



# Digital Smile Design concept delineates the final potential result of crown lengthening and porcelain veneers to correct a gummy smile

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## Abstract

Prior to initiating any treatment, it is necessary to visualize the desired outcomes. It then becomes possible to formulate the steps required to achieve this result. Digital Smile Design (DSD) utilizes patient input and information gathered through diagnostic procedures to create an esthetic treatment scheme. In the case presented here, the NYUCD Esthetic Evaluation Form, intraoral and

extraoral photographs, mounted diagnostic casts, physical examination, and radiographs were the diagnostic modalities. The gathered information served as a starting point for a wax-up and intraoral mock-up. This case report demonstrates how the DSD served as a template for crown lengthening procedures and design of the final porcelain veneer restorations.

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### Introduction

Esthetic dental concerns have become more widespread among people with relatively affluent lifestyles in at least some segments of the population in almost all countries. Patients' esthetic awareness and expectations have increased, so that close to what are perceived to be ideal outcomes are required. Long-term stability necessitates dental restorations that are congruent with the periodontium and occlusion.<sup>1</sup> An esthetic smile consists of three main constituents: the teeth, the lip framework, and the gingival scaffold.<sup>2</sup> An ideal smile has the following properties: minimal gingival display, symmetry and harmony between the maxillary gingiva and the upper lip, healthy gingival tissue filling the entire interproximal spaces, harmony between the anterior and posterior segments, teeth with correct form and position, proper tooth color and shade, and the lower lip parallel to the incisal edges of the maxillary anterior teeth and to an imaginary line going through the contact points of these teeth.<sup>3,4</sup> When a smile displays a disproportionate amount of gingiva, this phenomenon is referred to as a gummy smile.<sup>5</sup>

At rest, young women usually display 3 to 4 mm of the maxillary central incisors, and young men display an average of 2 mm or less. Extraoral causes of a gummy smile are vertical maxillary excess (VME), hypermobile upper lip (HUL) or a short upper lip. Face height is usually measured by dividing the face into thirds. A visual diagnosis of VME can be made when, on cephalometric analysis, the lower third of the face is longer than the middle and upper thirds.

The upper third may fluctuate due to the variability of the hairline. The middle and lower thirds are more involved in esthetic perception. The midface is measured from the glabella to the subnasale (the most protruding area on the forehead between the eyebrows and the point directly under the nose). The lower face is measured from the subnasale to the soft tissue menton. Often, VME can be treated by orthognathic surgery. A short upper lip (determined by measuring from the subnasale to the inferior border of the upper lip) can also cause a gummy smile. HUL is the result of hyperfunction of the lip elevator muscles and is usually the cause of a gummy smile if the lip length is within normal limits and the lower third of the face is in proportion to the remaining two thirds. Yet another cause of a gummy smile is altered passive eruption (APE), which is due to a deviation in normal development resulting in a large amount of the anatomic crown being covered by the gingiva, and minimal scalloping. APE has been classified into two types: Type 1 is a result of a disproportionate amount of gingiva measured from the free gingival margin to the mucogingival junction. In Type 2, there is a normal dimension of gingiva when measured from the free gingival margin to the mucogingival junction, but the gingiva extends over the coronal portion of the tooth. Based on an anatomic histological foundation, Type 1 can be categorized into 1A – an excessive amount of keratinized gingiva with normal alveolar crest-to-cementoenamel junction (CEJ) relationship; and 1B – an excessive amount of keratinized gingiva with the osseous crest at the CEJ level. The association of the osseous



**Fig 1** Full-face view.



**Fig 2** Smile full-face view.

crest to the CEJ of the tooth is the critical aspect. Type 2 can be categorized into 2A – normal amounts of keratinized gingiva with normal alveolar crest-to-CEJ relationship; and 2B – normal amounts of keratinized gingiva with the osseous crest at the CEJ level.<sup>6</sup> Anterior dentoalveolar extrusion is the overeruption of the maxillary anterior teeth in conjunction with the dentogingival complex, resulting in a more coronal position of the gingival margin and disproportionate gingival display. This is usually a result of tooth wear of the maxillary incisors and compensatory overeruption or an anterior deep bite.

