Clinical Effect of Different Shade Guide Systems on the Tooth Shades of Ceramic-Veneered Restorations

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Purpose: The objective of this study was to investigate whether a systematically arranged shade guide system (Vita 3D-Master) allows clinicians to achieve a better shade match of a restoration, as compared to a conventional shade guide with a design based on empirical values (Vita Classical). **Materials and Methods:** Fifty-nine restorations in 42 patients being treated by student clinicians were assessed. Using 1 of the 2 shade systems assigned randomly, each student independently determined the tooth shade. With the aid of a visual rating scale, the accuracy of the shade match of the finished restoration was assessed. **Results:** All restorations whose shades had been determined with the 3D-Master could be placed without any further shade corrections. In contrast, almost 17% of restorations determined with the conventional system required subsequent shade modifications. The match of the shades selected with the 3D-Master was judged significantly better by the clinicians. **Conclusion:** Within the limitations of the study, clinicians with less clinical experience who use a system that guides them through the shade-taking procedure in a relatively systematic manner will be more successful in selecting the correct tooth shade and in avoiding shade corrections. Clinical assessment of the restoration shades showed significant differences between the shade guide with a systematic design and that based on empirical values. *Int J Prosthodont 2005;18:422–426.*

The choice of the correct tooth shade for the fabrication of a restoration poses a challenge, even for experienced clinicians.[1] Various factors, such as the type and intensity of the light source, the time of day and year, the angle of incidence, and the patient's clothes and the color of the operatory furnishings will influence and complicate the shade-taking procedure.[2,3] Even the type and extent of the preparation and the fabrication process of the ceramic work will be reflected in the shade effect.[4–6]

Various shade systems from a number of manufacturers are designed to allow clinicians to correctly determine tooth shades by the comparison of their specific shade samples with the remaining teeth. Electronic aids for shade determination, intended to eliminate subjective impressions from shade taking, are also available.

Most shade determination systems on the market are characterized by an irregular distribution of the sample shades in the shade range. They are based on empirical values.[7] The world's most widespread shade guide working on the basis of this shade distribution is the Vita Classical System (Vita Zahnfabrik).[2] Clinicians have long been demanding a shade determination system that uses a more systematic approach.[8]

For a few years, the Vita 3D-Master (Vita Zahnfabrik), a new type of shade determination system, has been available. The shade-taking procedure is more systematically made up of the determination of the value, chroma, and hue of a shade, and veneer shades are more regularly and systematically arranged in the shade range.[9] However, it has yet to be determined whether this systematic approach to shade determination will clinically lead to a higher degree of acceptance of the shades of finished restorations.

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Therefore the objective of this investigation was to compare the clinical results of the shade-taking procedure on the basis of finished restorations using a conventional shade guide system and a more systematic type.

Materials and Methods

Shade Guide Systems Used

Since it is widely used throughout the world, the Vita Classical System was chosen as the conventional type of shade guide in this investigation. The Vita 3D-Master was chosen to represent the more systematic type of shade guide.

Clinicians

The participants in the clinical student course in restorative dentistry were divided randomly into 2 equally large groups (27 students; 8 men and 19 women) by allocation to the treatment units (with 2 students in 1 unit using 1 shade guide system). One shade system, either Vita Classical or Vita 3D-Master, was assigned to each group. The tooth shades for the restorations were determined only with the shade system of the respective group. During instructional seminars, the groups were jointly given a general introduction to the theory and practice of shade determination. Then they were separately trained to determine tooth shades with their respective systems. The duration of this training was 45 minutes for each group. The students had to undergo a color perception test. One male student was excluded because of color blindness.

Participating Patients and Investigative Procedure

With the exception of 2 cases missing questionnaires and the patients of the excluded student, the shade comparison results of all patients with fixed, ceramic-veneered restorations (no veneers) were recorded. The patients were assigned according to the course request to a single course participant without knowing his group. No student served more than 2 patients. No patients were treated with complete restoration of an anterior arch or complete jaw. Consequently, any shade selection based upon an anticipated esthetic outcome without a comparison to neighboring teeth was avoided. Previous restorations or natural teeth had to exist adjacent to the restoration to be constructed to be used for shade determination. Due to clinical conditions, unrestored and restored neighboring teeth (ie, teeth in need of restoration) were admitted. If the restoration contained more than 1 abutment or pontic,

only the most mesial abutment was assessed in comparison to the adjacent teeth. Only the mesial abutment was assessed in patients with more than 1 restoration in 1 quadrant. If the restorations were in different quadrants, a maximum of 2 restorations in different quadrants were assessed to avoid overrepresentation of one patient. The restorations of the different quadrants were not in contact. Accordingly, 59 restorations in 42 patients were assessed.

