Color Distribution and Visual Color Assessment of Human Gingiva and Mucosa: A Systematic Review of the Literature

Stefan Schnitzer, DDS[a]/Jens C. Türp, DDS, Dr Med Dent Habil[b]/Guido Heydecke, DDS, Dr Med Dent[c]

Purpose: This study undertook a systematic overview of the literature on the description and visual measurement of gingival color. ***Materials and Methods:*** Two research questions were formulated. The first addressed the description of gingival color, while the second aimed at visual color measurement techniques. An electronic search was performed in 22 literature databases. The electronic search was complemented by hand searching. The retrieved articles were independently reviewed by two members of the research team. The levels of evidence of the articles were classified following the guidelines of the Oxford Centre for Evidence-Based Medicine. ***Results:*** Of the nine articles retrieved by the two searches, six applied to the first question, two applied to the second question, and one applied to both questions. Three articles were published in Japanese and dealt with the color of gingival and alveolar mucosa. The clinical studies showed that the intraoral tissues of younger persons are of a lighter color. Evidence levels were no higher than 4. ***Conclusion:*** Studies on the description of gingival color used a narrative approach. Studies on visual gingival color measurement had diverse aims, methods, and parameters. It is impossible to compare or even combine their outcomes in a scientifically meaningful manner. Since none of the investigations used a controlled or randomized design, they represent low levels of evidence. *Int J Prosthodont 2004;17:327–332.*

Esthetic appearance plays an essential role in patient acceptance of removable prostheses.[1,2] However, in contrast to the refinement of the "white esthetics" of fixed prosthodontic work, the individual characterization of denture bases for achieving a thorough adaptation to intraoral soft tissues is rarely practiced. Currently, methyl methacrylate is the most frequently chosen acrylic resin for the fabrication of partial and complete removable denture bases.[3,4] Individual tinting of denture base resins is possible with, for example, the Dentacolor System (Heraeus Kulzer). Using this system, the outer surface of the denture base is coated with light-curing resins.[5] Denture bases made with the Ivocap system (Ivoclar Vivadent) can be individualized with the "Denture Stain Kit Ena Resin," a heat-polymerizing acrylic resin that contains several coloring agents. Additional individualization can be achieved by adding red fibers to imitate small gingival and mucosal capillary blood vessels.[6,7] Nevertheless, lack of long-term stability is one of the few disadvantages of acrylic resins as denture base materials. This is a result of their poor resistance to abrasion and, although low, solubility in water.[8]

Because of the wide variety of acrylic resins, tints, and their respective shade guides, the individual characterization of denture bases for an optimal esthetic result is a complicated and time-consuming process.[9] For optimal adaptation and an almost undetectable transition from prosthodontic restoration to intraoral soft tissues, superior artistic skills of the dental technician are crucial because selection and combination of materials rely solely on his or her subjective decision.[10] A photograph or mirror image

[a]*Assistant Professor, Department of Periodontology, School of Dentistry, University of Muenster, Germany.*
[b]*Associate Professor, Department of Prosthodontics, School of Dentistry, University Hospital, Freiburg, Germany; and Associate Professor, Clinic of Fixed and Removable Prosthodontics and Temporomandibular Disorders, School of Dentistry, University of Basel, Switzerland.*
[c]*Visiting Professor, Faculty of Dentistry, McGill University, Montréal, Canada; and Associate Professor, Department of Prosthodontics, School of Dentistry, University Hospital, Freiburg, Germany.*

Correspondence to: *Dr Guido Heydecke, Department of Prosthodontics, School of Dentistry, University Hospital, Hugstetter Strasse 55, D-79106 Freiburg, Germany. Fax: + 49-761-270-4824. e-mail: guido.heydecke@klinikum.uni-freiburg.de*

of the opposite side of the jaw can be used to aid in the selection of gingival color.[11]

Color assessment of human gingival and mucosal tissues is an essential first step in the development of an intraoral soft tissue shade guide. Such measurements can be performed using visual, spectrophotometric, or photographic techniques. Knowledge of the distribution of gingival and mucosal shades is almost equally important for the individual configuration of denture base color.

