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Correlation between subjective and objective evaluation of peri-implant soft tissue color

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Abstract

Purpose: While extensive references are present in the literature dealing with the correlation between subjective and objective evaluation of tooth shade, there is a lack of information on this correlation regarding the soft tissue color. The purpose of this experimental study was to verify whether a correlation between the objective and subjective evaluation exists in analyzing soft tissue color.

Material and methods: A total of 39 patients with at least one implant-supported restoration in the anterior maxilla were included in the study. The shade of the peri-implant mucosa was compared with the shade of the gingiva at the adjacent tooth in a subjective and in an objective manner. The subjective evaluation was performed by five dental professionals (prosthodontist, periodontist, general dentist, dental hygienist, and dental assistant) in a subjective scale (ranging from 1 to 4). The objective evaluation was obtained by means of a spectrophotometer in a CIELAB* Color Scale, and the differences were evaluated through formula $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$. To correlate the subjective and the objective evaluation, for each arithmetical median value of the subjective evaluation, a mean value of objective evaluation has been calculated, and the Spearman's rank correlation coefficient has been used. The differences have been also analyzed for thin and thick tissue biotypes.

Results: The mean ΔE value for the subjective evaluation between peri-implant soft tissue and adjacent tooth gingival tissue was $\Delta E = 9.74$. Also, mean ΔE values of 10.35 and 7.54 have been reported for thin and thick biotypes, respectively. Mean values of $\Delta E = 6.63, 8.54,$ and 15.54 were presented by median values of 1 (perfect matching), 2 (good matching), and 3 (clinically distinguishable), respectively. The threshold for the distinction of differences of mucosal color by the human eyes between perfect or good matching and distinguishable values has been calculated in $\Delta E = 8.74$.

Conclusions: Within the limitation of this study, a correlation between the subjective and the objective evaluation of the peri-implant soft tissue exists and the threshold for the distinction of mucosal color differences between perfect or good matching and distinguishable subjective values has been calculated in $\Delta E = 8.74$ in the objective evaluation.

The reproduction of a natural gingival architecture around dental implants placed in the anterior maxilla represents a challenge for the restorative dentist, particularly in patients with a high lip line when smiling (Chang et al. 1999). Furthermore, in the modern society, the final esthetic outcome is becoming more and more important, and it is a determinant factor for the treatment success (Belser et al. 2009; Benic et al. 2012; Lang & Zitzmann 2012; Lops et al. 2012).

Several studies have been conducted on the esthetic outcome of the white component of

the tooth, and a reduced number of studies have been conducted on the factors affecting the achievement of a natural gingival outcome (Sykaras et al. 2000; Gallucci et al. 2004; Grunder et al. 2005). More recently, increased attention has been addressed to the selection of the proper material for the prosthetic solution to influence significantly the peri-implant gingival shade. All-ceramic restorations have increasingly become popular due to their esthetic advantages on the soft tissues (Heydeck et al. 2002; Nakamura et al. 2002). A more natural outcome with the

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utilization of ceramic abutment over metal abutment has been well documented in different clinical and laboratory trials, especially when dealing with thin peri-implant tissues (Jung et al. 2008; Bressan et al. 2011). The modification of the prosthesis shade has been also suggested with the utilization of the pink color for both the abutment and the implant head (Ishikawa-Nagai et al. 2007). Nevertheless, all the techniques tested showed results significantly different from the natural soft tissue and concluded that the color of the soft tissue around dental implants was significantly different if compared to that around natural teeth (Park et al. 2007).

