Case Report

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A multidisciplinary approach for esthetic improvement in a patient with swimmer's dental erosion: a 5-year recall case report

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This study showcases a multidisciplinary digital approach for esthetic improvement in a patient with swimmer's dental erosion, particularly focusing on a predictable workflow of surgical crown lengthening and restoration in cases of gummy smiles and upper anterior teeth erosion. The patient presented with excessive gingival display and swimmer's erosion in the upper anterior teeth. Utilizing computer-aided design/computer-aided manufacturing (CAD/CAM) systems, a final digital outcome design was generated, serving as a diagnostic wax-up model for this patient. The determined position of the gingival margin level and the contour of the digital final restoration design information were transferred to produce a reference surgical guide for the surgical crown lengthening process. Additionally, the digital design model facilitated the fabrication of a silicone index for the direct restoration procedure. The combination of a simple direct restoration technique and surgical crown lengthening, enabled by the digital multidisciplinary approach, effectively addressed the patient's concerns.

Keywords: CAD/CAM, crown lengthening, erosion, gummy smile, swimming

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Introduction

The dental treatment aims to restore, repair, or rebuild to gain good function, esthetics, and healthy periodontal tissues. Dental esthetics is based on the "white component" of the teeth or restoration and the "pink component" of the periodontal tissues [1]. Often, an excessive gingival display is a challenge in patients requiring esthetic treatment. The first step of the treatment plan for a patient with excessive gingival display is to determine the cause of the problem, such as vertical maxillary skeletal growth, short upper lip, upper lip hyperactivity, dentoalveolar extrusion, or a combination of these factors [2, 3]. A vertical maxillary excess (VME) may be defined as excessive maxillary development in the vertical plane, a skeletal problem in a patient with a gummy smile [4, 5]. The patient with this skeletal problem needs orthognathic surgery [6, 7]. The difference in lip length is one factor used to determine the amount of maxillary incisal exposure in both the rest and maximum smile postures. Thus, a short upper lip length and hyperfunction of the lip lead to excessive gingival display [2, 7]. Another cause of the esthetic impairment with excessive gummy display is the altered passive eruption (APE) [2, 8]. According to the *Glossary of Periodontal Terms* of the *American Academy of Periodontology*, the passive eruption is defined as "tooth exposure secondary to apical migration of the gingival margin to a location at or

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slightly coronal to the cementoenamel junction (CEJ)" [9]. The dental eruption processes initiate with the active phase, in which the tooth erupts from the oral epithelium and creates occlusal contact with the antagonistic tooth. Both active and passive phases continue after the tooth eruption from the oral epithelium. The passive dental eruption is a migration of gingival tissue until reaching the CEJ. Therefore, the APE is a normal variation of the gingival migration process due to genetic or dentoalveolar developmental conditions. The APE results in a short clinical crown appearance from a coronal position of gingival tissue [10]. In a patient with tooth wear, a gummy smile was found to be the result of dentoalveolar compensation for the incisal edge wear by moving both dentoalveolar and gingival structures coronally.

Tooth wear refers to non-carious tooth substance loss. The etiology of tooth wear can be categorized into attrition, abrasion, erosion, and abfraction [11]. Dental erosion is defined as the dissolution of a hard dental structure caused by chemical agents [12, 13]. Savad's survey showed that swimming in an improper swimming pool may be a risk factor for dental enamel erosion [14]. Large swimming pools use chlorine gas to reduce bacteria contamination in the water. Hypochlorous acid and hydrochloric acid are by-products of the reaction between chlorine gas and water. Then, the pH of water is decreased rapidly. Soda ash is added to water to adjust the pH to 7.2-8.0. However, if the water is inadequately buffered, the acidity of the swimming pool may dissolve the tooth surface. The incidence of tooth wear lesions in swimmers can be found on both the labial and palatal sides of the anterior teeth [15, 16].

