An Exploratory Study on Assessment of Gingival Biotype and Crown Dimensions as Predictors for Implant Esthetics Comparing Caucasian and Indian Subjects

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Gingival biotype and crown dimensions may be important predictors for the esthetic outcome of surgical procedures. However, the visual distinction between “thick” and “thin” biotype may not be a suitable predictive parameter of surgical outcome. Intraoral photographs of 73 Indian and Dutch subjects were matched with respect to age and gender and were used to determine the gingival biotype (subjective assessment) and crown dimensions (objective assessment). Intraobserver and interobserver agreement was determined for subjective measurements (Cohen’s kappa), and the error of the method was calculated for the objective measurements (Dahlberg formula). Intraobserver agreement for the subjective assessment of gingival biotype was adequate ($\kappa = 0.49–0.60$), but interobserver agreement was poor ($\kappa = 0.10$), whereas the error of the method for objective assessment of crown dimensions was small. The mean crown width-length angle is smaller in Dutch as compared to Indian subjects in this sample ($P < .05$). Crown dimensions may be a more quantitative approach and could become a future norm to predict outcomes of implant restorative and surgical procedures, bearing in mind that cross-cultural differences may be present.

Key Words: gingival biotype, gingiva, crown height-width ratio, crown angle, implant esthetics

INTRODUCTION

Complete reconstruction of tooth and gingiva-related esthetics has become the primary objective of contemporary (implant) dentistry, especially in the esthetic zone. In some instances, it can be very difficult to achieve.1 It requires adequate bone volume, proper soft tissue thickness, as well as esthetic-appearing restorations.2,3 With modern day ceramics, the tooth shade and tooth surface structure are controlled factors. However, the same cannot be said about the hard and soft tissues. It is a popular notion that gingival response to surgery is particularly difficult to predict.4

The chance of esthetic success depends on the amount of tissue loss present at the initiation of treatment.1 Just as bone volume is crucial to ideal positioning of the implant, soft tissue volume may predict the ideal emergence profile and esthetics of the eventual implant restoration. The attached gingiva, which is attached firmly to the underlying buccal and lingual alveolar bone, varies in thickness between individuals and between teeth. It has been hypothesized that gingival biotype is one of several

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useful predictors of gingival recession and implant soft tissue esthetics.\(^5,6\)

The gingival biotype has been a matter of controversial discussions for several decades now and has been defined or characterized by several authors based on tooth shape, degree of scalloping,\(^6,7\) gingival width, its thickness, the degree of keratinization of its epithelium, melanin pigmentation, the height of the papilla, bone characteristics, and crown dimensions.\(^8,9\)

The “thin” scalloped periodontium or biotype is characterized by a delicate soft tissue curtain and a scalloped underlying osseous form that often has bone dehiscences or fenestrations and a reduced quantity and quality of keratinized mucosa. Generally, interproximal tissues do not completely fill the space between adjacent teeth.\(^1\) The thin biotype in the natural dentition as well as around implants reacts to insults by receding more facially and interproximally.\(^10\) As recession occurs and the interroot bone resorbs, the subsequent soft tissue loss compromises the overall esthetic result.

The “thick” periodontal biotype is seen in conjunction with thick buccal alveolar bone.\(^4\) It is fibrotic and resilient, making it resistant to surgical procedures with a tendency for pocket formation (rather than to recession).

The shape of the central incisor seems to distinguish between different periodontal biotypes, also around other teeth in the same dentition.\(^8,9\) So, the tooth morphology appears to be correlated with the soft tissue quality. The triangular tooth shape is associated with the scalloped and thin periodontium. The contact area is located in the coronal third of the crown underlining a long and thin papilla. Furthermore, triangular teeth have divergent roots with thicker interproximal bone, resulting in reduced vertical bone loss compared with square teeth, whose root proximity and thinner interdental bone have a higher incidence of vertical bone resorption. However, squarer teeth yield better interproximal papilla maintenance due to a smaller interproximal distance from the osseous crest to the free gingival margin.\(^11\)

The triangular tooth shape creates the highest risk for black triangles because the proximal contact point is more incisally positioned and would require more tissue height to fill the interproximal area. The square anatomic crown shape combines with a thick and flat periodontium. The contact area is located at the middle third supporting a short and wide papilla. The thick biotype is presumably more prone for scarring.

