Etiology-Based Treatment Strategy for Excessive Gingival Display: Literature Review

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Abstract

To-date, ‘pink esthetics’ raises a great concern among various disciplinaries in cosmetic dentistry. When one smiles, not only teeth are visible but for some, gingiva is also noticeable. ‘Gummy smile’ is a descriptive term for excess gingival display. Excessive gingival display is classified by the American Academy of Periodontology (AAP) as a mucogingival deformity and condition that occurred around the teeth. Even though gummy smile is only a defining sign rather than a diagnosis, symptomatic treatment is important and should be emphasized. Esthetic correction requires an understanding of the true etiology behind the presenting flaws. The manifestation of gummy smile is interdependent on many factors. These include the craniofacial features, dentogingival complex, oral muscles, soft tissue anatomy, iatrogenic factors and a combination of these. The principal aim of this article is to summarize the treatment modalities for gummy smile, their applications, improvement in skills and techniques, and their potential complications and solutions based on individual etiologic factors.

Introduction

In the present era, orthodontic procedures are not merely for medical needs, fulfilling smile esthetics expectations has become one of the important goals as well. The esthetic smile is measured through the relationship between the teeth, the gingival scaffold and the lip framework [1]. Any changes to this optimal relationship will adversely affect the facial esthetic appearance. Excessive gingival display is classified by the American Academy of Periodontology (AAP) as a mucogingival deformity and condition that occurred around the teeth [2]. It is widely accepted that gingival display within 3 mm is esthetically acceptable and, a slight exposure of gingival actually gives a youthful appearance and is considered attractive [1,3]. Gingival display of more than 3 mm is esthetically unacceptable and generally known as ‘gummy smile’. Even so, this concept might not be applicable when subjected to social, ethnic and cultural considerations.

To date, there is no specific classification for clinical diagnosis of gingival display. The term, Gingival Smile Line (GSL) mentioned by Peck et al., [3] defines the gingival exposure demarcated by the upper anterior teeth and upper lip when individuals smile at the fullness. Tjan and Miller [4] classified smile line into three categories based on the dentogingival visibility. They classified high smile line as 100% maxillary incisor display in accordance with a continuous band of gingiva. Other groups, measured the gingival display based on the vertical height from the Cementoenamel Junction (CEJ) and smile pattern respectively [5,6]. In spite of that, in relation to its predominant sites on the upper arch, gummy smile can be divided into: (i) the anterior gummy smile, or (ii) the posterior gummy smile [7,8]. An individual may present with one, or both conditions, either unilaterally or bilaterally.

The clinical diagnosis of gummy smile is assessed through the extension from the facial appearance, lip structure, anterior dentition and mucogingival level. The examination of facial appearance includes the evaluation of facial symmetry and face height. A direct judgment can be made by examining the overall transition from repose to full smile during doctor-patient interactive sessions, without the patient being aware of it. So, asymmetrical droopy or raised lip and nose, or paralytic face can be noted, if present. However, the classical transverse rule-of-fifths and the vertical facial trisection provide a more systematic evaluation. Lip symmetry can be assessed using the intercommisure line in reference to the occlusal plane when the patient smiles [9]. If there is no cant on the occlusal plane, a deviation seen upon smiling may suggest lip anomalies. Upper lip length is measured to diagnose if a short lip is present. In young adults, the average upper lip lengths for females are 21.2 mm and 23.4 mm for males [10]. In addition, a change of 6 mm to 8 mm in lip length...
from repose to full smile is considered normal but in the hyperactive lip, it is about 1.5 to 2 times the average [1]. Intraorally, the assessment of crown length should be made in relation to age and lip position. As the age increases, the difference in soft tissue drapes will indirectly result in lesser incisor display [11]. Peck et al., [3] discovered that gummy smile patients showed an increase of 1 mm in an overbite and 1.5 mm in overjet as compared to the non-gummy smile patients. In the same accord, a narrow arch width and lingually inclined tooth can be the associated factors as well. For gingival assessment, transgingival probing and radiographic examinations are commonly used to evaluate the gingival margin, gingival biotype and bioform, amount of keratinized gingiva and height of the osseous crest. This is to ensure the preservation of biological width and keratinized ginviga as a violation to these structures will jeopardize the treatment results. In fact, gummy smile is not only an issue in dentate patients but also in edentulous patients [12].

Gummy smile can be of skeletal, dentoalveolar, dentogingival, and neuromuscular origins or a combination of these. In addition, Wei et al., [13] identified nasal septum dysplasia as a new etiologic factor of gummy smile. The multifactorial manifestation of gummy smile made the problem and goal-oriented treatment planning challenging. In order to meet the functional and esthetic demands, an accurate diagnosis of the etiologic factors causing the problem is critical to dictate the best treatment option and approach.