Esthetic crown lengthening is a periodontal surgical procedure that resolves incorrect tooth proportions to gain a greater amount of clinical crown in a patient with a gummy smile from the dentoalveolar problem [17]. Communication between interdisciplinary dentists is essential to achieve the best treatment plan and sequence [8, 18]. The use of digital technology and CAD/CAM systems can improve treatment outcomes and facilitate communication between dentists [19]. This can be achieved by utilizing an intraoral scanner instead of traditional impressions, using the digital design to visualize the expected results, and creating surgical guides for periodontal surgeries.

This report aims to present a multidisciplinary treatment approach using digital tools to predict treatment outcomes before invasive procedures are performed. These digital tools also assist in both surgical and restoration procedures to enhance the esthetic appearance of a swimmer's dental erosion case.

Clinical Report

A 19-year-old competitive swimmer was referred with a chief complaint of labial surface erosion, incisal edge wear, and short clinical crown proportion with excessive maxillary gingival display in anterior maxillary teeth The esthetic evaluation was performed, including digital scanning, radiographic examination, photographic evaluation, and digital smile design. An extra-oral examination, an intra-oral examination, and a diet counseling questionnaire clarified the etiology of tooth wear and excessive gingival display in this patient [13, 20]. The patient's facial proportions and skeletal structure are normal, with no abnormalities or inconsistencies noted. A close-up view of the patient's smile shows excessive gingival display, dental erosion, and the incorrect width-to-height ratio of the maxillary central incisors (100%-125%). The upper central incisor teeth had exposed dentin. An uneven gingival margin was found in the upper anterior teeth (Figures 1-2).

Figure 1 A close-up view of the smile during pre-treatment esthetic analysis shows excessive gingival display, dental erosion, and the incorrect width-to-height ratio of the maxillary central incisors (100%- 125%). The upper central incisor teeth had exposed dentin. An uneven gingival margin was found in the upper anterior teeth and

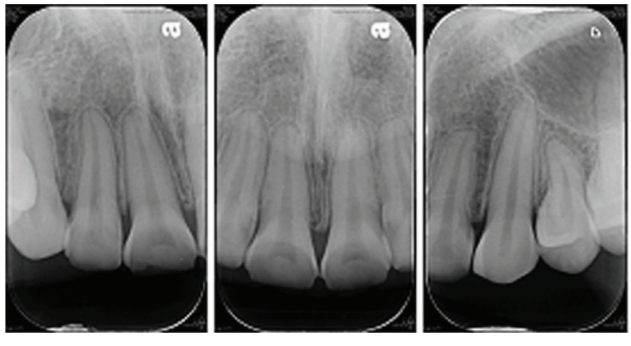

Figure 2 The pre-operative radiograph examination

She provided information about her daily training regimen to become a competitive swimmer for over ten years. The problem list of this patient consisted of dental erosion on both labial and incisal surfaces from swimming, uneven gingival margin, and excessive gingival display of upper anterior teeth. With optimal patient economic conditions, the patient accepted the treatment plan, consisting of surgical crown lengthening and direct veneer restoration for exposed dentin from tooth number 12 to 22. The intraoral digital impression of the maxilla, mandible, and maximal intercuspal position was done with an intraoral scanner (CEREC Omnicam and CEREC SW software version 4.6, Dentsply Sirona). The digital impression model and clinical photograph were used to create the digital design model of a final restoration tooth shape and gingival contour. The restoration profile and the optimal gingival margin were designed using data from esthetic analysis and proper tooth proportions [21]. This information was used to design a surgical guide stent for the crown lengthening procedure with CAD-CAM technology, employing inLab CAD SW software version 18.0 from Dentsply Sirona. The virtual articulator estimated the upper anterior teeth' position of the incisal edge with the preset average parameters of the software's articulation function. The dynamic contacts (centric, eccentric, and protrusion) were identified and corrected. Then, those digital design data were transferred to the 3D-printing machine (Perfactory 4 DDP M, EnvisionTEC) to produce a design model and a surgical guide stent (Figure 3). For final evaluation before treatment, the diagnostic design model was used to fabricate a silicone putty index which was used as a matrix in the restoration mock-up testing with temporization material (Protemp™4, 3M ESPE) in the upper anterior teeth of the patient. The temporary restorations regarding shape form, chewing, and phonetic function were evaluated. Moreover, the planning of surgical procedures was developed by the restoration profile, the optimal gingival margin of the design model and surgical guide, the bone sounding, and the pre-operative radiograph.