It is important to note that although a relationship between gingival biotype and tooth shape with surgical and restorative outcome in implant dentistry has often been suggested in the literature, it has never been confirmed in a prospective study. A prerequisite for such a study would be to establish that these variables can be assessed reliably.

In the past, gingival morphotype and crown dimensions co-relations have been assessed for limited ethnic diversity. Only data for the Caucasian group are available.\(^1,12,13\) Thirty-five percent of cases were classified as “thin” biotype on visual examination.\(^5\)

Though the importance of assessing gingival biotype presurgically has been stressed in literature, most clinicians invariably use subjective visual assessment.\(^1,2,4,5,7,14\) The present study explores the reliability of the assessment of gingival morphotype with the aid of visual and crown dimension assessment. The use of visual assessment was examined since it is popularly used by clinicians, and there is need to justify the practicality of using this technique while predicting esthetic outcomes.\(^1,2,4,5,7,14\) A comparison of crown dimensions is made between the Indian and Dutch population under the null hypothesis that they are similar.

**Materials and Methods**

Frontal view intraoral photographs in maximum occlusion were made of 73 age- and gender-matched patients from a dental practice for implant and/or general dental treatment in India (EOS rebel XT with 100 mm macro lens and a ring flash; Cannon, Melville, NY) and in 2 practices for general dentistry in The Netherlands (Minolta Dimage with 50 mm macro lens and ring flash; Tokyo, Japan). A ratio of approximately 1:3 was used, and the teeth were in maximum occlusion. Exclusion criteria consisted of:

- diastema;
- severe gingival inflammation or signs of (past or present) periodontitis;
- heavily restored teeth (among which crowns);
- absent tooth number 7 or tooth number 9; and
severe incisal tooth wear.

The images were modified by discarding their color information and selecting an area ranging from approximately the upper right to the upper left lateral incisor (Adobe Photoshop CS3, extended edition; San Jose, Calif). This left black and white images (Figure). These measures were taken to blind the observer for the origin of the image, be it from India or from The Netherlands.

Subjective assessments: Assessment of the gingival biotype

The clinical mucogingival condition in relation to area in the vicinity of the right central incisor was characterized subjectively by 2 observers as a “thin” or a “thick” biotype. No attempts were made to calibrate the 2 observers since most clinicians use visual judgment and calibration might create bias. The assessors were given a popularly accepted definition of thick and thin biotype and were allowed to subjectively interpret the same for scoring. The biotype was defined as follows:

- Thin biotype: thin, scalloped, fragile mucogingival appearance and stretched papillae in conjunction with a triangular tooth shape.
- Thick biotype: thick, flat, firm mucogingival appearance in conjunction with a more square tooth shape.1,5,7,14

Twenty randomly selected images were remeasured by both observers, approximately 1 week after the initial measurements.

Objective measurements: Quantitative measurements of crown dimensions

The images were analyzed by 1 observer (R.v.B.) in a commercially available software computer program for the analysis of digital images (Viewbox, dHal Orthodontic Software, Athens, Greece). The following landmarks were digitized on the number 8, in accordance with those used by Olsson and Lindhe8 (Figure):

- incisal point (I), the incisal edge in mid axis;
- cervical point (C), the gingival margin or, if discernible, the cemento-enamel junction;
- distal tooth width point (DW), the length of the crown was divided into 3 equal portions—the distal tooth width point is located at the borderline between the lower and middle portion;
- mesial tooth width point (MW), the length of the crown was divided into 3 equal portions—the mesial tooth width point is located at the borderline between the lower and middle portion;
- distal papilla point (DP), the most distal-caudal point of the interdental papilla, in contact with the tooth; and
- mesial papilla point (MP), the most mesial-caudal point of the interdental papilla, in contact with the tooth.