## Case report

The patient, an Afro-American social worker in her late 30s, presented with the chief complaint of broken veneers. She reported that she had never liked the appearance of the old veneers, which she had lived with for 18 years (Figs 1 to 3). A medical history was taken and a comprehensive extraoral and intraoral examination conducted. The patient's previous dental history included veneers on the maxillary and mandibular arches and two amalgam restorations that appeared to be in good condition. An esthetic evaluation was also performed, which



**Fig 3** Smile profile close-up view.

included mounted models, radiographs, photographs, and an esthetic evaluation form incorporating the changes desired by the patient (Figs 4 to 6).

The following problem list was created from the gathered data:

- Excessive maxillary gingival display;
- Broken veneers on teeth 12, 13, and 21;
- Margins of veneers broken or stained on teeth 5 to 10, and 22 to 28;
- Unattractive proportions of the anterior teeth.

The first thing one does with every gummy smile patient is determine the origin of the problem, which may be skeletal, muscular, dentogingival, or a combination of these factors. Knowing the origin of the problem helps to guide treatment decisions.

Evaluation of the facial thirds is the first step in the process. The finding of an incremented lower third will lead to a suspicion of maxillary excess. A cephalometric study can be performed to confirm the diagnosis. In this case, the origin was not skeletal, as the lower third of our patient's face was equal to the middle and upper thirds.

The second step is to evaluate the lip length. A short lip can be diagnosed whenever the distance from the anterior nasal spine (ANS) to the lower border of the vermilion is less than 15 mm. This was not the case with our patient, as her lip length was found to be average (within the range of 20 to 24 mm). Another muscular origin of gummy smile could be lip hypermobility, which is the default diagnosis in the absence of evidence of any other origin.

The third step is to evaluate the incisal edge position of the incisors. In patients with incisal edge wear, a gummy smile can be due to the overeruption of these teeth. The dentoalveolar complex will compensate for the wear of the incisal edge by moving teeth, bone and gingiva coronally, as if it were a slow forced eruption.

If there is no wear, the next step is to assess individual tooth proportions. If these are correct, the problem is related to an altered active eruption (AAE). Our patient presented with incorrect proportions, for which there were two possible scenarios:



**Fig 4** Rest position close-up view.



**Fig 5** Smile close-up view.



**Fig 6** Retracted close-up view.



**Fig 7** Disproportional anterior teeth.

The first could be a gingival overgrowth due to medicine or systemic conditions; the second could be related to an APE.

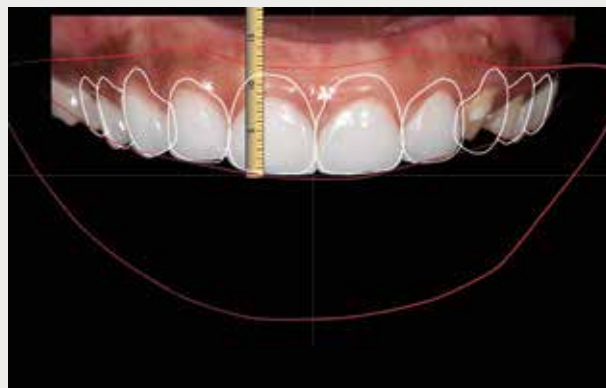
After investigating the origin of the patient's gummy smile, it was determined to be dentogingival rather than skeletal, which meant that the problem could be addressed restoratively and periodontally (Fig 7). Having determined the cause, we could move on to the first step in treatment planning, which is visualization of the final outcome. In this case, we used Digital Smile Design (DSD) to preview the final esthetic result. A diag-

nostic wax-up, in conjunction with an intraoral mock-up, would also allow the patient to visualize the outcome of the proposed treatment.

The digitally designed images allowed the patient to visualize the final result and comprehend the issues raised by her current oral condition. The number of teeth requiring restoration and the need for periodontal surgery became apparent. The patient's approval to proceed with the treatment was based on her viewing the potential outcome via the DSD images (Figs 8 to 11).



**Fig 8** DSD facial reference lines.



**Fig 9** Appropriate tooth measurements.



**Fig 10** Full-face smile project.



**Fig 11** Intraoral calipered teeth project.

Precisely replicating every detail of our DSD, and strictly adhering to the information derived from the DSD, enabled us to achieve the predicted esthetic outcome. A digital caliper was used to measure some reference points on the casts. With the aid of a calibrated virtual digital ruler, the reference points were transferred to the computer photographs of the patient. Incisal edge position, as always, dictated the design of the restorations, and the initial position of the edge was considered correct.

