile physiological saline. Measurements were made using a Boley gauge to distribute 6 test implants on each side of the lower jaw. The implant recipient site was prepared with torque reduction rotary instruments at 500 r.p.m. using again chilled saline. Three of each kind of test implants were placed per side in an alternating manner according to a randomized starting selection. Three out of the possible 72 implants could not be placed due to anatomical limitations resulting in a total of 69 inserted implants. Horizontal mattress and interrupted sutures were placed. After 7–10 days, sutures were removed as described earlier. Mechanical and chemical plaque control was carried out 3 times per week for the duration of the study using 0.2% chlorhexidine gel (PlakOut® Gel, Hawe-Neos AG, Bioggio/TI, Switzerland) in combination with a soft toothbrush and a soft sponge.

Prosthetic reconstruction

Four out of the 6 dogs formed the loaded implant groups, B and C (Fig. 2). Individual impressions
This photograph demonstrates multi- and single-unit gold crowns (screw-retained) in situ in the P₁–M₁ area of the canine mandible.

were taken in these dogs 2 months after implant placement, and consequently, screw-retained gold crowns were fabricated (Fig. 3). To imitate the natural dentition of the dogs as closely as possible, the P₁ area had single crowns placed, whereas in the P₂–M₁ area, connected crowns on 2 implants were made. In some cases the connected crowns were sectioned as a passive fit was not achieved on both implants. Octa® abutments (ITI® Dental Implant System, Institut Straumann AG, Waldenburg/BL, Switzerland) were placed in the implants and precise impressions were taken using repositional transfer copings. Implant analogs were placed in the impressions and models made for fabrication of the restorations. Highly precise gold copings were incorporated into the wax-ups for the crowns and bridges. All parts used were standard components of the ITI® Dental Implant System (Institut Straumann AG, Waldenburg/BL, Switzerland). Restorations were inserted 3 months after implant placement (Fig. 2).

Sacrifice

Two out of 6 dogs (group A) were sacrificed after a healing period of 3 months and constituted the unloaded implant group (Fig. 2). The other 4 dogs were sacrificed after loading, 2 of them after 3 months (group B) and 2 after 12 months of loading (group C), respectively. Mandibles were block-resected and the recovered segments with the implants were immersed in a solution of formaldehyde 4% combined with CaCl₂ 1% for histologic preparation and analysis. Each implant with surrounding tissues was prepared for histology as described by Schenk et al. (1984). Briefly, radiographs were taken after the tissue blocks had been fixed in neutralized formalin (4% with 1% CaCl₂). The specimens were dehydrated and embedded without prior decalcification in methylmethacrylate. Around 500 μm thick saw cuts were made with a diamond blade. From each implant 2 axially oriented sections in the bucco-lingual plane were obtained and the remaining parts of the block were glued together and cut in a transverse plane. This allowed optimal harvest of 6–8 orthograde sections through the interface. They were ground to a final thickness of about 80 μm and stained with toluidine blue, followed by basic fuchsin as a counterstain. Histometric quantification was carried out utilizing a high-resolution video camera (CCD-color video camera, Sony Corporation, Fujisawa, Japan) interfaced to a video monitor (Hyper HAD video monitor, Sony Corporation, Fujisawa, Japan). This optical system was associated with a digitizing pad and a bone morphometry software package with image capturing capabilities (Bioquant bone morphometry software, R & M, Biometrics Inc., Nashville, TN, USA). All sections were analyzed under several magnifications of light microscopy to locate anatomical reference points (Table 1, Figs 4–8).

Statistical analysis

Each of the readings for the measurements taken from the oro-facial sections were averaged so that each implant had a single value for each measurement. Implant measures were compared across the 3 treatment groups by Analysis of Variance (ANOVA). If the ANOVA was statistically significant (P<0.05), then pairwise comparisons were made between groups using the Bonferroni method to