Subsequently, the ratio between the width of the tooth (the distance DW-MW) and the tooth length (distance I-C) was calculated. The crown angle is formed by the lines MP-C and DP-C (Figure). Absolute distances are not presented because the photographs were not calibrated.

Twenty photographs were remeasured approximately 1 week after the initial measurements.

Statistical analysis

Data are presented by means of descriptive statistics. The paired Student t test is used to compare the mean values of the width-length tooth ratio and the crown angle between the matched Dutch and Indian subjects. A standard statistical program was used (SPSS version 16, SPSS Inc, Chicago, Ill).

Intraobserver and interobserver agreement of subjective assessments and error of the method of objective measurements

The intraobserver and interobserver readings were measured, both for subjective assessment and to determine the error in the method of objective measurements in this study. Cohen’s kappa was used to determine the intraobserver and interobserver agreement with respect to the subjective assessment of the biotype. The casual and systematic measurement error of the objective crown-dimension assessments were analyzed by means of Dahlberg formula15 and paired Student t tests.

Results

The population consisted of 73 Indian and 73 Dutch subjects, with a perfect match on gender (35 male
and 38 female subjects in each group) and an excellent match on age. The mean age for the group of Indian subjects was 23.9 (SD 7.3) years and 23.9 (SD 7.4) years for the Dutch subjects (paired samples t test, \( t = 0.16, df = 72, P = .87 \)).

Subjective assessments

The results for intraobserver and interobserver measurements of the subjective assessments of the gingival biotype are presented in Tables 1 and 2. Cohen’s kappa for intraobserver agreement was 0.60 for observer 1 and 0.49 for observer 2, respectively. Cohen’s kappa for interobserver agreement was only 0.10. For a moderate to excellent agreement, Cohen’s kappa should exceed 0.40.\(^{16}\) Hence, observers tend to agree with themselves to an acceptable degree, but disagree with each other. In particular, observer 1 considered the biotype to be “thick” relatively more often than observer 2.

Hence, the subjective assessment of gingival biotype based on the predefined descriptions between 2 noncalibrated observers may be considered unreliable because of poor interobserver agreement (and as a consequence, descriptive data of subjective assessments are not presented).

Objective measurements

No statistically significant differences were observed between the initial and repeated quantitative measurements using the Dahlberg formula.\(^{15}\) The systematic measurement errors for tooth width-length ratio and tooth angle were 0.02 mm and 1.1° respectively, which was deemed acceptable.

The results of the quantitative crown dimension measurements are presented in Table 3. The mean crown width-length ratio is smaller in Dutch subjects when compared to Indian subjects in this sample (paired samples t test, \( t = 2.3, df = 72, P = .025 \)). However, a difference in crown angle between the 2 populations does not reach a statistically significant level (paired samples t test, \( t = 1.8, df = 72, P = .085 \)).

Discussion

The pink drape forms an important esthetic component in surgical reconstructive dentistry and in implant dentistry in particular. A perfectly osseointegrated implant restoration with ideally matched shade may still be unesthetic if gingival esthetics are marred by recession or change in color. Preoperative assessment of gingival biotype, “thin” or “thick,” is commonly considered to be an important parameter for esthetic success or failure,\(^{4,14,17}\) although prospective studies to support

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**Table 1**

<table>
<thead>
<tr>
<th>Observer 1</th>
<th>Observer 2</th>
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<tbody>
<tr>
<td>Thin, n</td>
<td>Thick, n</td>
</tr>
<tr>
<td>Thin</td>
<td>6</td>
</tr>
<tr>
<td>Thick</td>
<td>2</td>
</tr>
</tbody>
</table>

