The effect of all-ceramic and porcelain-fused-to-metal restorations on marginal peri-implant soft tissue color: a randomized controlled clinical trial

Jung, R E; Holderegger, C; Sailer, I; Khraisat, A; Suter, A; Hämmerle, C H


Postprint available at:
http://www.zora.uzh.ch

Posted at the Zurich Open Repository and Archive, University of Zurich.
http://www.zora.uzh.ch

Originally published at:
The effect of all-ceramic and porcelain-fused-to-metal restorations on marginal peri-implant soft tissue color: a randomized controlled clinical trial

Abstract

The aim of this study was to test the color-change effect of all-ceramic restorations compared with porcelain-fused-to-metal (PFM) restorations on marginal peri-implant soft tissue. Thirty patients were randomly divided into 2 groups of 15 subjects each. The all-ceramic group received all-ceramic crowns on aluminum oxide-based abutments, while the PFM group received crowns on titanium or gold abutments. A reflectance spectrophotometer was used to measure the color difference (deltaE(Implant)) between the midfacial peri-implant mucosa before and after restoration insertion. The color difference (deltaE(Tooth-implant)) between the midfacial peri-implant mucosa and the gingival margin of the corresponding neighboring tooth was tested. The mucosal thickness was measured midfacially around the implant (MT(Implant)) and neighboring tooth (MT(Tooth)). deltaE(Implant) values were similar for the all-ceramic (7.4 +/- 2.7) and PFM groups (7.6 +/- 2.8). The all-ceramic group induced significantly less visible mucosal color change (3.4 +/- 1.4) compared to the PFM group (5.2 +/- 2.3). The MT(Implant) value of the all-ceramic group was 3.4 +/- 0.8 mm, while that of the PFM group was 2.9 +/- 0.9 mm, which was not significantly different. Significant differences were found when comparing MT(Implant) (3.1 +/- 0.9) and MT(Tooth) (1.2 +/- 0.3) values for test and control groups. All-ceramic restorations revealed a better color match to the neighboring teeth than PFM restorations.
The effect of all-ceramic and porcelain fused to metal restorations on marginal peri-implant soft tissue color: A randomized controlled clinical trial

Ronald E. Jung a, Claudia Holderegger b, Irena Sailer a, Ameen Khraisat c, Ana Suter d, Christoph H. F. Hammerle e

a Senior lecturer, Department of Fixed and Removable Prosthodontics and Dental Material Science, University of Zurich, Switzerland
b Former post-graduate student, Department of Fixed and Removable Prosthodontics and Dental Material Science, University of Zurich, Switzerland
c Former post-doctoral fellow, Department of Fixed and Removable Prosthodontics and Dental Material Science, University of Zurich, Switzerland, and Assistant Professor, Dept of Conservative Dentistry and Prosthodontics, Faculty of Dentistry, University of Jordan, Amman, Jordan
d Master dental technician, Department of Fixed and Removable Prosthodontics and Dental Material Science, University of Zurich, Switzerland
e Professor and Chairman, Department of Fixed and Removable Prosthodontics and Dental Material Science, University of Zurich, Switzerland

Address for correspondence: Dr. Ronald E. Jung
Department of Fixed and Removable Prosthodontics and Dental Material Science
Dental School, University of Zurich
Plattenstrasse 11
CH-8032 Zurich, Switzerland
Phone: +41 44 634 32 51
Fax: +41 44 634 43 05
e-mail: ronald.jung@zzmk.uzh.ch
ABSTRACT

The aim of this study was to test the color-change effect of all-ceramic restorations compared with porcelain fused to metal (PFM) restorations on marginal peri-implant soft tissue. Thirty patients were randomly divided into two groups of 15 subjects each. The all-ceramic group received all-ceramic crowns on Al₂O₃-based abutments, while the PFM group had PFM crowns on titanium or gold abutments. A reflectance spectrophotometer was used to measure the color difference ($\Delta E_{\text{Implant}}$) between the mid-facial peri-implant mucosa before the restoration was inserted and afterwards. In addition, the color difference ($\Delta E_{\text{Tooth-Implant}}$) between the mid-facial peri-implant mucosa after insertion of the restoration and that of the gingival margin of the corresponding neighboring tooth was tested. The mucosal thickness was measured mid-facially around the implant (MT$_{\text{Implant}}$) and the neighboring tooth (MT$_{\text{Tooth}}$). The data of $\Delta E_{\text{Implant}}$, $\Delta E_{\text{Tooth-implants}}$, MT$_{\text{Implant}}$, and MT$_{\text{Tooth}}$ were compared and analyzed using unpaired $t$-test.