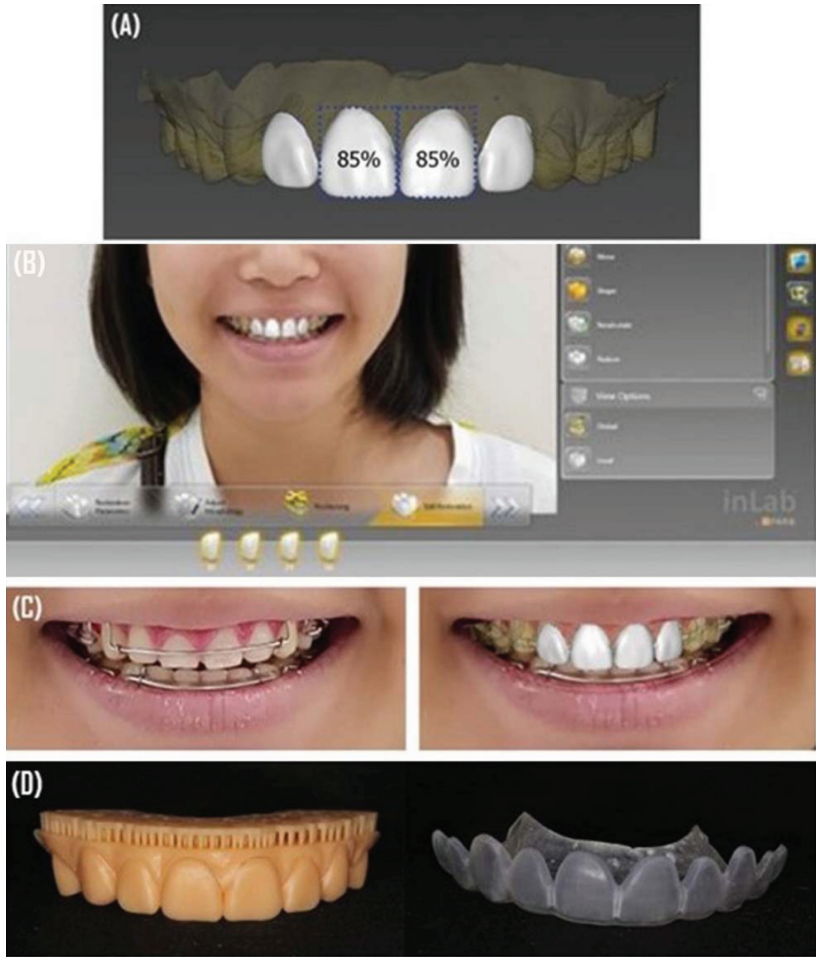

Figure 3 Digital smile design of final restoration A. In the 3D digital design model, the restoration was designed on teeth 12-22. the width-to-height ratio of the maxillary central incisors was corrected to 85%. B and C. The Smile close-up view of the designed final restoration was transferred into the clinical 2D photograph. D. a digital design model and surgical guide stent were created from the digitally designed data.

Surgical crown lengthening

Before the surgical crown lengthening procedure, the periodontal examination revealed that the gingival margins were generally slightly red and typically rounded. The interdental papillae exhibited a pyramidal shape. The mucogingival tissue showed a keratinized tissue width of approximately 3-6 mm and was classified as a thick gingival biotype. The sulcus depths ranged between 2-3 mm, with clinical attachment levels ranging from 1-2 mm. The distance between the alveolar bone crest and the gingival margin was approximately 3 mm.