*\( \kappa = 0.60 \) for observer 1, 0.49 for observer 2.*
this are lacking and needed. A first step would be to establish whether assessment of gingival biotype can be done in a reliable manner by means of subjective assessment. Preliminary studies have tried to establish a co-relation between crown dimensions and gingival biotypes, and it has been suggested that biotypes may be distinguished by the crown width-length ratio and that gingival thickness in central incisors was significantly influenced by the buccolingual width of the crown.9

The data in the present study suggest that subjective biotype assessment across 2 noncalibrated observers may not be reliable. Biotype assessment may vary among different observers because the generally accepted descriptions of "thin" and "thick" biotype seem to allow different interpretations. Instead, a more quantitative approach in which crown dimensions are measured may be preferred where the margin of error is less.

Calibration of the 2 observers was not done since it would limit the scope of biotype diagnosis. The parameters set for visual or subjective assessment of biotype would represent what is commonly used by implant surgical or restorative dentists.1,5,7,14 Standardized objective assessments were made by 1 observer with the aid of a computer software, Viewbox (dHal Orthodontic Software; Kifissia, Greece), and was considered free of individual biases.

Cross-cultural differences in crown dimensions appear to be present. Since tooth size may vary between different racial groups,9 the sample included 2 racial groups—Dutch and Indian. Significant difference is noted in width-length ratio but not in the crown angle. The mean crown width-length ratio is smaller in Dutch subjects when compared to Indian subjects in this sample. Further studies need to be done to evaluate the degree of racial differences and their relevance in postrestorative gingival esthetics. With implant therapy finding a worldwide acceptance, objective crown dimension assessment may prove to be a valuable parameter in unbiased treatment planning.

Both dental and gingival esthetics act together to provide a smile with harmony and balance.1 Treatment planning must address hard and soft tissue deficiencies and combine this with precision in implant placement. In case of the soft tissue, the primary implication is the degree of recession seen post implant placement. Knowledge and interpretation of the exact biotype can aid surgical planning. Biotype and crown form have been co-related with bone thickness,9 and accurate knowledge of biotype could help assessment of buccal bone thickness, which is an important factor in soft tissue retention and long-term implant stability.

Further clinical studies are required to quantify the impact of objective assessment of crown dimensions (as a derivate of biotype) on the final esthetic outcome post implant restoration and to evaluate the indication and effect of soft tissue enhancement surgery.

**CONCLUSIONS**

The visual distinction between "thick" and "thin" biotype is difficult to make and subject to interpretation. As a consequence, it may not be a suitable predictive parameter of the esthetic outcome of implant restorative and surgical procedures. However, the quantitative assessment of crown dimensions can be performed more reliably and could become a future norm to predict outcomes of implant restorative and surgical procedures. Cross-cultural differences in crown dimensions may be present and should be borne in mind.

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**TABLE 2**

Interobserver agreement (n = 146)*

<table>
<thead>
<tr>
<th></th>
<th>Observer 1</th>
<th>Observer 2</th>
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<tbody>
<tr>
<td></td>
<td>Thin</td>
<td>Thick</td>
</tr>
<tr>
<td>Thin</td>
<td>31</td>
<td>20</td>
</tr>
<tr>
<td>Thick</td>
<td>48</td>
<td>47</td>
</tr>
</tbody>
</table>

*κ = 0.10.

**TABLE 3**

Crown dimensions (and standard deviation)

<table>
<thead>
<tr>
<th></th>
<th>Indian</th>
<th>Dutch</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width-length ratio</td>
<td>0.79 (0.11)</td>
<td>0.75 (0.08)</td>
<td>.025</td>
</tr>
<tr>
<td>Angle, degrees</td>
<td>93.7 (11.0)</td>
<td>90.8 (9.1)</td>
<td>.085</td>
</tr>
</tbody>
</table>
odontics and Special Dental Care, University Medical Centre Utrecht, Utrecht, The Netherlands. The authors are also grateful to the staff of the Department of Oral-Maxillofacial Surgery, Prosthodontics and Special Dental Care, St Antonius Hospital, Nieuwegein, The Netherlands, for their continuous support.

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