$\Delta E_{\text{Implant}}$ values were similar for the all-ceramic (7.4 ± 2.7) and PFM groups (7.6 ± 2.8) revealing no statistical significant difference. Regarding the $\Delta E_{\text{Tooth-Implant}}$, the all-ceramic group (3.4 ± 1.4) induced significantly less visible mucosal color change compared to the PFM group (5.2 ± 2.3) ($P = 0.0169$). The MT$_{\text{Implant}}$ of the all-ceramic group was 3.4 ± 0.8 mm and that of the PFM group was 2.9 ± 0.9 mm with no statistical significant difference. In contrast, high statistical significant differences were found, when comparing MT$_{\text{Implant}}$ (3.1 ± 0.9) with MT$_{\text{Tooth}}$ (1.2 ± 0.3) for both test and control groups.

It can be concluded that all-ceramic restorations on Al₂O₃-based abutments revealed a better color match to the neighboring teeth than PFM restorations. At all sites with either type of restorations the peri-implant mucosa was significantly thicker than the gingiva around corresponding natural teeth.
INTRODUCTION

The use of dental implants to restore function and esthetics following the loss of a single tooth has been well demonstrated.\textsuperscript{1-4} As high implant survival and success rates had been reported, the esthetic outcome has become the main focus of interest in esthetically sensitive areas.\textsuperscript{5, 6} Esthetic rehabilitation in implant dentistry was mainly focused on position, inclination, shape, and color of the restoration.\textsuperscript{7, 8} However, to imitate the appearance of natural teeth, the soft tissues around implant-borne restoration are an additional factor of importance.\textsuperscript{9, 10}

Several approaches have been performed to characterize the peri-implant mucosa.\textsuperscript{10-12} Recent studies revealed that the topography and the appearance of the periodontal and peri-implant soft tissue showed relevant differences in thickness.\textsuperscript{10, 11} Moreover, the color of the alveolar gingiva or the peri-implant mucosa was considered as a factor that plays a crucial role in soft tissue esthetics.\textsuperscript{6, 7, 13}

It was reported that restorations can cause a discoloration of the mucosa.\textsuperscript{14-16} Furthermore, different studies have proposed the use of all-ceramic restorations for esthetic rehabilitation on single-tooth implants.\textsuperscript{17, 18} However, the benefits of all-ceramic restorations over the use of porcelain fused to metal (PFM) restorations in terms of soft tissue discoloration have never been investigated. For that reason, it might be postulated that the color of abutment and superstructures might play an important role in influencing the color of the peri-implant mucosa around single-tooth implants.

The aim of the present clinical study was to evaluate the color-change effect on marginal peri-implant soft tissue of all-ceramic restorations based on Al\textsubscript{2}O\textsubscript{3} abutments compared with PFM restorations based on titanium or gold abutments.
MATERIALS AND METHODS

Study design and patient selection

The present study was a prospective randomized controlled clinical trial. All procedures and materials were approved by the local ethical committee, and all patients provided informed consent to participate in this trial.

Thirty patients (16 men and 14 women) in need for a single tooth replacement of an incisor, a canine, or a premolar were recruited for the present study. In patients with multiple single tooth gaps requiring implant therapy, the site to be included was randomly selected by throwing a dice. The patients were in good general health and had a median age of 61.5 years that ranged from 20 to 80 years. All patients underwent comprehensive dental care and were instructed to maintain a high level of oral hygiene. In the present study, inclusion criteria that had to be fulfilled by all patients are listed in Table 1.

Surgical procedure

After local anesthesia, crestal incision was made at the implant site and sulcular at the adjacent teeth. Subsequently, a vertical releasing incision was done at the distal adjacent tooth and the muco-periosteal flap was raised. A screw implant (Straumann® Dental Implant System, Straumann AG, Basel, Switzerland) with dimensions best suited to obtain primary stability and optimal reconstruction for the respective situation was chosen. Guided bone regeneration (GBR) was applied to promote bone fill of the gap between the implant surface and the bone walls when needed. Deproteinized bovine bone mineral (Bio-Oss® spongiosa particles, Geistlich-Pharma, Wolhusen, Switzerland) was used as a membrane supporting material and a resorbable collagen membrane (Bio-Gide®, Geistlich-Pharma, Wolhusen, Switzerland) was placed to cover the defect. Periosteal releasing incisions were then placed
to allow tension-free adaptation of the muco-periosteal flap. Horizontal mattress and single interrupted sutures were finally used for flap adaptation.