The aim of this article was to systematically identify the literature on gingival and mucosal color to answer the following questions:

1. Which studies describe color and its distribution within human gingiva and mucosa?
2. Which studies report on visual color measurement and shade matching of human gingiva and mucosa?

Materials and Methods

For the search in the electronic databases, a search strategy was created for each of the two research questions by combining the following keywords and Boolean operators:

(gingiva* OR gum*) OR ((soft OR gingiva*) AND tissue*) AND (color* OR colour* OR tint*) AND (pigment* OR distribut* OR spectr*)

(color* OR colour* OR tint*) AND (visual* OR optic* AND (match* OR spectr* OR diff* OR percept* OR test* OR observation* OR inspect* OR stud* OR survey* OR probe* OR trial*)) AND (gingiva* OR (soft* OR gingiva*) AND tissue*) OR gum* OR esthetic* OR ((red OR pink) AND esthetic*)

For databases that did support the entry of the complete search strategy in clear text, individual searches for each keyword were carried out. The results were combined using Boolean operators (AND, OR). Truncation of keywords was performed for databases 1 to 10 and 12 to include variations of the keyword; truncation was not supported by the remaining databases.

The literature search was conducted in January 2003 using the following databases:

- PubMed (National Library of Medicine; NLM). PubMed is NLM's online search interface for MEDLINE and PreMEDLINE (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi).
- WebSPIRS (SilverPlatter) MEDLINE; CD-ROM database (1966–2002/11/Serfile1902) (http://www.ovid.com/site/products/tools/silverplatter).
- Cochrane Controlled Trials Register, Cochrane Database of Systematic Reviews, EBM Reviews–Best Evidence; online database (2002, Issue 4) (http://cochrane.redi-fr.belwue.de).
- Embase (EM74)/Embase Alert (EA08) (Elsevier Science, 2002); online database (last updated 11/2002).
- Current Contents Connect (Institute for Scientific Information); online database.
- Science Citation Index (Institute for Scientific Information); CD-ROM database (http://www.isinet.com/isi/products/citation/sci/).
- Web of Science (Science Citation Index Expanded; Institute for Scientific Information); online database (1993–December 21, 2002).
- RUSSMED (SU88); online database (1988–) (http://www.dimdi.de/de/db/recherche.htm).
- Biosis (BA70); online database.
- CCMed (Current Contents Medizin); online database (http://medsun.zbmed.uni-koeln.de/webOPAC/welcomede.html).
- *International Poster Journal of Dentistry and Oral Medicine;* online database (http://ipj.quintessenz.de).
- *Deutsche Zahnärztliche Zeitschrift* (DZZ); online database until 1992 in PubMed; online database from 1992 (http://www.dzz.de/archiv/default.asp?zid=DZZ).
- LILACS (Latin American and Caribbean Health Sciences) (http://www.bireme.br/bvs/P/pbd.htm).
- PAHO (Pan American Health Organization) HQ Library Online Catalog (http://www.bireme.br/bvs/P/pbd.htm).
- ADOLEC (Literature on Adolescent Health) (http://www.bireme.br/bvs/P/pbd.htm).
- AdSaude Health Services Administration (http://www.bireme.br/bvs/P/pbd.htm).
- BBO Odontology (http://www.bireme.br/bvs/P/pbd.htm).
- SIDORH Human Resources in Health (http://www.bireme.br/bvs/P/pbd.htm).
- MedCarib Caribbean Health Sciences Literature (http://www.bireme.br/bvs/P/pbd.htm).
- WHOLIS (World Health Organization Library Information System) (http://www.bireme.br/bvs/P/pbd.htm).
- SeCs Serials in Health Sciences/Collections of BIREME (http://www.bireme.br/bvs/P/pbd.htm).
- DESASTRES (Disaster Documentation Center Collection) (http://www.bireme.br/bvs/P/pbd.htm).

The electronic search was complemented by hand searching in the leading German dental journal (DZZ; 1996 to 2002). The reference lists of all retrieved and relevant articles were screened for additional references. Finally, the bibliographic references of all retrieved articles were entered into PubMed, and the link "Related Articles" was used to identify additional material.