One of the difficulties in determining different shades is related to its subjectivity; for this reason, it is extremely important to utilize objective methods to compare different shades (Okubo et al. 1998; Chu et al. 2004). One of the objective methods for evaluating color in dentistry is through colorimetric or spectrophotometric analysis. These instruments use the CIELAB color scale, which identifies color through the black/white (L^* value), green/red (a^* value), and yellow/blue dimensions (b^* value). This technique has been extensively utilized in measuring tooth color and tooth color differences through the equation $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$ (Hasegawa et al. 2000; Paul et al. 2002; Chu et al. 2004). The correlation between ΔE values and subjective clinical observations has been conducted in several studies considering tooth shade. Johnston & Kao (1989) set $\Delta E = 3.7$ as the average color difference among teeth rated as a match in the oral environment. In other studies on metal-ceramic restorations, thresholds for acceptability were reduced to $\Delta E = 1.7$ (Douglas & Brewer 1998). More recently, different thresholds for perceptibility ($\Delta E < 2.6$) and acceptability ($\Delta E < 5.5$) of shade mismatch have been described also in a clinical setting (Douglas et al. 2007; Yilmaz et al. 2009).

Differently, a reduced number of studies on the shade of the gingiva has been published with the utilization of a spectrophotometer (Dummett 1960; Takeda et al. 1996; Schnitzer et al. 2004); moreover, interestingly, no correlation between subjective and objective evaluation has been conducted.

The purpose of this clinical trial was to verify whether the correlation between subjective and objective color evaluation, considered valid for tooth structure, can be also applied on gingival tissue with more appropriate thresholds for the soft tissue.

Material and methods

Participants

Healthy adult patients were scheduled for a single-tooth extraction and consequent prosthetic treatment at School of Dentistry of the University of Padova, Italy.

All patients were treated with single Astra-Tech implants (AstraTech®, Mölndal, Sweden) between December 2009 and November 2011. Subjects qualified for participation in the study were followed for at least 6 months after the definitive restoration delivery.

The following evaluations were performed at the first visit, aimed to select the patient for the enrollment in the present study: (i) controlled periodontal condition (no Probing Pocket Depth Index superior to 4 mm, no Bleeding on Probing and Plaque Index inferior to 20%); (ii) no active intraoral or systemic disease; (iii) single implant-supported restoration in place since at least 6 months in the anterior area (from the first premolar forward); and (iv) natural vital virgin tooth adjacent to the implant.

Exclusion criteria were as follows: (i) patients with systemic diseases (such as heart, coagulation, and leukocyte diseases or metabolic disorders); (ii) history of radiation therapy in the head and neck region; (iii) current treatment with steroids; (iv) neurologic or psychiatric handicap that could interfere with good oral hygiene; (v) immunocompromised status, including infection with human immunodeficiency virus; (vi) severe clenching or bruxism; (vii) smoking habit (≥ 10 cigarettes/die); (viii) drug or alcohol abuse; and (ix) inadequate compliance.

Six months after the definitive restoration delivery, all patients were recalled for the clinical and instrumental measurements: The gingival tissue facial to the implant-supported restoration and to the adjacent tooth has been evaluated both objectively and subjectively. Informed consent was obtained for all the patients. In obtaining the informed consent and in conducting the study, the principles outlined in the Declaration of Helsinki on experimentation involving human subjects were adhered to as revised in 2000 (Salako 2006).

Measurements

The subjective evaluations have been performed by five different operators: (i) prosthodontist; (ii) periodontist; (iii) general dentist; (iv) dental hygienist; and (v) dental assistant. Each one has been instructed to grade the matching between the peri-implant soft tissue and the periodontal soft tissue of the

adjacent tooth. Four different level of matching have been considered:

Grade 1: Perfect matching, no differences are perceptible at visual inspection.

Grade 2: Good matching, but clinically distinguishable in intra-oral examination.

Grade 3: Clearly distinguishable at "extra-oral" examination, but clinically acceptable.

Grade 4: Clearly distinguishable and clinically not acceptable, evident differences are present, and adjunctive surgical procedure is recommended.