Each operator independently selected the tooth shade. The exertion of influence by other persons and the use of additional aids were not permitted. Shade determination was performed outdoors, with protection from direct sunlight, between 10:00 A.M. and 4:00 P.M. In a commercial dental laboratory, the restoration to be fabricated was veneered using the ceramic material with the color code that matched the selected sample. The ceramic materials used were VITA Omega 900 (Vita 3D-Master) and VITA VMK 95 (VITA Classical).

Before the clinical try-in, the operator compared the finished restoration with the selected sample in daylight, against a neutral, dark gray background. The result of this comparison was documented with the aid of a scale ranging from 1 to 3 (1 = very good match; 2 = minor deviations; 3 = mismatch).

The shade of the restoration was then compared intraorally with the residual teeth, by both the patient and the supervising clinician. The degree of match was rated with the aid of a visual rating scale ranging from 1 to 10 (with 10 being the best possible rating). If the compared shade was found to be completely incorrect by the patient or the supervising clinician, the restoration was either customized or newly veneered in a different shade in the laboratory.

Statistical Evaluation

Statistical evaluation was performed with the aid of SPSS 11.5.1 for Windows (SPSS). The results of the rating scales were depicted by means of box-plot representations. For comparison between the groups, the nonparametric Mann-Whitney U test for independent random samples was used.

A significance level of $P \leq .05$ was chosen. The agreement of the raters using the rating scales was determined with the help of the interclass correlation coefficient (ICC). In accordance with Fleiss et al,[10] values ≥ 0.75 were considered acceptable.

Results

For 30 restorations, tooth shade was determined with the Vita Classical shade guide (group 1). For 29 restorations, tooth shade was determined with the Vita 3D-Master (group 2).

Extraoral Comparison with the Shade Samples

In only 1 case (1.7%), the shade comparison between the finished restorations and the selected samples by the students revealed a mismatch. In 16 cases (27.1%), minor deviations were found. The percentages of the rating "very good match" were approximately the same for both systems (70%, group 1; 72.4%, group 2).

If the shade comparison between the restoration and the selected sample by the operator revealed minor deviations or a mismatch, subsequent shade assessments by both the patient ($P < .001$) and the supervising clinicians ($P < .015$) showed a significantly worse mean value for the shade rating (Table 1).

Shade Comparison in Relation to Adjacent Teeth

In group 1 (Vita Classical), the basic shade had to be changed in 2 cases. Refiring and customizing was necessary in 3 other cases. So almost 17% of all shades selected by group 1 fulfilled the criteria for failure. In group 2 (Vita 3D-Master), the basic shade did not have to be changed or customized in any cases, and the restorations could be placed without any shade corrections.

The rating of the shade match by the patients did not show significant difference between the 2 groups ($P = .39$). The median values were the same (10), but a greater degree of variation and more distinct outliers were found in group 1 (Fig 1). The mean values of the ratings were 8.93 ± 1.66 in group 1 and 9.38 ± 0.98 in group 2.

The ratings by the clinicians showed identical median values (9). The degree of variability of the values of group 1 was greater (Fig 2). The mean values were 8.00 ± 1.53 in group 1 and 8.72 ± 1.41 in group 2. The difference between these mean values was significant ($P = .046$).

Interrater Shade Rating

The comparison of the shade ratings by the patient and those of the supervising clinician showed an acceptable degree of correspondence in the assessment, with an ICC of 0.82. However, the mean value of all shade ratings by the clinicians was found to be significantly worse than the mean value of all shade ratings by the patients ($P < .001$).