**Prosthetic components**

All patients included in the study were randomly assigned to two groups consisting of 15 subjects each. The test group (all-ceramic group) received Al₂O₃-based abutments (SynOcta® In-Ceram blank, Straumann AG, Basel, Switzerland) and all-ceramic restoration (Veneering ceramic: Creation AV®, Klema, Meiniugen, Austria; Core material: alumina, Procera, Nobel Biocare, Göteborg, Sweden) (Fig. 1 and 2a). The restorations were either screw-retained by directly veneering the ceramic blank or cemented with resin cement (Panavia®, Kuraray, Okayama, Japan) to an individualized Al₂O₃-based abutment. For the control group (PFM group), each implant received either a titanium abutment (SynOcta® cementable abutment, Straumann AG, Basel, Switzerland) or a gold abutment (SynOcta® gold coping, Straumann AG, Basel, Switzerland) and the corresponding restoration was porcelain (Creation CC®, Klema) fused to metal (Esteticor Special®, Cendres Metaux SA, Biel, Switzerland) (Fig. 2b and 3). The PFM restoration was either cemented with glass ionomer cement (Ketac Cem®, ESPE, Seefeld, Switzerland) or screw-retained. A standardized type of marginal design with a shoulder preparation was followed for both types of restorations (Fig. 2).

A reflectance spectrophotometer (Spectroshade, No. LUA005, Medical High Technologies, Zürich, Switzerland; software version 2.5) was used to measure the color of the peri-implant mucosa in an objective manner. The used spectrophotometer and the measuring setup have been described in previous studies.¹³,¹⁹,²₀
**Spectrophotometric assessment**

*Color assessment of the peri-implant mucosa*

Spectrophotometric measurements (SpM) for all 30 sites were performed immediately before the restoration was inserted (SpM before) and 1 to 2 weeks after the restoration was finally placed (SpM after) (Fig. 4). This period (1 to 2 weeks) was designated to overcome gingival blanching resulted from stretching effect caused by the prosthetic parts. For obtaining the measurements, the adapter of the spectrophotometer standard lens or intraoral adaptor camera was positioned perpendicular to the alveolar process over the respective site (Fig. 5). The spectrophotometric data were then recorded three consecutive times for each of the 30 sites. Thus, three images of the SpM before and 3 images SpM after were obtained.

In order to calculate the color difference between spectrophotometric measurements SpM before and SpM after, the two respective images were matched by placing them on top of each other by means of the corresponding computer software. Subsequently, two standardized circular measuring areas (3mm diameter) were positioned over the same part of the peri-implant mucosa in each of the two images. The area of interest was the mucosal margin at the top of the gingival zenith. The computer software of the spectrophotometer calculated the color difference (ΔE$_{Implant}$) in these areas according to the following equation:

$$\Delta E_{Implant} = \sqrt{(L_{before} - L_{after})^2 + (a_{before} - a_{after})^2 + (b_{before} - b_{after})^2}$$

Where L is lightness, a is chroma along red-green axis, and b is chroma along yellow-blue axis.19-21

Each comparison was done 3 times and the final ΔE$_{Implant}$ was the average of the 3 comparisons for each study site.

*Color assessment of peri-implant and natural tooth mucosa*
Spectrophotometric measurements were used to assess the color difference ($\Delta E_{\text{Tooth-Implant}}$) between the peri-implant mucosa after the insertion of the restoration ($\text{SpM}_{\text{after}}$) and the gingival margin of the corresponding-unrestored mesial neighboring tooth (Fig. 6).

**Assessment of the soft tissue thickness**
During the implant healing period, the soft tissue thickness was evaluated. In cases where the peri-implant mucosal thickness was less than 2 mm, a connective tissue graft was placed in an attempt to have similar mucosal thickness.