Two members of the research team independently reviewed the retrieved articles. All identified publications were classified (levels 1 to 5) following the guidelines of the Oxford Centre for Evidence-Based Medicine (http://www.cebm.net/levels_of_evidence.asp).[12,13]

Table 1 Summary of Results of Studies Pertaining to Question 1*

Study	Evidence level[12]	Method	Subjects	Intraoral test area	Results†
Dummett[18]	5	Not reported	Not reported	Not reported	Gingival color is variable from pale pink to bluish purple
Dummett[19]	5	Not reported	Not reported	Not reported	Degree of melanotic pigmentation influences color; gingival pigmentation in whites as well as blacks
Koshi[17]	4	Spectrophotometric measurement; No. of raters not reported	15 (10 male, 5 female)	Maxillary and mandibular anterior teeth, interdental papilla, marginal gingiva	Hue: papillae = 4.6 R–5.0 R; marginal gingiva = 5.3 R–6.5 YR
Jones and McFall[20]	4	Photometric color measurement using He-Ne laser; No. of raters not reported	80 whites; additional variables: hair/eye color, geographic origin	Not reported	No influence of gender, age, toothbrushing, eating apple, smoking, drinking coffee on gingival color; lighter hair = lighter gingiva; darker eyes = darker gingiva
Powers et al[14]	4	Visual measurement (Munsell tabs); 3 raters; fluorescent light, daylight	200 (100 black, 100 white); gender distribution not reported	Maxillary attached gingiva between central and lateral incisors	Hue: 2.5 R–7.5 R; value: 5–7; chroma: 4; differences because of light source < 3.6
Nakashima[15]	4	Visual measurement (Munsell tabs); 30 raters	Not reported; gender distribution not reported	Not reported	Comparison of imagined and measured gingival color; hue: 2.5 R–5.0 R; value: 5.0–7.5; chroma: 6–8
Fukai[16]	4	Spectrophotometric measurement; 1 rater	24; gender distribution not reported	Maxillary and mandibular free gingiva	Higher value in maxilla; higher % R in mandibular and female gingiva

*Which studies describe color and its distribution within human gingiva and mucosa?
†Notations follow Munsell nomenclature: R = red; YR = yellow-red.

Results

Of the nine articles identified by the two search strategies, six applied to the first question, two referred to the second question, and one applied to both questions. It became obvious that the colors of gingiva and alveolar mucosa were evaluated separately in these studies because there are marked differences in color. Also, the clinical studies showed that the intraoral tissues of younger persons are of a lighter color than those of older persons.

1. Which Studies Describe Color and Its Distribution Within Human Gingiva and Mucosa?

The MEDLINE searches in PubMed and WebSPIRS yielded 119 and 166 hits, respectively. Four references were relevant to the above question; three of those were Japanese-language publications.[14–17]

The search using the Embase, Embase Alert, RUSSMED, Biosis, CCMed, IPJ, DZZ, LILACS, PAHO, ADOLEC, AdSaude, BBO, SIDORH, MedCarib, WHOLIS, SeCs, and DESASTRES databases did not result in any additional hits. The search in the reference lists of the retrieved articles while using the "Related Articles" feature in PubMed resulted in three additional hits (Table 1).[18–20]

Dummett[18] presented a narrative overview of his experience with gingival color. He described healthy human gingival tissue as follows:

> The color of healthy gingiva is variable, ranging from a pale pink to deep bluish purple. . . . Colors depend primarily upon the intensity of melanogenesis, the degree of epithelial cornification, the depth of epithelialization and the arrangement of gingival vascularity. . . . Non-pigmented gingivae are found more often in fair-skinned individuals, while pigmented gingivae are usually seen in dark-skinned persons.

In an additional article,[19] the author focused on pathologic changes of intraoral soft tissues and suggested further studies on the description of color and appearance of gingival tissue.

Koshi[17] spectrophotometrically measured the color (hue) of the interdental papillae and marginal gingiva. However, the number of participants in that study was low ($n = 15$), with a restricted age bracket (19 to 27 years). Only hue, not value or chroma, was evaluated.

In a study by Jones and McFall,[20] the color of the maxillary central interdental papilla was measured using a helium-neon gas laser. Only the reflectance (relative to a specific standard) was considered; the actual color was not measured or reported.