Dependence of the Shade Rating on Operator Gender

On average, the patients gave almost identical ratings to the tooth shades selected by female students and

Table 1 Shade Ratings (Means and Standard Deviations) According to Degree of Match of Veneer and Shade Sample

	Very good match (n = 42)	Minor deviations/ mismatch (n = 17)
Patient rating	9.52 (0.99)	8.24 (1.75)
Clinician rating	8.76 (1.03)	7.35 (2.00)

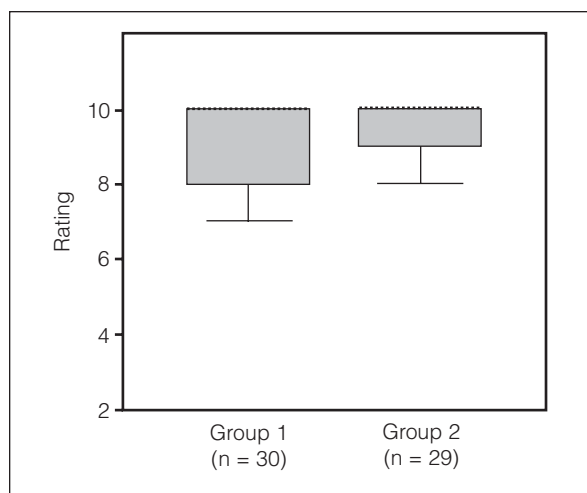Match was rated on a 10-point scale (with 10 = best match).

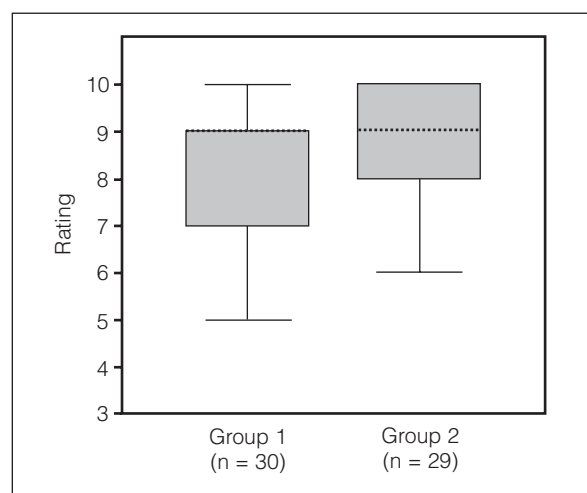**Fig 1** Rating of shade match by patients..

Fig 2 Rating of shade match by clinicians.

those selected by male students (9.13 ± 1.86 and 9.16 ± 1.17). The same applied to the shade ratings by the clinicians.

Discussion

To observe the accuracy of the shade of a restoration intraorally, it would be optimal to assess single restorations in comparison to natural (not restored) adjacent teeth. Because of clinical reasons, this was difficult to achieve in the present clinical population. Therefore, this investigation included more than single crowns, and compared restoration shade to that of both natural teeth and restored teeth. However, the use of results from the student course led to a high number of operators with the same knowledge of both shade guide systems. Consequently, the results of this investigation must be interpreted with these limitations in mind.

In tooth shade determination, there has so far been a lack of adequate standardization. Consequently, shade determination is highly subjective.[2] Shade scanners may help to make it more objective, but these devices are not suitable for routine use,[1,11] and no superiority to visual shade determination has been observed.[12] Shade scanners determine the shade on the basis of a 2-dimensional image[2] and cannot correctly process the 3-dimensional changes of translucence and opacity, as well as the variable distribution of shade nuances in the 3-dimensional body of the tooth. So studies employing electronic aids have frequently examined level shade samples[1,12–14] or limited surface areas.[12,15,16] To ensure a correct shade impression, however, the clinical crown has to be assessed as a whole.[15] This is why shade determination by a human observer has so far been irreplaceable, even though it may be subjective.

The use of a visual rating scale therefore seems an appropriate means of assessment. The separate rating of the finished restorations against a neutral background was used to assess the accuracy of reproduction of the selected tooth shade in the dental laboratory. The results were intended to reveal any fabrication-related difficulties in shade reproduction.[4] The operators were able to perform the rating of this work step, because they did not assess one of their own steps. However, the operators were excluded from subsequent intraoral rating of the finished restoration.