The objective evaluation has been obtained by using a spectrophotometer (Spectroshade "Micro" Device, MHT SpA., Medical High Technologies, Arbizzano di Negrar, Verona, Italy). The device was managed by a single operator who captured an area of about 5 mm around the gingival margin of the selected tooth or crown. All the measured areas were analyzed through the spectrophotometer software (Spectroshade 3.01, MHT SpA.) which identified a specific area (Fig. 1). The selected area extended from the mucosal margin to 4 mm apically, and from the long axis of the tooth 2 mm on each side (Fig. 1). Each selected area was measured for three times; the results were recorded through LAB* color scale, and the values from the three measurements were averaged before proceeding with the statistical analysis. The comparison between the peri-implant soft tissue and the adjacent gingival tissue was performed with the use of the following ΔE formula: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$. (Munsell 1923; Hunt 1987; Johnston & Kao 1989; Berns 2000).

Immediately after the subjective and objective evaluations, the periodontal and peri-implant biotypes have been identified with the insertion of a periodontal probe in the facial sulcus; if the probe was shading through the tissue, the biotype was

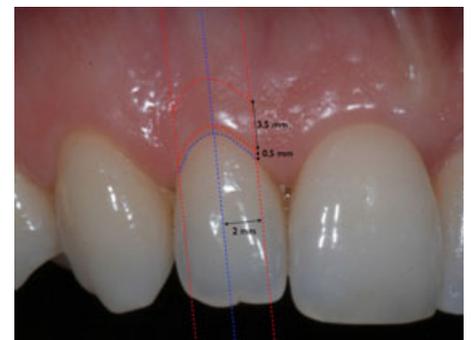


Fig. 1. Selected area identified through spectrophotometer software.

considered thin, if not it was considered thick (Kan et al. 2003).

Statistical analysis

The subjective evaluations on the patients have been analyzed with the calculation of the median and standard deviations of the five different professional operators. The objective evaluations have been calculated with the analysis of mean, median, and standard deviations.

To identify a correlation between the objective and subjective evaluation, for each arithmetical median value of the subjective evaluation, a mean value of objective evaluation has been calculated. The Spearman's rank correlation coefficient has been calculated to assess the level of correlation.

Results

Thirty-nine patients have been included in the study. The group of patients was made up of 14 men and 25 women (mean 49 years old, ranging from 19 to 71).

The values of the objective evaluation, Lab* values for each site and ΔE values for each chromatic correlation are described in Table 1. The mean ΔE values between peri-implant soft tissue and adjacent tooth gingival tissue were 9.74 (minimum = 1.25, maximum = 27.26). The objective spectrophotometer evaluation has also been related to the peri-implant biotype with mean ΔE values of 10.35 (thin biotype) and 7.54 (thick biotype) (Table 2).

The median values obtained for the subjective evaluation have been of 2 (mean 1.98, standard deviation 0.56). The subjective evaluation has also been related to the peri-implant biotype with median values of 2 for the thin tissue group ($n = 8$, mean = 2.10, SD = 0.52) and of 1 for the thick group ($n = 31$, mean = 1.80, SD = 0.44). Frequency distribution of the subjective scores related to the gingival biotype is reported in Table 3.

The analysis of the median showed that eight patients presented median of 1 (perfect matching), 22 patients median of 2 (good matching), and nine patients median of 3

Table 2. Mean ΔE , ΔL , Δa , and Δb values for the correlation between peri-implant biotype and adjacent tooth gingival tissue, subdivided by peri-implant biotype

Biotype	ΔE		ΔL		Δa		Δb	
	Mean	Standard deviation						
Thin ($n = 8$)	10.352	7.00	6.155	6.10	6.613	5.73	4.376	2.15
Thick ($n = 31$)	7.545	6.69	4.447	7.10	3.179	6.03	2.813	3.24

(clearly distinguishable). No patient showed median of 4 (clinically not acceptable). The mean value of ΔE has been calculated for each of the three groups of subjective median (1, 2 and 3) as described in Table 4. Median subjective values of 1 (perfect matching) present a lower value of $\Delta E = 6.63$. Median subjective values of 2 (good matching) present a value of $\Delta E = 8.54$. Median subjective values of 3 (clinically distinguishable) present a higher value of $\Delta E = 15.54$.