In 200 subjects, Powers et al[14] performed a visual color assessment of the attached gingiva at the central and lateral incisors under natural daylight as well as under fluorescent light. A total of 522 color assessments were performed, but the distribution across the three raters was asymmetric: One person performed 380 color assessments, while double assessments were carried

Table 2 Summary of Results of Studies Pertaining to Question 2*

Study	Evidence level[12]	Method	Subjects	Intraoral test area	Results†
Ibusuki[21]	4	Visual measurement (Munsell tabs); 1 rater; light source not reported	60; gender distribution not reported	Maxillary and mandibular anterior teeth, interdental papilla, marginal gingiva	Hue: 10.0 RP–2.5 YR; value: 4–8; chroma: 1.5–7.0; papillae, attached/free gingiva different colors; no gender or left/right difference
Powers et al[14]	4	Visual measurement (Munsell tabs); 3 raters; fluorescent light, daylight	200 (100 black, 100 white); gender distribution not reported	Maxillary attached gingiva between central and lateral incisors	Hue: 2.5 R–7.5 R; value: 5–7; chroma: 4; differences because of light source < 3.6; value under daylight 0.5–1.0 units higher
Ibusuki et al[22]	4	Visual measurement (Munsell tabs); No. of raters, light source not reported	Not reported; gender distribution not reported	Marginal gingiva (jaw location not reported)	No differences between dental technician, clinician, dental student raters; no color notations reported

*Which studies report on visual color measurement and shade matching of human gingiva and mucosa?
†Notations follow Munsell nomenclature: R = red; RP = red-pink; YR = yellow-red.

out by two judges for the remaining 142 tests. Because of the small number of tests, the reliability of the color assessments and the validity of the results are questionable. Only the attached gingiva was evaluated.

Nakashima[15] used a different approach. Thirty raters (dental technicians, clinicians, and dental students) were first asked to imagine the color of gingiva. Then, they rated the gingival color of an unspecified number of subjects. The research and diagnostic value of imagined gingival colors is questionable.

Fukai[16] spectrophotometrically measured the color of 30 subjects' gingiva after blow drying. It remains unclear whether unequal air drying affected the color measurement. Also, the authors did not report the color relationship between dry and moist gingiva.

2. Which Studies Report on Visual Color Measurement and Shade Matching of Human Gingiva and Mucosa?

The search in MEDLINE using the WebSPIRS interface yielded 123 hits; in PubMed, 73 publications were identified. From both pools of references, two articles were relevant to the question. One was an English-language publication, and the second was written in Japanese.[21,22]

The search within Embase, Embase Alert, RUSSMED, Biosis, CCMed, IPJ, DZZ, LILACS, PAHO, ADOLEC, AdSaude, BBO, SIDORH, MedCarib, WHOLIS, SeCs, and DESASTRES did not result in additional hits. The search in the reference lists of the retrieved articles did not yield any additional results. Using the "Related Articles" feature in PubMed, one additional publication was found (Table 2).[14]

Ibusuki[21] attempted to visually measure the color of the attached, marginal, and papillary gingiva in 60 Japanese subjects using Munsell color tabs. No standardized light source was used because the room for the measurements had a window, and no attention was paid to changing daylight conditions. Raters were neither calibrated nor checked for normal color vision.

Details and an evaluation of the study by Powers et al[14] are given in the section regarding question 1.

Finally, Ibusuki et al[22] describe the results from a study with 20 raters (dental technicians, clinicians, and dental students), who also performed a visual color measurement of gingiva, on the influence of prosthetic restorations. The gingival color difference between areas with and without prosthetic restorations was calculated. The following function was extrapolated from the results:

$$Z = 14.844 - 0.300H - 1.741V - 1.001C$$

where H = hue; V = value; and C = chroma. For $Z > 0$, gingivitis induced by prosthetic restorations was likely, whereas for $Z < 0$, color change caused by gingivitis of nonprosthetic origin was likely. Unfortunately, the number of subjects was not reported, and the development of the formula used to identify a diagnostic color change was not described in sufficient detail.