<table>
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<th>Variable(s)</th>
<th>Group A</th>
<th>Number of implants (used for ANOVA)</th>
<th>Number of measured implant sites</th>
<th>Group B</th>
<th>Number of implants (used for ANOVA)</th>
<th>Number of measured implant sites</th>
<th>Group C</th>
<th>Number of implants (used for ANOVA)</th>
<th>Number of measured implant sites</th>
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<td>76</td>
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<td>93</td>
<td>1.88±0.61</td>
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<tr>
<td>CTC</td>
<td>1.36±0.64</td>
<td>21</td>
<td>80</td>
<td>1.01±0.32</td>
<td>24</td>
<td>93</td>
<td>1.05±0.38</td>
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<td>76</td>
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<td>24</td>
<td>93</td>
<td>3.08±0.78</td>
<td>24</td>
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</tbody>
</table>
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Histometric analysis
The overall dimensions of the Sulcus Depth, length of Junctional Epithelium and area of Connective Tissue Contact combined (=Biologic Width) were not significantly different between the evaluation time periods (Fig. 5 and Table 1). This finding is important as Group A implants were not loaded whereas Groups B and C implants were loaded.

Fig. 5. Mean values [mm] for Biologic Width (BW) in Groups A, B and C. No statistically significant differences (ns) among implant groups were apparent over time (P>0.05). (Fig. 6. Mean values [mm] for Sulcus Depth (SD) in Groups A, B and C. Significant differences (*) occurred between implants of Groups B and C as well as between A and C. (P<0.05). No significant differences (ns) were evident when Groups A and B were compared.

Results
Clinical observations
Postoperative healing after implant placement was uneventful in all dogs. Following 3 months of healing, all 69 implants demonstrated successful tissue integration with no mobility and no signs of peri-implant infection. No radiolucencies were apparent on radiographic examination. Forty-eight implants in groups B and C were restored with single crowns or fixed partial dentures. After loading, all implants were stable and no complications occurred in the follow-up period (up to 12 months of restoration).
The mean values for the Biologic Width of Group A implants was 3.01 mm, Group B implants was 2.94 mm and Group C implants was 3.08 mm. No significant difference was noted between Group A implants compared to Group B or Group C implants, nor was there a difference between Group B and Group C implants. The dimension of Sulcus Depth however changed over the 3 healing periods (Fig. 6). Implants in Groups A and B were not significantly different with mean dimensions of 0.49 mm and 0.50 mm, respectively. In contrast, however, the Sulcus Depth around implants in Group C were significantly different from implants in both Groups A and B with a diminished mean Sulcus Depth value of 0.16 mm.

The length of the Junctional Epithelium along the implant surface reflected the changes observed for Sulcus Depth (Fig. 7). Thus, for Junctional Epithelium, no significant difference was found between implants in Group A and B with mean values of 1.16 mm and 1.44 mm, respectively. In contrast, the dimension for the Junctional Epithelium around Group C implants was significantly increased compared to implants in Groups A and B with a mean value of 1.88 mm.

The area of Connective Tissue Contact along the implant showed a different response compared to the dimensions found for Sulcus Depth and Junctional Epithelium (Fig. 8). In the case of Connective Tissue Contact, the dimension after 3 months of non-loaded healing was 1.36 mm and was significantly different from the 6 month and 15-month healing periods (Groups B and C, respectively). The dimensions for Connective Tissue Contact were decreased for implants in groups B and C with values of 1.01 mm and 1.05 mm, respectively which were not significantly different from one another.

A comparison of the changes in the Biologic Width as determined by the linear dimensions of Sulcus Depth, Junctional Epithelium and Connective Tissue Contact are shown in Fig. 9 and Fig. 10. Fig. 9 demonstrates that Sulcus Depth and Connective Tissue Contact decreases over time, but that the decrease occurs earlier in the healing process for connective tissue compared to the decrease in Sulcus Depth. Fig. 10 demonstrates that while the Biologic Width dimension stays approximately the same over the 15-month healing period, the increase in linear dimension occurs in Junctional Epithelium and compensates for the decrease in Sulcus Depth and Connective Tissue Contact.

**Discussion**

This study has evaluated the dimensional changes in the soft tissues around non-submerged, one-
piece titanium dental implants over a period up to 15 months and included both a non-loaded period and a loaded period. The most significant finding was that the combined dimension of soft tissues, the Biologic Width, did not change over the three evaluation periods. Additionally, significant changes did occur within the soft tissue compartments such that Sulcus Depth and Connective Tissue Contact dimensions decreased over time while the length of the Junctional Epithelium increased. The fact that the overall dimension of the Biologic Width did not change over the healing period suggests that the non-submerged, one-piece design of the implant allows for overall physiologically stable peri-implant tissues. A comparison of these dimensions to those described around teeth (Gargiulo et al. 1961; Vacek et al. 1994) further suggests that this is a physiologically formed structural unit. Evidence for the stability of this unit is provided by the fact that this overall dimension did not change in spite of three times weekly mechanical and chemical oral hygiene procedures.