At the time of restoration placement, the thickness of the peri-implant mucosa ($\text{MT}_{\text{Implant}}$) was measured mid-facially one millimeter apical to the margin. After local anesthetizing the facial peri-implant mucosa, an endodontic file (Hedstroem Nr. 20, Maillefer, Ballaigues, Switzerland) was used to pierce the mucosa until solid resistance was encountered (Fig. 7). Mucosal thickness was measured to the nearest half millimeter. The same procedure was repeated to assess the thickness of the mid-facial gingival margin of the corresponding mesial neighboring tooth ($\text{MT}_{\text{Tooth}}$). These measurements were performed in order to correlate the color assessments with the soft tissue dimensions.

**Data presentation and statistical analysis**
It was hypothesized that all ceramic restorations would cause significantly less color change of the peri-implant mucosa than PFM restorations. Mean values of color difference, mucosal thickness, and the corresponding standard deviations were determined. The data of $\Delta E_{\text{Implant}}$, $\Delta E_{\text{Tooth-Implant}}$, and $\text{MT}_{\text{Implant}}$ were compared between the two groups and analyzed using unpaired student’s t-test ($\alpha = 0.05$). Further analyses were accomplished using student’s t-test to compare $\text{MT}_{\text{Implant}}$ and $\text{MT}_{\text{Tooth}}$ within the individual group. The same statistical analysis was performed for the test and control subgroups to compare color changes in sites treated
with a connective tissue graft (with graft) and sites without receiving a connective tissue graft (without graft).

RESULTS

Color assessment of the peri-implant mucosa

Descriptive data analysis revealed that the insertion of all-ceramic restorations had a slightly lower mean $\Delta E_{\text{Implant}}$ value ($7.4 \pm 2.7$) compared to PFM restorations ($7.6 \pm 2.8$) (Table 2). Statistical analysis demonstrated the absence of a statistically significant difference between the two groups regarding the peri-implant mucosal color change at the time of insertion of the restorations ($\Delta E_{\text{Implant}}$ values). Nine patients in the all-ceramic group and 10 in PFM group had connective tissue graft placement. Neither the grafted nor the non-grafted cases showed any statistical significant difference in $\Delta E_{\text{Implant}}$ values between the two groups (Table 2).

Color assessment of peri-implant and natural tooth mucosa

When the color difference ($\Delta E_{\text{Tooth-Implant}}$) of the peri-implant mucosa of the implant restoration and the gingival margin of the corresponding tooth were assessed, the all-ceramic group showed a mean value of $3.4 \pm 1.4$, while the PFM group exhibited a higher mean value with a relatively broad standard deviation ($5.2 \pm 2.3$) (Table 2). Statistical analysis showed a significant difference between the two groups regarding $\Delta E_{\text{Tooth-Implant}}$ ($P = 0.0169$). When the $\Delta E_{\text{Tooth-Implant}}$ values for the grafted and non-grafted cases were compared between the two groups, no statistical significant difference was proved for the grafted cases. In contrast, the non-grafted cases of the two groups showed a statistical significant difference ($P = 0.0475$).

Assessment of the soft tissue thickness

Regarding the peri-implant mucosal thickness, the mean $MT_{\text{Implant}}$ value was $3.4 \pm 0.8$ mm for the all-ceramic group and $2.9 \pm 0.9$ mm for the PFM group. The $t$-test showed no significant difference between $MT_{\text{Implant}}$ values of the two groups (Table 2).
On the other hand, the mean $MT_{\text{Tooth}}$ value of the neighboring tooth in the all-ceramic group was $1.3 \pm 0.4$ mm and that of the neighboring tooth in the PFM group was $1.3 \pm 0.6$ mm (Table 2). The overall $MT_{\text{Implant}}$ mean value in the 30 patients was $3.1 \pm 0.9$ mm and that for $MT_{\text{Tooth}}$ mean value was $1.2 \pm 0.3$ mm. High significant differences were found between $MT_{\text{Implant}}$ and $MT_{\text{Tooth}}$ values for either individual group or total patient comparisons ($P < 0.001$).

**DISCUSSION**

The present clinical trial revealed that the insertion of an all-ceramic or a PFM restoration causes similar changes to the color of the peri-implant mucosa. However, when the restoration is in place, the gingival color of the corresponding-unrestored tooth and the peri-implant mucosal color of the all-ceramic restoration revealed a more favorable color match compared to the PFM restoration.