Discussion

This article reports on the results of a systematic search of the literature on *(1)* the description of the color of intraoral soft tissues, and *(2)* its measurement using a visual technique. Nine publications were identified by the outlined search strategy.

The PubMed database is one of the most popular among dental researchers for the identification of literature relevant to a specific topic. However, its exclusive use cannot be recommended, since the search result is often insufficient, as shown in the present work.[23] A related problem arises from the fact that MEDLINE mostly includes Anglo-American literature, without verification of its scientific value.[24] Hence, to achieve a comprehensive search result, a number of additional databases were considered for the present work. The electronic search was complemented by hand searching in DZZ. Indexing of this leading German dental journal in MEDLINE was

discontinued 1992 without explicit reason. In general, a manual search approach adds quality to the search process because it may result in additional hits.[23,25] Therefore, it is a standard procedure for reviews following the Cochrane Collaboration protocol.

The low number of retrieved references on the topic of gingival color is surprising. For the overall esthetic result, the soft tissues surrounding prosthetic restorations are as important as the appearance, form, and color of the prosthetic teeth.[26–28] The modest interest in the topic of gingival color is most likely a consequence of the difficulties in finding a suitable system for soft tissue color measurement and matching. Two systems, visual and spectrophotometric, were identified in the retrieved publications. In all studies, visual color measurement of oral soft tissues was accomplished using the world-renowned Munsell color system,[29] which has been repeatedly used in dentistry.[30–32] Ibusuki[21] and Powers et al[14] found similar color values for human gingiva; their results can be deemed identical with respect to measurement error. These results validate the visual technique within its inherent limits, such as interindividual variability and external noise factors because of different light sources.

The publications by Dummett[18,19] were among the first to describe the color of intraoral soft tissues. However, they only narratively describe the experience of the author and his impression of color. There is no foundation in the form of a planned scientific test using statistical methods. Nevertheless, later clinical papers by others mostly confirm Dummett's statements, such as those about the different color of attached gingiva and alveolar mucosa.[21,33]

Comparisons of the imagined color of gingiva and an actual visual color measurement[15] are of doubtful scientific value. The findings of Nakashima[15] show that imagined color is more yellow-red and higher in chroma but of equal lightness (value) than measured color. However, these findings do not appear to have any meaningful clinical relevance.

Using a photometric approach, Jones and McFall[20] confirmed that the color of human gingiva is generally independent of age and sex, and lighter colors and less chroma are described for younger persons.[21] Fukai,[16] using a spectrophotometric technique, complemented these results insofar as the free marginal gingiva in the maxilla is higher in value and female gingiva tends to be more red compared to male gingiva. Koshi,[17] also using a spectrophotometer, only reported on the hue of the interdental papillae (4.6 red to 5.0 yellow-red) and the marginal free gingiva (5.3 red to 6.5 yellow-red). However, these data are of limited value, since the large area of attached gingiva was not evaluated.

Considering the diverse aims, methods, and parameters used in the discussed studies, it is impossible to compare or even combine their outcomes in a scientifically meaningful manner. In addition, none of the studies used a controlled or even randomized design, and their level of evidence, following the hierarchy of evidence, is low.[13] The same applies to a comparison of visual and spectrophotometric color measurement. Although the results obtained with either method appear similar, the influence of confounding variables such as light source or background is often high, yet uncontrolled. Hence, results obtained using one method are highly variable.

In future studies on the description of the color of human gingiva, standardization of the measurement environment, specification of the measurement method, controlled design, and evaluation of rater reliability should be given due regard.