The additional finding that significant differences occurred within the components of the Biologic Width at the various time points measured indicate that important dynamic factors affect the Junctional Epithelium, Connective Tissue Contact and Sulcus Depth. While these factors are not known, several possibilities exist. One such factor is loading of the implant. Due to the experimental design utilized, the effect of loading cannot be definitively addressed on soft tissue remodeling as all the implants evaluated at each time point were either not loaded or loaded. Secondly, tissue maturation may certainly influence dimensional changes including collagen crosslinking in the soft connective tissues and bony remodeling, maturation for the hard connective tissues. A further possibility for the soft tissue changes could be related to the occlusal forces placed on the implants over time. Future work will need to be performed to investigate such possibilities.

Sicher (1959), in describing the soft tissue structure around teeth, indicated that the connective tissue attachment was the most stable component of the soft tissue unit while the Junctional Epithelium was more variable in its dimension. The data in the present study suggests that this finding may be applicable to the soft tissues around non-submerged, one-piece titanium implants as well. The length of the Connective Tissue Contact in this study changed 0.3 mm while the length of the Junctional Epithelium changed 0.72 mm (a 240% greater change). These changes are also consistent with the dimensions of the soft tissues reported around similar implants placed in a human study (Buser et al. 1990). In this human study, 70 partially edentulous patients were treated with 100 non-submerged ITI® Dental Implants, restored with fixed partial dentures and evaluated after 12 months. With these implants, the implant margin was placed 3 mm coronal to the alveolar crest. In these relatively healthy tissues (mean plaque index of 0.16 and mean sulcus bleeding index of 0.26) the mean pocket depth was 2.74 mm with a mean attachment level (from the implant margin) of 2.62 mm. The attachment level calculated from the coronal aspect of the implant margin was 3.79 mm to bone indicating an approximately 1.17 mm length of connective tissue attachment. Similar levels of attachment were found in another study of 11 humans with the same type of implant where the range at 4 and 12 months was 2.78 to 3.38 mm (Hämmerle et al. 1996).

These findings are consistent with previous investigations of soft tissues around implants. Weber et al. (1996), comparing non-submerged and submerged implants in beagle dogs, found significant differences between implant types. Epithelium had a mean length of 1.18 mm for non-submerged implants and a 1.71 mm length around submerged implants. In every case where the implant was initially submerged, the epithelium was found apical to the interface (microgap) between the implant and the transgingival abutment. The length of the connective tissue attachment was larger (1.35 mm) in the non-submerged group compared to the submerged group (0.79 mm). Attachment level for non-submerged implants was located more coronally at 1.60 mm compared to 2.14 mm for submerged implants.

In studies comparing the soft tissues around teeth and implants where an implant and an abutment were connected in beagle dogs (but not restored or the abutment loosened), the apical extent of the Junctional Epithelium was 2.14 mm and the length of the Connective Tissue Contact 1.66 mm (Berglundh et al. 1991; Berglundh et al. 1992). The distance from the gingival margin to the bone crest around those implants was 3.80 mm with this dimension and the length of Connective Tissue Contact being significantly different from the same dimensions around teeth. The authors concluded that “…Junctional Epithelium terminated about 1–1.5 mm coronal to the alveolar bone crest…”. This dimension combined with the expectation of marginal bone loss after a year of loading to be 1–1.5 mm (Albrektsson & Zarb 1986) suggests that the epithelium extends past the implant/abutment interface (microgap) as found in the Weber et al. (1996) study noted earlier. None of these studies described the soft tissue dimensional changes over time.
This finding of the epithelium apical to the implant/abutment interface around submerged implants was also confirmed in a study of beagle dogs (Abrahamsson et al. 1997). This more clinically relevant finding, where the abutment was loosened, contradicted earlier findings by this research team where an abutment was placed on submerged implants and never loosened (Abrahamsson et al. 1996). In this latter more experimental model, the conclusion suggested that one-piece non-submerged and two-piece submerged implant systems had similar soft tissue healing. The findings in the study, where abutments were loosened, confirmed the finding by Hermann et al. (1997), which found significant differences in crestal bone levels between one-piece and two-piece implant/abutment systems. Interestingly, in the Hermann et al. (1997) study, the presence of an implant/abutment interface (microgap) correlated with crestal bone resorption and it did not make a difference if the two-piece system was placed with a non-submerged or submerged technique. Thus, the presence of an interface on two-part implant/abutment systems appears to correlate with crestal bone loss. This does not occur with a one-piece, non-submerged technique (Hermann et al. 1997; Cochran et al. 1997).