The adaptation of the surgical guide was thoroughly verified. During the surgical procedure, the periodontist conducted a gingivectomy with an internal bevel incision on the gingiva of teeth 11 and 21, as well as an intrasulcular incision on teeth 13-23 at a level consistent with the surgical guide. A full-thickness flap was raised on the labial side of the anterior maxillary teeth (13-23) to expose

the alveolar bone while ensuring the interdental papilla (IDP) on the palatal side was preserved. The surgical guide was utilized as a reference for determining the new gingival margin of the final restoration during the ostectomy and osteoplasty procedures. The bone was removed to establish an optimal 3-mm distance of biological width between the alveolar crest and the gingival margin [8]. Following this, the flap was repositioned and sutured using 4-0 Polyglactin 910 (Vicryl, Ethicon) with a continuous sling suture (Figure 4). The sutures were removed nine days post-surgery.

Figure 4 Crown lengthening procedure. A-B: A labial incision was made according to the stent. C-D: Full-thickness flap elevation and alveolar crest finding. E-F: Alveolar bone was removed according to the stent. G-H: The flap was repositioned and sutured.

Three months after surgery, a clinical evaluation was performed. Periodontal examination revealed a generalized slightly red gingiva with knife-edge margins, except for the marginal gingiva of teeth 11 and 21, which were rolled. The interdental papillae were edematous, with stippling present and a firm consistency. Bleeding on probing was noted, but no tooth mobility was observed. The probing depths of the upper anterior teeth ranged from 2-3 mm. A slight recession of the marginal gingiva was found in the mid-labial area of tooth 11. The patient was involved in a motorcycle accident, resulting in an injury to the upper anterior teeth. The patient complained that she had tooth sensitivity in her upper maxillary teeth. The diagnosis revealed subluxation on teeth 11 and 21. Tooth number 11 exhibited a persistent negative response to the electric pulp test (EPT) and displayed clinical discoloration. Following the guidelines established by the International Association of Dental Traumatology [22], it was recommended to continue monitoring the pulp condition for a minimum of one year, as false negative responses may persist for several months. As a result, an ongoing follow-up of the pulpal status was scheduled.

Direct resin composite veneers

The direct veneer restorations of the upper anterior incisor were accomplished step by step. The diagnostic model was used to fabricate a silicone putty index, which was used as a matrix to fabricate the direct veneer restorations. The putty was cut through the incisal edge and created the palatal shell and the incisal edge of the restorations [12]. The Shade selection step was done using the Vita classical shade guide (Vita, Ivoclar Vivadent) and a mock-up technique with the composite resin to be used (Filtek Z350 XT, 3M ESPE).

The body shade, A2, was selected based on the chroma of the cervical and middle third of the tooth, whereas in the discolorated tooth, the dentin shade, A2, and body shade, A2, were used. A brighter enamel shade, A2, was selected for the enamel layer. Firstly, the teeth were cleaned with pumice and a rubber cup. The putty index was tested for adaptation. The Teflon tape was used to protect the canines from the etching agent. The teeth were etched with 37% phosphoric acid for 15 seconds over the labial and palatal surface of the tooth and then washed with air-water spray. The adhesive (Optibond™ solo plus, Kerr) was applied and cured for 20 seconds (Bluephase N, Ivoclar Vivadent) following the manufacturer's guidelines. The thin layer of selected enamel shade material was placed and spread on the putty index. The index was positioned on the teeth to create a palatal shell on the tooth (Figure 5). The resin composite was cured, and the putty index was removed.

Then, the body and dentin shade were placed to create a direct veneer overall contour shape and interproximal contact area. The thin layer of dentin shade resin composite was used to conceal the discoloration of tooth number 11 before the body shade resin composite was placed.

Figure 5 A silicone putty index created a palatal shell on the tooth12 -22 for direct veneer procedures after three months of surgery.