In this investigation, a high degree of match of the shades of the finished restorations with the selected shade samples was found for both shade determination systems. In only case, it could not be confirmed beyond doubt that the ceramic veneer had been made of the material with the selected color code. The occur-

rence of more or less considerable shade deviations in spite of the use of a correct ceramic base material may be explained by, eg, an inadequate ceramic layer thickness resulting from insufficient preparation, the framework material, the ceramic batch, the firing process, shadows, the surface quality, and variations in layering.[1,13] The subjective assessment of shades is also subject to influences such as age, eye fatigue, color impressions perceived immediately before, and psychologic factors. A perception of minor shade deviations may even result from these influences alone. Therefore, the indication of a shade correction after the try-in step was used as a reliable criterion of shade selection failure.

When a systematic approach with regard to value, chroma, and hue was used, there were no failures. All restorations could be placed without any changes in their shades, whereas 17% of the restorations made with the shade system that represented the conventional type of shade guide and was based on empirical values had to be modified.

There were no significant differences between the 2-shade determination systems in the shade ratings made on a rating scale by the patients, whereas the difference in the shade ratings made by the clinicians was found to be significant. This may be explained by the fact that patients primarily desire white, rather than gold-colored, restorations. Minor shade differences are of secondary importance to most patients. As expected, the clinicians showed a more critical attitude toward the veneer shade than the unpracticed patients. Still, the interrater comparison between the shade ratings of clinicians and patients showed a high degree of correspondence. However, the absolute mean value was lower in the rating by the supervising technicians. It has also been confirmed that more or less extensive training in shade taking influences ratings.[1,13]

Furthermore, it was found that in cases of deviations of the finished veneer from the selected sample, both clinicians and patients—who did not know this result—clinically rated the shade as less matching. This relationship proved to be significant and was independent of the shade determination system used.

The tendency toward a better performance of the shade guide with a systematic design in this investigation contradicts the results of other researchers[1] who found a lower failure rate in visual shade taking with Vita Lumin, a traditionally designed shade guide system. In their investigation, however, the shades were determined in vitro and by investigators with years of experience with Vita Lumin but little experience with Vita 3D-Master. The present investigation was performed by students with little experience with both systems, and the influence of clinical experience on shade selection is described.[17] An inconsistent intrarater repeatability

was shown by Hammad, who found better values with general practitioners who used Vita 3D-Master (versus Vita Lumin); in contrast, prosthodontists achieved better values with Vita Lumin (in comparison to general practitioners).[18]

The capability of selecting correct tooth shades is considered to be gender-dependent,[19] and it has been stated that women have fewer color vision deficiencies.[20] In our investigation, this could not be confirmed. The mean values of the ratings that patients and clinicians gave to restorations whose shades had been selected by female operators and those whose shades had been selected by men were almost equal. This is supported by results showing that dental shade color discrimination is nearly equal between genders.[19]

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Literature Abstract

A clinical investigation of the morphological changes in the posterior mandible when implant-retained overdentures are used

The aim of this study was to determine the morphological changes seen in the posterior residual ridges over a 1-year period using a nonradiographic device. Sixteen patients (ages 36 to 72) who received 2 to 4 implants were selected. Inclusion criteria included but were not limited to: *(1)* uneventful healing phase; *(2)* moderate bone quality and resorption; *(3)* no systemic or psychological contraindications to dental treatment; *(4)* edentulous maxillary ridge with maxillary denture. Impressions were made of the mandibular ridge using standardized measuring techniques with 1 operator at baseline (after implant placement) and after 1 year of wearing the implant-retained overdentures. Resulting casts were oriented using 3 orientation points: v-notches on precise locations in the retromolar pads and midway between the anterior implants. The casts were mounted using the exact tripoded location and placed on a profiling apparatus capable of 2-dimensional reproduction of the surface of a cast. Statistical analysis used a paired *t* test at .05 significance level. Results indicated that the mean reduction in the total sagittal surface contour areas of the mandibular residual ridge distal to the implants averaged 5 cm^2 or 20% (SD = 9%). In conclusion, the method used in this study is an effective way of examining sagittal dimensional changes in bone while minimizing patient exposure to radiation.

Blum IR, McCord JF. *Clin Oral Impl Res* 2004;15:700-708. **References:** 28. **Reprints:** Dr I.R. Blum, 11 Austin Drive, Manchester M20 6EB UK. E-mail: i.blum@ntlworld.com—*Esquivel-Upshaw, San Antonio, TX*