The results of the present study suggest that dental implants can have similar soft tissue dimensions as teeth. Certain criteria, however, appear to be necessary in order to achieve this result. These criteria can be ascertained by noting similarities between teeth and implants. With natural teeth, there is a structure intended for periodontal ligament and bony integration and a separate structure for epithelial attachment. Similarly on the implants used in this study, there was a rough surface – either sandblasted and acid-etched (SLA) or titanium plasma-sprayed (TPS) – intended to promote osseous tissue integration and a coronal area of machined titanium (Fig. 1) to discourage bone apposition and encourage epithelial and connective tissue attachment/contact. Both natural teeth and the implants used in this study are one-piece structures meaning that no interface (microgap) exists to separate the coronal structure from the more apical one. Lastly, both structures resulted in a Biologic Width of similar dimensions suggesting that the physiologic reaction to a natural tooth or a non-submerged, one-piece implant is to form an overall dimensionally stable, soft tissue structural unit known as the dentogingival unit (Sicher 1959) or implantogingival unit (Cochran et al. 1997), respectively. The present results confirm the overall stability of the implantogingival unit (referred to as “perimucosal” tissues by the First European Workshop on Periodontology, Albrektsson and Isidor, 1994) over time with a 15-month healing period and a 12-month loading period. However, significant changes did occur within the overall dimension over time and with loading. Thus, natural teeth and non-submerged, one-piece implants share a physiologically formed and stable overall soft tissue structure over time.

**Conclusion**

Overall, the findings from the present investigation reveal that while changes occur in the dimensions of the Sulcus Depth, Junctional Epithelium and Connective Tissue Contact, the overall dimension was not altered whether unloaded or loaded for 1 year around non-submerged, one-piece titanium dental implants. Furthermore, these results were similar to those same dimensions around natural teeth and suggest that these two structures share physiologically formed and stable soft tissue units.

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**Résumé**

La recherche en médecine dentaire implantaire s’est surtout occupée de l’intégration des tissus durs avec beaucoup moins de données en ce qui concerne l’intégration des tissus mous comprenant l’épithélium et le tissu conjonctif. Dans l’étude présente, la jonction implanto-gingivale d’implants en titane chargés et non-chargés non-enfouis a été analysée histométriquement dans la mandibule de chiens. Chez six chiens fox-terriers, soixante-neuf implants ont été placés. Les chiens du groupe des implants non-chargés ont été tués trois mois après le placement des implants. Les implants chargés étaient restaurés avec ces couronnes en or et ces chiens ont été tués après trois mois et douze mois de charge. Des coupes histologiques non-décalcifiées ont été analysées histométriquement mesurant les dimensions de la profondeur du sillon (SD), l’épithélium de jonction (JE) et le contact de tissu conjonctif (CTC). L’évaluation histométrique a révélé des variations signification dans ces comparatifs tissulaires avec le temps (P<0.05). SD avait une moyenne de 0.49 mm et 0.50 mm après respectivement trois et six mois de guérison mais était après quinze mois de 0.16 mm, ce qui est statistiquement différent. De même JE après trois et six mois...
de guérison était respectivement de 1.16 mm et 1.44 mm et ces valeurs étaient significativement différentes des mesures prises après quinze mois (1.88 mm). À trois mois, CTC était de 1.36 mm et après six et quinze mois respectivement de 1.01 mm et 1.05 mm. Il est intéressant que la somme de SD, JE et CTC formant l’équilibre biologique de l’attache ne changeait pas durant la période d’observation ($P=0.05$). Ces données indiquent que cet espace biologique est formé physiologiquement et est un équilibre stable des structures dans le cas d’implants en tita- ne en une pièce et non-enfouis, avec ou sans charges. Des varia- tions dynamiques sont cependant apparues avec la dimension de cet espace biologique général. L’utilisation d’implants en une pièce non-enfouis permet la stabilité générale des tissus mou- parotimplantaires sous des conditions de charges allant jusqu’à douze mois.