The first wax-up was created based on the DSD measurements (Fig 10). The restorations proposed in the wax-up were transferred to the patient's mouth (the mock-up) through the use of a silicone putty matrix (Lab Putty, Coltène Whaledent) and bis-acryl (Luxatemp Ultra, DMG). The incisal edge position and parallelism to the horizontal reference line were verified. A few minor intraoral modifications were carried out, and an impression of the mock-up was made. The final wax-up was created



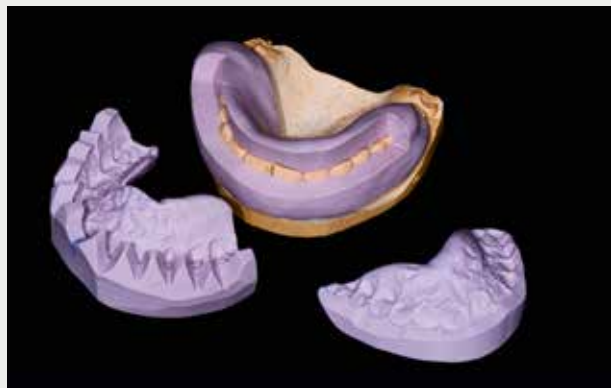
**Fig 12** Wax-up based on DSD measurements.



**Fig 13** Mock-up.



**Fig 14** Impression of the mock-up after a few corrections.



**Fig 15** Final preparation indexes.

on the newly poured models. Indexes fabricated from this new wax-up were used as the surgical and preparation guides (Figs 12 to 15). With the aid of the guides, the esthetic crown lengthening surgery and gingival margin correction were accomplished.<sup>7</sup>

The thickness and adaptation of the mock-up makes it a precise surgical stent and increases the predictability of the procedure. A gingivectomy was accomplished and the mock-up removed. Once the soft tissue collar was removed,

new provisional restorations were fabricated from the putty silicon index. As the provisional restorations will remain in place until the end of the soft tissue healing process, they were highly polished and bonded for retention. Osseous recontouring to establish an acceptable biologic width was then accomplished. A full thickness flap was raised to allow visualization during the osteoplasty and to permit accurate positioning of the gingival margin with interrupted sutures (Figs 16 to 27).





**Fig 16** Old veneer removal.



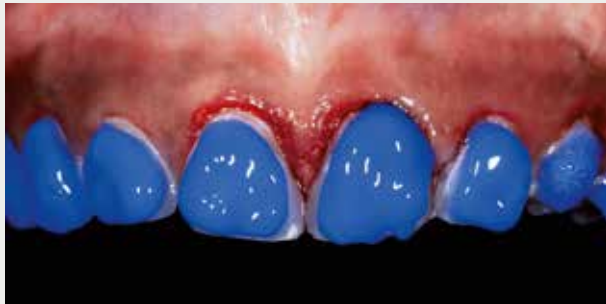
**Fig 17** Mock-up used as a surgical stent.



**Fig 18** Gingivectomy, mock-up removal, and tissue collar removal.



**Fig 19** Acid etching the old porcelain.



**Fig 20** Acid etching the enamel.



**Fig 21** Silane application.

Preparation modification was accomplished, and final impressions were made 6 months post-surgery. Retraction cord (Ultrapak, Ultradent) and a polyvinyl siloxane impression material

(Aquasil, Dentsply Caulk) were used. Maximum intercuspation (centric occlusion) bites were recorded (Blu-Bite HP, Henry Schein). Impressions, bites, clinical photographs, and shades were



**Fig 22** Bonding application.



**Fig 23** Provisional restorations.



**Fig 24** Once the provisional restorations are in place, a full thickness flap is raised to expose the bone.



**Fig 25** Osteoplasty conducted.



**Fig 26** Interrupted vertical mattress sutures.



**Fig 27** After 3 months of healing.

sent to the laboratory. The models were mounted in centric relation on a semi-adjustable articulator with a face-bow transfer (Artex Articulator System, Amann Girrbach).