When the correlation between the subjective and the objective evaluations was assessed, the Spearman's rank correlation coefficient was 0.395 (P -value = 0.013) which resulted to be statistically significant. (Fig. 2)

Discussion

The present study aimed to correlate the subjective and the objective evaluation of the soft tissue color. As reported in most of the literature, the peri-implant soft tissue color has been analyzed in relation to the periodontal soft tissue (Park et al. 2007; Jung et al. 2008; Bressan et al. 2011).

In the present study, the objective evaluation showed significant differences in color between these two different tissues, with mean ΔE values of 9.74 ($\Delta L = 4.79$, $\Delta a = 3.88$, and $\Delta b = 3.13$). These data confirmed what has been previously mentioned by the literature: In fact, all the studies on this topic reported that there is a significant chromatic difference between the peri-implant soft tissue and the periodontal one with ΔE values ranging from 6.5 to 11 (Park et al. 2007; Jung et al. 2008; Bressan et al. 2011). Nevertheless, all these researches used threshold

Table 3. Frequency distribution of the subjective scores related to the gingival biotype

Biotype	Median					
	2		3		Total	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Thick	25	80.65	6	19.35	31	100
Thin	5	62.50	3	37.50	8	100
Total	30	76.92	9	23.08	39	100

references from studies previously performed on a different substrate, tooth structure of natural dentition. With this substrate analysis, values of ΔE ranging from 2 to 4 have been reported as limit of acceptability (Johnston & Kao 1989; Douglas & Brewer 1998; Douglas et al. 2007; Yilmaz et al. 2009). Therefore, the present trial was justified by the need to understand whether subjective evaluation of soft tissue color is different from that of hard tissue.

Heterogeneous and different professional operators have been selected to provide a critical evaluation of the periodontal and peri-implant soft tissue: a prosthodontist, a periodontist, a general dentist, a hygienist, and a dental assistant. The performed subjective evaluations reported results different than the objective ones, with median values of 2, corresponding to "good matching, but clinically distinguishable in intra-oral examination." It is significant to notice that with mean objective value of 9.74, the median subjective values corresponded to a good matching; nevertheless, this value is quite higher than the thresholds for acceptability reported in the literature (Johnston & Kao 1989; Douglas & Brewer 1998 and Douglas

Table 1. Mean ΔL , Δa , Δb , and ΔE values for the comparison between peri-implant biotype and adjacent tooth gingival tissue

	Mean	Standard deviation
ΔL	4.79794	6.87
Δa	3.88376	6.06
Δb	3.13410	3.10
ΔE	9.74596	6.72

Table 4. Mean value of ΔE (objective evaluation) for each group of subjective median

Median	Means	Standard deviation	Minimum	Maximum
1 ($n = 8$)	6.63	3.7480	1.26	11.5
2 ($n = 22$)	8.54	5.3228	2.74	19.9
3 ($n = 9$)	15.48	8.8018	2.74	27.3
All Grps*	9.75	6.7259	1.26	27.3

*No patient showed median of 4 (clinically not acceptable).