The proximal surface's placement was established by adapting the proximal matrix (celluloid strips). Sufficient space for the enamel shade layer was left according to the enamel thickness, which is thinner at the cervical area than the incisal area of the tooth [23]. The final labial enamel layer was applied to complete the restoration. Each layer of the composite restoration was light-cured for 20 seconds. The final curing was performed for 40 seconds. The initial finishing of the restorations and the occlusal adjustment were defined according to the design model. A blade no.12 was used to remove the excessive material in the cervical and interproximal areas. A coarse abrasive disc (Sof-Lex™, 3M ESPE) was used to shape the restoration to achieve the initial outline of the restorations. The palatal excess material was reduced with a high-speed rugby ball shape bur. According to the patient and clinician's view, the restorations were refined in a shape form with a flame-shaped fine diamond bur and abrasive disc. According to the planning design, the cervical-to-incisal and mesial-to-distal lengths were measured and adjusted to achieve the 85% width-to-height ratio of the final restoration. Moreover, the surface texture was created and polished by the flame-shaped fine diamond bur, abrasive disc, and silicone polishing bur (Astropol, Ivoclar Vivadent). After the end of the finishing and polishing, the centric and eccentric contacts were checked (Figures 6-7).

After five years of restorative treatment, the endodontic treatment was done on the right upper central incisor tooth (tooth 11). The patient refused to have a tooth bleaching due to satisfaction with the current tooth shade. All direct veneer restorations were assessed. Minor staining along the margins and a loss of surface luster were observed in this case. All restorations were addressed by polishing. The patient expressed satisfaction with the treatment received over the past five years (Figure 8).

Figure 6 The final restoration after polishing and the postoperative radiograph examination.

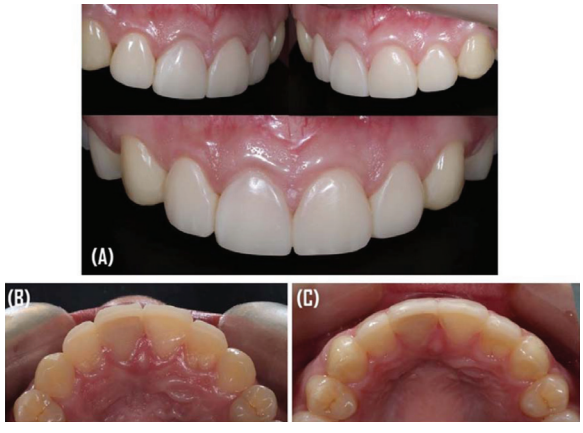

Figure 7 After one year of restorative treatment: A; Frontal view. B; Palatal view. C: Incisal view.

Figure 8 The close-up view of restorations after a 5-year recall and the final full-face smile view. The patient was satisfied with the treatment outcome, and an excellent periodontal response was found.

Discussion

As previously mentioned, this patient had two significant problems: excessive gingival display and tooth wear of the upper anterior teeth. Different causes of excessive gingival display require other treatment options [24]. In this case, the problem did not lie in the patient's skeletal skull or upper lip. Facial profile and cephalometric analysis revealed no evidence of a long face with anterior or posterior maxillary overgrowth. Upon extra-oral examination, the patient displayed normal facial proportions, with the lower third being equal to the remaining two-thirds.

The evaluation of lip length and lip mobility indicated that the patient's average lip length from the subnasale to the inferior border of the upper lip was 20 mm, falling within the range of 18-22 mm [25]. There was no hyperactivity of the upper lip. The patient presented with loss of enamel structure at the labial surface and incisal edge of upper anterior teeth due to exposure to swimming pool acidity, consistent with the findings of Buczkowska-Radlińska *et al.,* who identified swimming duration and training intensity as risk factors for dental erosion on the labial and palatal surfaces of anterior teeth [15].

For keeping a functional position in occlusion with the opposing arch, the dentoalveolar compensation for incisal edge wearing by adaptive coronal teeth, alveolar bone, and gingiva displacement are exhibited [10, 13]. Therefore, the excessive gingival display of the upper anterior teeth in this patient likely resulted from a dentoalveolar structural issue. The loss of enamel tooth structure led to dentine exposure, tooth sensitivity, and esthetic complications with inappropriate tooth proportions [8, 13, 20]. As a result, the planned treatment for this patient involved crown lengthening and restoration, in accordance with the excessive gingival display's classification and the proposed treatments outlined in Gerber and Salama's report [5, 24].