In consultation with the laboratory, it was decided to fabricate feldspathic porcelain veneers on teeth 4 to 13 in the maxilla, and on teeth 21 to 28 in the mandible. The material was chosen for



**Fig 28** Final preparations.

its esthetic qualities and due to the absence of contraindicating occlusal issues. Although not as strong as pressed veneers, feldspathic veneers provide better color control. Moreover, less reduction is required. When the veneers were returned from the laboratory, they were inspected for conformity to the final wax-up. They were then tried in using a



**Fig 29** Feldspathic veneers.

transparent shade try-in gel (Variolink II, Ivoclar Vivadent). The patient was given the opportunity to see the restorations in her mouth and consented to their cementation. A water rinse was used to remove all traces of the try-in gel from the restorations. The internal surfaces of the restorations were scrubbed for 15 s with a 35% phosphoric acid solution (Ultra-Etch, Ultradent) and ultrasonically cleaned in alcohol for 1 min. Silane primer (Ultradent) was placed on the internal surface of the veneers and allowed to air dry. Bonding agent (Prime & Bond NT, Dentsply) was applied, allowing 30 s for the solvent to evaporate. The veneered teeth were isolated with rubber dam, etched with Ultra-Etch for 15 s, then rinsed with water for 30 s. Prime & Bond NT bonding agent was applied to the internal surface of the veneers. The restorations were then loaded with the base shade (Variolink II cement transparent) and seated on the teeth. A small brush



as well as floss was used to remove the excess cement before light curing for 40 s. A final check of the occlusion was made with articulating paper (AccuFilm, Parkell) and minor adjustments were performed (Figs 28 to 31).

Due to its dentogingival origin, we were able to completely correct the patient's gummy smile. The final result achieved in this case demonstrates what may be accomplished by using a systematic interdisciplinary approach, assisted by DSD (Figs 32 to 36).

## Discussion

Excessive gingival display or gummy smile represents an emotionally charged esthetic concern for many patients and a technique-sensitive challenge for clinicians. The clinician must understand the various causes, determine the correct diagnosis, and formulate a clinically predictable esthetic treatment plan. The diagnosis of gummy smile is not rare; the incidence of excessive gingival display is 10% of the population between 20 and 30 years of age, and is more commonly diagnosed in women.<sup>8,9</sup> In their study, Peck et al found a significant gender dimorphism in the vertical lip–tooth–jaw relationship: the upper lip of the females in the study was positioned on average 1.5 mm more superiorly at maximum smile than that of the males ( $P < 0.01$ ).<sup>10</sup> The gingival smile line is the smile at its fullest and exposes the gingiva superior to the maxillary anterior teeth.<sup>10</sup> According to orthodontists, clinicians and laypeople, the most attractive female smile is when the upper lip rests on the gingival margin of the maxillary



**Fig 30** Complete isolation cementation.



**Fig 31** Incisal characterization of the veneers.



**Fig 32** Final profile close-up view.



**Fig 33** Final full-face smile view.

incisor and the whole incisor crown is displayed ( $P < 0.05$ ). In the case of the male smile, laypeople consider it most attractive when the upper lip rests on the gingival margin of the maxillary incisor clinical crown. Orthodontists and clinicians differ slightly – they consider it esthetically most pleasing when the upper lip is on the gingival margin of the maxillary incisor crown, and when there is 2 mm of upper lip incisor coverage ( $P < 0.05$ ).<sup>11</sup> Oshagh et al found that in short-face patterns, lower smile lines are more acceptable by both dentists and laypeople, and in long-face patterns, higher smile lines are more acceptable. Additional findings are that in short-face patterns, lower smile lines are more acceptable by both dentists and laypeople, while in long-face patterns, higher smile lines are more acceptable. All these findings should be considered when setting orthodontic treatment goals.<sup>12</sup>

A correct diagnosis can be made from an appropriate examination consisting of: facial symmetry and proportions in both frontal and lateral views; upper lip length at rest; display of maxillary teeth at rest; amount of gingival exposure at rest, during speech, smile, and laughter; smile line; and gingival margin line.