This article reviews the etiology-oriented treatment modalities for gummy smile, their applications, improvement in skills and techniques, and their potential complications and solutions.

**Excessive incisor display**

Gummy smile of dentoalveolar type caused by deep bite, over-erupted and retroinclined anterior teeth can be corrected orthodontically by intrusion. Lewis [14] stated that if the lower lip covers more than 4 mm of upper central incisors on a lateral cephalogram and the patient has a deep bite; it is the result of upper incisor over-eruption. Traditionally, upper incisors intrusion is achieved using segmented intrusion arches reverse curved arches and functional appliances. The major limitations of these appliances include the labial tipping of the incisors and counteractive moment acting on the molars [15,16]. Even though the buccal and distal tipping of the molars (reaction forces) can be intercepted with the use of headgears, transpalatal bar lingual arch and segmented arch without extending to the posterior teeth. However, the use of Temporary Anchorage Device (TAD) simplified the intrusion mechanics. Various studies had proven that TAD greatly reduced the side effects from conventional intrusive arches and give true intrusion [17]. The ease of TAD placement and removal, excellency in anchorage control [18,19] and more patient compliant have gained its popularity in orthodontic treatment. Burstone [20] suggested that true intrusion can be achieved with low intrusive force passing through the center of resistance of the intruded tooth. In extension to this, Dermaut et al., [21] investigates the location of the center of resistance of a tooth and a group of teeth, and give an insight of possible tooth displacement to the applied forces. Their results showed that when four or six anterior teeth were included in the sectional wire, traction forces applied between the central incisors or between the central and lateral incisors will be evenly distributed over the teeth and react as one unit. In spite of that, if the applied traction forces were before the center of resistance, the teeth inclined labially and if it is just behind that, the teeth inclined lingually. Another author reported that true intrusion was seen in TAD placement between lateral incisors and canines in contrast to more tipping movement of incisors when posterior TAD was used [22]. Therefore, the multiple placement sites between the central incisors [18,23], the central and lateral incisors [17], the lateral incisors and canines [19,22], and the posterior region between premolars and first molars are of utmost importance in patients with normal incisor inclination [22]. However, the long-term stability of TAD-induced intrusion remains unknown.

Many studies have reported that external apical root resorption in the upper incisors can occur as a result of intrusion using orthodontic treatment, regardless of using conventional appliances [23,24], TAD-induced intrusion [22] or Clear Aligner Therapy [25]. The amount of root resorption is hard to predict due to the variations of intrusive mechanics (continuous or transient), duration of intrusion, type of tooth movements and root proximity to the alveolar bone [26,27]. Therefore, from a mechanical and biological standpoint, root resorption can be minimized using a constant force with low deflection rate and positioned the root within the alveolar bone [20].

**Gingival overgrowth and altered passive eruption**

Dentogingival type of gummy smile appears in the form of gingival excess. Gingival excess in the form of pseudopocket formation, drug-induced gingival enlargement, and inconsistent gingival margin can be treated with routine periodontal therapy by removal of local irritants [2]. If the gingival overgrowth is not resolved, a gingivectomy may be needed. When the gingiva fails to migrate apically toward the CEJ and leads to a short, square-looking crown, this condition is known as the Altered Passive Eruption (APE). There are two types of APE [28]. Type 1 displays excessive keratinized gingiva while type 2 has a normal dimension of keratinized gingiva. In term of the distance of osseous crest to CEJ, both APE is further subdivided into subcategory A and B with the distance of osseous crest greater than 1 mm or at proximity to the CEJ respectively.

Crown lengthening surgery is well documented for the treatment of APE to eliminate excess gingiva and restore the clinical crown length through dentogingival complex remodeling. The procedure includes gingivectomy, apically positioned flap with or without osseous resection, and forced eruption of tooth. The treatment of choice depends on the amount of biological width and keratinized gingiva available, and crown-root ratio of the tooth [29]. Since type 1 APE resulted from excess keratinized gingiva, a conventional gingivectomy will be the treatment of choice. The excision of excess gingiva is performed through scalpel surgery, electrocautery, and diode laser on the basis of maintaining a normal dimension of keratinized gingiva through pre-surgical evaluation [30]. Gingivectomy is contraindicated in type 2 APE. In cases with reduced biological width, a full thickness mucoperiosteal flap with intact interdental papilla is indicated in conjunction with osseous surgery. Once the vertical bony dimensions have been reduced and shaped to create a scalloped contour that will support the scalloped gingival architecture, the flap is positioned and sutured apically but slightly coronal to CEJ with minimal pocket depths. Then, a new biological width is established.