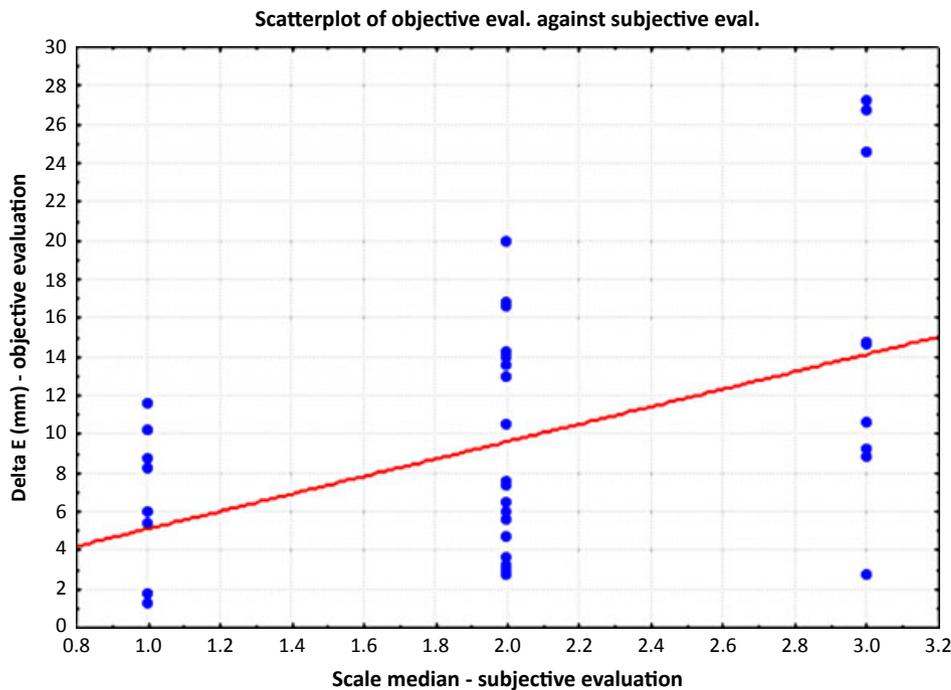


Fig. 2. Graphic representation of the correlation between subjective and objective evaluation.

et al. 2007; Yilmaz et al. 2009). Hence, it seems that the human eye could be more sensitive to differences in the white tissue of the teeth than to differences in the pink tissue of the gingiva (Dummett 1960; Takeda et al. 1996; Schnitzer et al. 2004).

To find a precise correspondence between subjective and objective evaluation, the groups of patients have been divided into three different groups according to their median: eight patients presented a median of 1 (perfect matching), 22 patients a median of 2 (good matching), and nine patients a median of 3 (clearly distinguishable). The mean value of ΔE has been calculated for each of the three groups of subjective median (1, 2 and 3) and described in Table 4. These results showed that subjective values of 1 (perfect matching) presented a lower values of $\Delta E = 6.63$. Subjective values of 2 (good matching) presented

average values of $\Delta E = 8.54$. Subjective values of 3 (clinically distinguishable) presented a higher values of $\Delta E = 15.54$;

By considering the fact that the Spearman's rank correlation coefficient had a P -value lower than 0.005, it can be concluded there is an association between subjective values and objective values. The Spearman's correlation coefficient is positive and significant, so the subjective values tend to increase when the objective values increases.

The relevance of the soft tissue biotype thickness was significant in both the type of evaluation; furthermore, as mentioned by several authors (Sykaras et al. 2000; Grunder et al. 2005; Jung et al. 2008), an increased soft tissue thickness improved the tissue matching. Even if the subgroups sample size was extremely reduced, on the subjective evaluation, median values of 2 (mean 2.10)

were reported in the thin biotype group and of 1 (mean 1.80) in the thick biotype group. Similarly with objective evaluation, ΔE values of 10.352 and 7.545 were reported for the thin and thick biotype groups, respectively.

Even if the results of this study are interesting, limitations should be considered. The professional observation of the tissue might be different from the observation of the general population, not competent in the field. In more, even if spectrophotometric tissue evaluations are extensively utilized for soft tissue measurement, spectrophotometers are fabricated to measure dental hard tissue.

Conclusions

Within the limitation of this study, the following conclusions can be drawn:

1. With the application of spectrophotometric evaluation, the peri-implant soft tissue color is different from the soft tissue color around natural teeth.
2. With a subjective evaluation, the peri-implant soft tissue color appears to be similar to the soft tissue color around natural teeth.
3. Perfect matching subjective evaluation presented values of $\Delta E = 6.63$, subjective values of good matching presented average values of $\Delta E = 8.54$, clearly distinguishable subjective evaluations correspond to objective evaluations of "15.54."
4. The threshold for the distinction of differences of mucosal color by the human eyes between perfect or good matching and distinguishable values has been calculated in $\Delta E = 8.74$.
5. Thick tissue biotype improve the soft tissue color quality for both the used evaluations.

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