### Zusammenfassung

Die Forschung in der zahnärztlichen Implantologie hat sich meist auf die Integration in den Hartgeweben konzentriert. Über die Integration in den Weichgeweben, welche vor allem im Epithel und Bindegewebe stattfindet, sind nur wenige Daten vorhanden. In der vorliegenden Studie wurde die Berührungsfläche zwischen Implantat und gingivalen Geweben bei unbelasteten belasteten transmukosal einhei- lenden Implantatente im einem Tierexperiment an Hunden histometrisch analysiert. Bei 6 Hunden wurden 69 Implantate eingesetzt. Die Hunde der Gruppe mit den unbelasteten Implantaten wurden 3 Monate nach dem Einsetzen der Implantate geopfert. Die belasteten Im- plantate wurden mit Goldkronen rekonstruiert. Die Hunde mit belasteten Implantaten wurden nach 3 und 12 Monaten Belas- tungszeit geopfert. Die nichtentkalkten histologischen Präpa- rate wurden histometrisch analysiert. Gemessen wurden die Ausdehnungen der Sulkustiefe (SD), des Saumepithels (JE) und des Bindegewebskontakts (CTC). Die histologische Auswertung ergab, dass signifikante Veränderungen in der Gewebezusammen- setzung (SD; JE; CTC) über die Zeit auftraten ($P<0.05$). Die Sulkustiefe zeigte einen Mittelwert von 0.49 mm und 0.50 mm nach 3 und 6 Monaten Einheilzeit. Nach 15 Monaten be- trug die Sulkustiefe 0.16 mm. Der Unterschied war statistisch signifikant. Die Länge des Saumepithels betrug nach 3 und 6 Monaten 1.16 mm und bzw. 1.44 mm. Diese Werte differierten statistisch signifikant von den Messwerten, welche nach 15 Mo- naten aufgenommen wurden (1.88 mm). Die Region des Bindegewebskontakts zeigte ein anderes Veränderungsmuster. Nach einer Heilungszeit von drei Monaten betrug der Bindegewebs- kontakt 1.36 mm, während er nach 6 und 15 Monaten 1.01 mm bzw. 1.05 mm betrug. Die Unterschiede zwischen 3 und 6 bzw. 15 Monaten waren statistisch signifikant. Interessanterweise veränderte sich die Summe von SD, JE und CTC, welche die biologische Breite darstellt, während der Beobachtungsperiode nicht ($P<0.05$). Diese Daten zeigen, dass es sich bei der biologi- schen Breite bei transmukosal einhei- lenden einteiligen Titanimplantaten, welche histologisch bei belasteten unbelasteten Implantaten ermittelt wurde, um eine physiologischerweise ge- bildete und über die Zeit stabile Struktur handelt. Jedoch traten dynamische Veränderungen innerhalb der einzelnen Bestandtei- le der biologischen Breite auf. Während der Belastungszeit von bis zu 12 Monaten konnte gezeigt werden, dass einteilige transmukosal einhei- lende Implantate die Bildung von allen in allem stabilen peri-implantären Weichgeweben erlauben.

### Resumen

La investigación en dentistería de implantes de han enfocado principalmente sobre la integración en el tejido duro con muchos menores datos disponibles de la integración del tejido blando que incluye el epitelio y el tejido conectivo. En el presen-
Hermann et al.

を示し、治癒3ヶ月後の値（1．36mm）が、6ヶ月後（1．01mm）及び15ヶ月後（1．05mm）とは有意に異なっていた。興味深いことに、生物学的幅角をなす、S D、J E、C T Cの3番を観察中変化しなかった（P > 0.05）。これらのデータから、非埋入型のチタン製インプラントは非荷重及び荷重条件下での組織形態学的評価において、生物学的幅角は生理的に形成され、経時的に安定した構造となることを示唆している。しかし生物学的幅角とされる寸法全体の内訳には動的な変化が生じた。従って12ヶ月までの荷重条件下の評価においては、非埋入型インプラントの使用は、安定したインプラント周囲の軟組織の達成を可能とするものである。

References