Previous studies reported that the final position of the gingival margin after surgical crown lengthening is influenced by the surgical procedure and healing time [5]. In this particular case, CAD-CAM systems were utilized for visualizing the treatment planning and esthetic outcomes. A digitally fabricated surgical guide was employed to provide reference points for the gingival margin and alveolar crestal bone resection during the crown lengthening surgery. This aided the periodontist in the precise removal of soft and hard periodontal tissue. The final position of the gingival margin was determined by the adjusted position of the alveolar bone crest during the surgery [17, 26]. Various aspects of alveolar crest bone architecture, such as interproximal peak level, labial crest curvature, and zenith, must be taken into consideration. Consequently, the amount of bone resection was based on the location of the final restoration margin, which was used as reference points for a digital stent fabrication [27]. The use of a digital stent allowed for a precisely predictable outcome [28]. Healing time was found to be dependent on tissue maturation [5]. In cases involving osseous reduction, it generally takes 3-6 months for the biologic width to be re-established and for the attachment and bone stability to be achieved before the restorative procedure can take place [29]. According to Fletcher's study, bone remodeling may continue for more than 12 months, whereas soft tissue healing typically stabilizes within eight weeks [30].

In this case, direct veneer restorations were performed three months after the surgery or two months after the dental trauma on the incisor teeth. The patient displayed stable gingival margins, good periodontal tissue response, no tooth mobility, and no tenderness to percussion or palpation testing. The decision to use direct veneer restoration was made after an interdisciplinary discussion to address the patient's tooth sensitivity and reduce the risk of pulpal irritation in the upper anterior teeth. Subsequent observation of the pulp and periapical tissue was conducted in accordance with dental trauma guidelines for the subluxation of teeth [22]. Direct resin composite veneer treatment offers numerous advantages. It is a highly conservative, minimally invasive, and predictable approach for restoring dental erosion [13]. Modern resin composite materials are available in multiple shades and translucencies, allowing for a natural esthetic appearance. Furthermore, resin composite materials result in less wear on opposing teeth compared to porcelain. They can also be filled, adjusted, and repaired as needed [31]. Therefore, it is suitable in a condition where the incisal edge position of this patient has changed. Moreover, the overall cost of direct veneer treatment without involving a laboratory in the restoration process is more economical than indirect treatment [12, 31]. However, they are prone to color changes and high porosity [32]. In contrast, indirect ceramic veneers excel in fracture resistance, durability, and long-term stability but come with higher costs, require multiple appointments for molding, and can be fragile during handling. Achieving optimal aesthetic outcomes in both techniques demands professional skill, precise execution of restorative procedures, and meticulous finishing, polishing, and maintenance. Success in either direct or indirect veneer applications hinges on accurate diagnosis, appropriate case selection, and a well-planned treatment approach [32].

The surgical stent was created using digital design data, and the restoration was designed with a CAD system, which was transferred into a 2D full-face picture. The patient was able to see a demonstration of the final outcome. Moreover, we printed out the digital design model and created a silicone index. Intraoral mock-up, using the silicone index, allowed the patient to visualize and discuss the treatment outcome. The silicone palatal index helped prevent excessive palatal restorative material, reducing the time spent on palatal finishing and occlusal adjustment process [12]. Finally, the patient was referred for the fabrication of a sports mouthguard

for swimming to prevent further tooth structure loss due to the acidity of the swimming pool [16] and was advised to use dental remineralization agents such as fluoride, Casein Phosphopeptide-Amorphous Calcium Phosphate (CPP-ACP) and Tri-Calcium Phosphate (TCP) to inhibit erosive processes [33].

Clinical Relevance

Treatment of a gummy smile case utilizing surgical crown lengthening and resin composite direct veneer can yield the anticipated results through meticulous diagnosis, a well-suited digital treatment plan, and robust collaboration within the interdisciplinary dental team.

Ethical approach

This report was approved by the Faculty of Dentistry and the Faculty of Pharmacy, Mahidol University, Institutional Review Board (MU-DT/PY-IRB), reference number: COE.No.MU-DT/PY-IRB 2020/006.2602.

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Disclosure

The authors do not have any financial interest in the companies whose materials are included in this case report.

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