Spectrophotometric measurements at the time of restoration insertion revealed that both restoration types induced a color change ($\Delta E_{\text{Implant}}$) greater than 7.4 (Table 2). The human eye is able to see intraoral color differences exhibiting a $\Delta E$ greater than 3.7. In the present study all the cases except two showed values higher than this threshold. Therefore, it can be concluded that the insertion of a restoration induced a visible color change regardless of the abutment type. This might be explained by the fact that a mucosa, which is not supported by any structure (either enamel or restoration material) reveals a different light transmission than a mucosa which is underlined either by a tooth or by a restoration.

The mean $\Delta E_{\text{Tooth-Implant}}$ values were 3.4 and 5.2 for the all-ceramic and PFM groups, respectively. Statistical analysis revealed significant difference between the two groups. The $\Delta E_{\text{Tooth-Implant}}$ values were higher than the $\Delta E$ that can be distinguished by the human ($\Delta E = 3.7$) in less than one third of the all-ceramic group patients (4) and about two thirds of those of the control (PFM) group (11).
It seems reasonable to assume that the mucosal thickness will have an effect on color changes induced by placing restorations on implants. In a recent in vitro study the effect of titanium and zirconia with and without veneering ceramic was analyzed on the color of mucosa of three different thicknesses. In that study, no change could be detected by the human eye for any of tested material when the mucosa reached a thickness of 3 mm. In situations with thicknesses of 2 mm or less the all-ceramic group (zirconia) showed the least color change. In the present study, the mean mucosal thickness was 3.4 ± 1.4 mm for the all-ceramic group and 2.9 ± 0.9 mm for the PFM group. For both groups the thickness of the mucosa was above the critical threshold for a visible color change induced by zirconia as determined in the above-mentioned in vitro study. This might be the reason, why no significant difference was found between the all-ceramic and PFM groups regarding the color change at the time of restoration insertion. On the other hand, the present study demonstrated better color match to the neighboring teeth in all-ceramic group, specifically, the non-grafted cases. That might be explained either by the presence of a slightly thicker peri-implant mucosa around the implants in the all-ceramic group (0.5 mm, as a mean difference) or may be by a better esthetic appearance of the all-ceramic restorations. However, further clinical investigation with greater no. of cases might be needed to define a correlation between soft tissue thickness and the optimal material of implant restoration.

Regarding peri-implant and tooth mucosal thickness, a recent study evaluated the soft tissue dimensions around 21 single-tooth implant restorations and the contralateral natural teeth. With the assessment by an ultrasonic device, the facial peri-implant mucosal thickness was found to be 2.0 mm. This was approximately 1 mm thicker than that of the contralateral tooth (1.1 mm). The measurements of the present study using an endodontic file support the abovementioned results, however, the mean peri-implant mucosal thickness was about 1 mm greater than that in the abovementioned study. A similar dimension of 3.6 mm was reported in another clinical study of 45 patients when the thickness was measured with a periodontal
The variability of the dimension reported in the literature might be due to different study sample sizes, clinical procedures, methods of measurement, implant positions, and implant head diameters. The latter two factors might explain the statistically high significant difference between $MT_{\text{Implant}}$ and $MT_{\text{Tooth}}$ values for either individual group or the total patient comparisons in the present study.

In the literature, no colorimetric or spectrophotometric device has been validated for measuring intraoral gingival color so far.\textsuperscript{14, 23} It was suggested to use visual matching test, using Munsell color tabs and their corresponding notations to construct an intraoral soft tissue shade guide.\textsuperscript{14} In a recent study the color shade difference was visually assessed between the peri-implant mucosa around single-tooth implants and the gingiva around reference teeth.\textsuperscript{6} In that study, the color change of the peri-implant mucosa was demonstrated in about two thirds of examined patients. However, recent studies comparing both methods concluded that spectrophotometric shade analysis, based on CIE-Lab parameters\textsuperscript{21}, was more accurate and reproducible than visual shade assessment.\textsuperscript{13, 19, 20}

**CONCLUSION**

Within the limitations of the present study, the following conclusions were reached:

- The insertion of either all-ceramic restorations on $\text{Al}_2\text{O}_3$-based abutments or PFM restorations induced a similar and visible color change to the marginal soft tissue.