References

1. Kohler W. Die Optimierung von Totalprothesen durch individuelle Gestaltung. Quintessenz Zahntech 1993;19:557–568.
2. Fischer J. Ästhetik und Prothetik. Eine Interdisziplinäre Standortbestimmung. Berlin: Quintessence, 1995.
3. Engelmeier RL. Complete-denture esthetics. Dent Clin North Am 1996; 40:71–84.
4. Ali A, Hollisey-McLean D. Improving aesthetics in patients with complete dentures. Dent Update 1999;26:198–202.
5. Kelkel H, Palla S. Individualized coloring of the denture base. A virtually practice-ready method for the staining of the external denture surface. Schweiz Monatsschr Zahnmed 1991;101:886–892.
6. Kiuchi H, Nagai E. Producing an esthetic complete denture (1) [in German]. Quintessenz Zahntech 1990;16:1025–1033.
7. Kiuchi H, Nagai E. Producing an esthetic complete denture (2) [in German]. Quintessenz Zahntech 1990;16:1145–1154.
8. Heath JR, Boru TK, Grant AA. The stability of removable temporary prosthetic base materials. II: Water sorption and its effects. J Oral Rehabil 1993;20:517–524.
9. Estafan DJ, Dussetschleger F. Fabrication of resin-bonded three-unit prostheses. Am J Dent 1999;12:51–52.
10. Powers JL. Brush-on technique in natural coloring of cured cross-linked plastic artificial denture materials. J Prosthet Dent 1953;3:350–353.
11. Hoßfeld W. Totale Prothesen—Individualisiert und äesthetisch. Quintessenz Zahntech 1989;15:1123–1129.
12. Phillips B, Ball C, Sackett D, et al. Levels of Evidence. Oxford, UK: Oxford Centre for Evidence-Based Medicine, University Department of Psychiatry, 2001.
13. Canadian Task Force on the Periodic Health Examination. The periodic health examination. Can Med Assoc J 1979;121:1193–1254.
14. Powers JM, Capp JA, Koran A. Color of gingival tissues of blacks and whites. J Dent Res 1977;56:112–116.
15. Nakashima T. Color range of color memory of gingival color in dentists [in Japanese]. Nichidai Koko Kagaku 1986;12:88–97.
16. Fukai K. A study of gingival color [in Japanese]. Nippon Shishubyo Gakkai Kaishi 1988;30:428–451.
17. Koshi T. A study on the correlation between the Munsell value and histopathological findings in human gingiva [author's translation]. Nippon Shishubyo Gakkai Kaishi 1976;18:179–188.
18. Dummett CO. Oral pigmentation—Physiologic and pathologic. N Y State Dent J 1959;25:407–412.
19. Dummett CO. Oral pigmentation. J Periodontol 1960;31:356–360.
20. Jones J, McFall WT. A photometric study of the color of healthy gingiva. J Periodontol 1977;48:21–26.
21. Ibusuki M. The color of gingiva studied by visual color matching. Part II. Kind, location, and personal difference in color of gingiva. Bull Tokyo Med Dent Univ 1975;22:281–292.

22. Ibusuki M, Asaoka K, Uchida T. Screening of inferior prostheses by gingival color observation and visual color matching [in Japanese]. Kokubyo Gakkai Zasshi 1978;45:696–697.
23. Türp JC, Schulte JM, Antes G. Nearly half of dental randomized controlled trials published in German are not included in Medline. Eur J Oral Sci 2002;110:405–411.
24. Dickersin K, Scherer R, Lefebvre C. Identifying relevant studies for systematic reviews. Br Med J 1994;309:1286–1291.
25. Delamere FM, Williams HC. How can hand searching the dermatological literature benefit people with skin problems? Arch Dermatol 2001;137:332–335.
26. Pini Prato G. Mucogingival deformities. Ann Periodontol 1999;4:98–101.
27. Oringer RJ, Iacono VJ. Periodontal cosmetic surgery. J Int Acad Periodontol 1999;1:83–90.
28. Morley J, Eubank J. Macroesthetic elements of smile design. J Am Dent Assoc 2001;12:39–45.
29. Schultze W. Farbenlehre und Farbmessung. Stuttgart, Germany: Springer, 1975.
30. Sproull RC. Color matching in dentistry. 3. Color control. J Prosthet Dent 1974;31:146–154.
31. Sproull RC. Color matching in dentistry. Part II. Practical applications of the organization of color. 1973. J Prosthet Dent 2001;86:458–464.
32. Sproull RC. Color matching in dentistry. Part I. The three-dimensional nature of color. 1973. J Prosthet Dent 2001;86:453–457.
33. Ibusuki M. The color of gingiva studied by visual color matching. Part I. Experimental studies on the discrimination threshold for color difference and effect of training. Bull Tokyo Med Dent Univ 1975;22:249–261.