As previously stated, the treatment required to address a gummy smile is dependent on the diagnosis of the cause of the problem. Gummy smile cases diagnosed as being the result of VME can often be treated by orthognathic surgery. A LeFort I procedure involves the down fracture of the maxilla with the repositioning of the dentoalveolar complex.<sup>13</sup> However, a multidisciplinary approach is required in some instances, in addition to or instead of surgery. Orthodontic treatment, periodontal treatment or restorative dentistry is often indicated.<sup>14,15</sup> The development of temporary



**Fig 34** Final smile close-up view.



**Fig 35** Final retracted view.



**Fig 36** DSD vs final result.



anchorage devices (TADs) has resulted in a variety of techniques used to treat a gummy smile with orthodontics.<sup>16</sup> Botulinum toxin type A, with effects lasting 3 to 6 months, has been reported.<sup>17,18</sup> Reestablishing the depth of the vestibule to treat a short upper lip has also been reported. Similarly, a surgical procedure to limit the movement of the elevator muscles has also been recommended.<sup>19</sup>

In this case, the origin of the gummy smile was determined to be dentogingival. Once that assessment had been made, DSD was used to visualize the final esthetic result. The key to successful treatment was then to select the appropriate techniques to correct the anatomic problems, maintain the biologic width, and achieve the visualized final esthetic result. Based on the work of Gargiulo et al, the biological width is defined as the dimension of the soft tissue that is attached to the portion of the tooth coronal to the crest of the alveolar bone.<sup>20</sup> After evaluating 171 cadaver tooth surfaces, Vacek et al reported the following mean dimensions: a sulcus depth of 0.69 mm; an epithelial attachment of 0.97 mm and a connective tissue attachment of 1.07 mm; observed mean measurements of 1.34 mm for sulcus depth; 1.14 mm for epithelial attachment; and 0.77 mm for connective tissue attachment.<sup>21</sup> Esthetic crown lengthening is categorized as being either Type I, II, III, or IV. In Type I cases, there is sufficient attached gingiva coronal to the osseous crest, and the need for osseous recontouring is therefore obviated. A simple gingivectomy that simultaneously sculpts, contours and maintains appropriate zeniths may be all that is required.<sup>22</sup> Type II crown lengthening

is categorized by gingival proportions that permit an apical positioning of the gingival margin, do not reveal the osseous crest, but violate the biologic width. In these cases, the body will spontaneously attempt to reestablish the correct biologic width. Recession will occur in thin biotypes due to crestal resorption, and protracted inflammation will occur in thick biotypes. Either scenario would be detrimental to any restoration placed in this environment. Osseous recontouring is required to rectify the violation of the biologic width. As in this case, this can be accomplished by placing provisionals at the preferred crown length and then waiting for soft tissue healing. A flap is later raised while the papilla is maintained, and osseous recontouring is accomplished, with the provisional restoration providing a surgical template. The flap is then replaced in its previous position. Type III crown lengthening is needed when repositioning of the gingival margin would result in disclosure of the osseous crest. To encourage reestablishment of a healthy biologic width, a surgical template is required to assist in appropriate bone reshaping under the elevated flap. The gingival margin is repositioned coronally to conserve soft tissue. Type IV esthetic crown lengthening is required when inadequate attached gingiva is present. An apically positioned flap is required with a definitive margin, and provisional construction accomplished at a later date.

For this patient, a Type III one-stage surgical crown lengthening procedure was selected as being the most beneficial. According to Sonick et al,<sup>23</sup> a single-stage crown lengthening procedure often results in a 1 to 3 mm rebound of



the free gingival margin 6 months to 1 year post-surgery. This would especially apply to patients with a thick biotype. The procedure allowed for the gingivectomy and placement of the provisional veneers at the same visit. Sonick et al recommend a two-phase crown lengthening procedure, in which an ostectomy is initially accomplished and, several weeks later, a gingivectomy is performed subsequent to initial attachment and bone healing. In Lee's opinion,<sup>22</sup> since the reaction of the soft tissue to violation of the biologic width is not immediate, restorations can be placed immediately after a gingivectomy, and osseous recontouring surgery can be done later. This allows precise placement of the osseous crest relative to the margins of the provisional restoration so as to reestablish the biologic width.

## Conclusion

Precise treatment planning is essential to achieve a long-lasting esthetic outcome for patients presenting with a desire to correct a gummy smile. DSD is a powerful tool that can be used to expedite the analysis of the patient's facial and dental features and assist in determining how the finished case will look. The proper diagnosis of a gummy smile is a prerequisite to any restorative treatment that may be required.

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