It has been reported that gingival rebound, gingival recession and loss of interdental papilla are the possible complications from crown lengthening surgery [31]. These can be overcome by a definitive treatment plan with the use of radiographic analysis (periapical and bite-wing radiographs) and transgingival probing (gingival measurement). Furthermore, transgingival probing is superior to radiographs in the planning of crown lengthening surgery [32].
Recently, the use of Cone-Bean Computed Tomography (CBCT) makes the diagnosis and treatment planning of the APE more predictable [33,34]. Even so, from a surgical standpoint, there may be a need for small revision surgeries to refine the result in order to achieve an ideal esthetic outcome due to individual variations [35].

**Vertical maxillary excess**

The primary etiology of the skeletal type of gummy smile is Vertical Maxillary Excess (VME). Waldrop differentiates the excess gingival expression of APE and VME by defining them as excessive coronal gingiva and excessive apical gingiva respectively [36]. VME is a feature commonly seen in patients with long face syndrome with either a dental open or closed bite [37]. Increase in facial lower third, excess maxillary incisors exposure and gingival display are pathognomonic features of VME [37,38]. Graber and Salama classified VME into three degrees based on the amount of the gingival display. Degree I VME (VME-I) has a gingival display of less than 4 mm, VME-III with more than 8 mm gingival display and VME-II between 4 mm to 8 mm [1]. In his studies, VME-II and VME-III require a multiple interdisciplinary approach, which may include combined orthodontic and orthognathic surgery treatment, periodontal surgery, or restorative treatment. Whereas, VME-I can be treated less invasively through orthodontic treatment alone, periodontal surgery or restorative treatment. From surgical perspective, it is crucial to identify the location of excessive vertical growth which may be manifested in anterior, posterior or both segments, either unilaterally or bilaterally.

A report mentioned that VME is dentoalveolar in nature and the most direct and appropriate method for treatment would be impaction of maxillary alveolus [38]. Surgical impaction for maxilla includes segmental maxillary osteotomy and Le Fort I osteotomy [39,40,41]. Anterior maxillary osteotomy has long been reported as a surgical procedure for repositioning the anterior segment of the maxilla, provided that the posterior occlusion is normal. The surgical incision is made interdentally, usually at the first premolar extraction sites, and connected by a transpalatal osteotomy to form a fractured free anterior segment. The mobilized anterior maxilla is then free to move posteriorly (Wunderer method), superiority (Cupar method) or to close the interdental spaces (Wassmund method) to achieve the desired treatment result [40]. In cases with severe skeletal discrepancy, posterior maxillary osteotomy, total maxillary osteotomy or Le Fort I osteotomy can be considered [39]. Sometimes, Le Fort I osteotomy with concomitant setback and intrusion of the maxilla provides an alternative to segmental maxillary osteotomy when tooth extraction is not needed. In some dentoalveolar cases, orthognathic surgery could produce an unfavorable result. When the patients have insufficient exposure of upper incisors (<2 mm) in relaxed lip position, over-impacting the maxilla will result in low smile line giving an aged appearance [1]. In contemporary orthodontics, the use of mini-implants to treat borderline VME cases is an increasing trend. Many successful cases have been published regarding the treatment for VME patients with dentoalveolar protrusion [42,43]. Kuroda et al., [42] compared the use of TAD and orthognathic surgery in the correction of skeletal anterior open bite and found that there were no significant differences in both treatments when the open bite is within 5 mm. The use of TAD to apply vertical intrusive force on maxillary or mandibular molars causes the mandible to auto-rotate in a counterclockwise direction giving the orthognathic-like outcome which is simpler, less invasive, and more practical in term of risk-benefit considerations. Regardless of the various treatment methods, the therapeutic outcomes are established based on the movements of the maxilla and mandibular anticipated, the vertical dimension desired at the end of the treatment and the relationship of upper incisors with upper lips.

**Short or hyperactive upper lip**

When attending to the neuromuscular type of gummy smile, greater attention is paid to the upper lip posture since the occurrence of gummy smile is secondary to the upper lip activity. In the absence of dentoalveolar deformity, lip mobility more than 8 mm is considered hyperactive upper lip [35]. Muscles responsible for upper lip elevation include the Levator Labii Superioris (LLS), Levator Labii Superiorioris Alaqué Nasi (LLSAN), Levator Anguli Oris (LAO), Zygomaticus Major (Zma), Zygomaticus Minor (Zmi), Depressor Septi Nasi and, risorius [44,45]. The treatment methods employed mainly focus on restricting the movement of elevator muscles, which include Botulinum toxin type A (BTX-A) injection, Hyaluronic injection, lip repositioning, myectomy, or combinations of them.