- All-ceramic restorations on $\text{Al}_2\text{O}_3$-based abutments revealed a significantly better color match to the unrestored neighboring teeth than PFM restorations.

- The peri-implant mucosa was significantly thicker than the gingiva around natural teeth regardless to the type of restoration.
Acknowledgment

The authors would like to thank Dr Patrick Schmidlin (Clinic for Preventive Dentistry, Periodontology and Cariology, University of Zurich) for his input in the statistical analysis of this study.
References


## Table 1: Subject and study site inclusion criteria

### Subject inclusion criteria:
- Need for placement of an implant to be restored with a single crown
- Age > 18 years
- No relevant Medical conditions
- Non-smoking or smoking ≤ 10 cigarettes/day (all pipe or cigar smokers were excluded)
- Full Mouth Plaque Score and Full Mouth Bleeding Score ≤ 25 %
- Possibility for follow-up for 36 months

### Study site inclusion criteria
- Presence of at least one adjacent tooth
- Presence of a minimum of 2-mm band of keratinized labial gingiva
- No implant presence or planned to be placed adjacent to study site, during the course of the trial
<table>
<thead>
<tr>
<th></th>
<th>All-ceramic group (n)</th>
<th>PFM group (n)</th>
<th><em>P</em> value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ΔE\textsubscript{Implant} ± SD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>7.4 ± 2.7 (15)</td>
<td>7.6 ± 2.8 (15)</td>
<td><em>P &gt; 0.050</em></td>
</tr>
<tr>
<td>With graft</td>
<td>8.1 ± 3.0 (6)</td>
<td>7.8 ± 1.8 (6)</td>
<td><em>P &gt; 0.050</em></td>
</tr>
<tr>
<td>Without graft</td>
<td>6.9 ± 2.5 (9)</td>
<td>7.5 ± 3.3 (9)</td>
<td><em>P &gt; 0.050</em></td>
</tr>
<tr>
<td><strong>ΔE\textsubscript{Tooth-Implant} ± SD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>3.4 ± 1.4 (15)</td>
<td>5.2 ± 2.3 (15)</td>
<td><em>P = 0.0169</em></td>
</tr>
<tr>
<td>With graft</td>
<td>3.4 ± 0.8 (6)</td>
<td>4.3 ± 1.8 (6)</td>
<td><em>P &gt; 0.050</em></td>
</tr>
<tr>
<td>Without graft</td>
<td>3.5 ± 1.7 (9)</td>
<td>5.6 ± 2.5 (9)</td>
<td><em>P = 0.0475</em></td>
</tr>
<tr>
<td><strong>MT\textsubscript{Implant} ± SD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>3.4 ± 0.8 (15)</td>
<td>2.9 ± 0.9 (15)</td>
<td><em>P &gt; 0.050</em></td>
</tr>
<tr>
<td>With graft</td>
<td>3.7 ± 0.5 (6)</td>
<td>3.5 ± 1.2 (6)</td>
<td><em>P &gt; 0.050</em></td>
</tr>
<tr>
<td>Without graft</td>
<td>3.2 ± 1.0 (9)</td>
<td>2.6 ± 0.7 (9)</td>
<td><em>P &gt; 0.050</em></td>
</tr>
</tbody>
</table>
Figures

Figure 1. A case of the all-ceramic group where 

(a) shows the marginal peri-implant mucosal condition before restoration insertion, 

(b) shows the Al₂O₃-based abutment in the working cast, 

and 

(c) shows the final restoration.
Figure 2. All-ceramic (a) and PFM (b) restorations with similar type of marginal design.
Figure 3. A case of the PFM group where a shows the marginal peri-implant mucosal condition before restoration insertion, b shows the cast-metal crown framework in the working cast, and c shows the final restoration.
**Figure 4.** Computer screen image of the spectrophotometric measurements of the peri-implant mucosa before and after the insertion of the final restoration. The light of the camera is split to illuminate the area of interest simultaneously from two sides allowing to have pictures without reflection.
Figure 5. A case, where the spectrophotometer adapter positioned perpendicular to the alveolar process for color measurement.
Figure 6. Computer screen image of the spectrophotometric measurements of the peri-implant mucosa (left maxillary central incisor) and the mucosa of the natural tooth (right maxillary central incisor).
Figure 7. Assessment of peri-implant mucosal thickness using an endodontic file.