Type A Botox (BTX-A) is commonly used in clinical disorders characterized by muscle hyperactivity, such as muscle-generated dental diseases (temporomandibular disorders, bruxism, clenching, masseter hypertrophy), and in esthetic dental conditions (deep nasolabial folds, high lip line, black triangles) [46]. It has gained popularity in gummy smile correction due to its ease of application, minimally invasive, rapid effect and cost-friendly [8]. Intramuscular injection of BTX-A solution results in transient paralysis of upper lip elevator muscles, and subsequent increase in relative upper lip length [45]. Most studies have BTX-A solution injected into the LLS, LLSAN, and Zmi but in the light of the degree of deformity and disfigurement, complement applications into depressor septi nasi or other upper lip elevator muscles also enhanced the therapeutic effect [8,44]. Hwang et al., [47] proposed a safe and reproducible point, namely Yonsei Point for BTX-A injection. This point is the center of a triangle constructed by the vectors of LLS, LLSAN and Zmi muscles, whereby a single injection of BTX-A solution in this point will affect all three muscles. The transient effect will be noticeable 10 to 14 days after injection and lasted for 3 to 6 months [44,46]. Thus far, the ideal dosage for BTX-A application in gummy smile has not been reported. Some authors suggest injection of 0.25U to 2.5U per site but some reported higher dosage depending on the concentration of BTX-A solution, site of application, individual variation and susceptibility [8,44–47]. The possible localized complications are pain, edema, inflammation, hematoma at the injection site; unwanted paralysis, asymmetry, and toxin diffusion to adjacent muscles due to overdose or improper injection technique [8,46,48]. To avoid this, solution should be injected slowly, with appropriate pressure and dosage, and the use of Electromyography (EMG) guided needle to locate the injection point that are difficult to identify. This reproducible and reversible procedure is an advantage for nonsurgical intervention and can be beneficial in formulating a treatment plan, particularly in surgical cases, before undergoing a more invasive procedure [8]. However, its constant reaplication and the effects of long term use have not been adequately researched. Some patients have developed antibodies to botulinum toxin but the factors contributing to it remained unknown [48]. Recently, Diaspro et al., [49] suggested the use of hyaluronic acid as an alternative option to botulinum toxin injection. He treated 32 patients with subcutaneous injection of hyaluronic acid into the paranasal area to compress the LLSAN and stretch its fibers, thus reducing the muscle contractility. Due to the
unclear clinical indications and possible complications, its standalone application should be questioned.

On the other hand, lip positioning and myectomy provide a permanent effect. Conventionally, lip repositioning is performed by the removal of epithelial mucosa strip apical to the mucogingival junction. A new mucosal margin is established by continuous interlocking sutures forming a shallow vestibule which restrict muscle pull, thereby reducing gingival display upon smiling [50]. So far, the extent of epithelium removal is restricted within the mucogingival junction and the vermilion border [51]. The maximum excision amount reported was 10 mm to 12 mm which is two times the amount of gingival display [50,52,53]. Over time, the conventional technique has been improvised by including myotomy [54], maxillary labial frenal sparing [53], and laser surgery [51]. All these modifications were made mainly to prevent relapse. Miskinyar reported that the conventional lip repositioning was a complete disappointment and gives only a minor success rate, but did not mention why and how the relapse had occurred [55]. He then performed a reoperation by myectomy and partial resection on one or both LLS. An adequate amount of muscles (10 mm to 20 mm) must be resected to avoid the muscle fibers from regeneration and resume their normal function. Nevertheless, the use of implant spacer or by creating a physical barrier at the periosteum level after myotomy were reported to prevent muscle realignment [54,56]. Regardless of conventional or modified lip repositioning, patients recommended for this technique must have sufficient attached gingival to ensure therapeutic longevity and stability [50].

Among the three treatment modalities, BTX-A injection provides the least invasive approach, therapeutic effect that lasts for weeks to months, and requires constant reapplication to sustain the desired outcome. However, conventional lip repositioning overcomes the limitations of BTX-A through surgical approach. It provides a longer lasting effect and treatment outcome is reversible by vestibular extension procedure [53]. Myotomy and myectomy are the most aggressive treatment with high post-surgery morbidity and the outcome is irreversible.

Conclusion

The objective of this review is to provide a clinician an overview of the new possibilities in treating gummy smile. Although the treatment modality is targeted to one etiologic factor, gummy smile caused by multiple etiologies require a multidimensional and interdisciplinary approach. There are three categories of treatment modality: corrective, adjunctive and palliative. Corrective treatment usually involves surgical intervention; it tackles and resolved permanently the underlying causes. Adjunctive treatment, when gummy smile is corrected as an additional treatment to an existing defect. On the other hand, palliative treatment does not resolve the underlying causes, has a fast but transitory effect. However, due to the difficulty in finding treatments that attend to gummy smile and effectively prove the efficacy of a certain technique, clinician and patient have to be in agreement toward the treatment procedures before the initiation of active treatment.

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