Gummy Smile - Advantages and Disadvantages of Botulinum Toxin Treatment Compared to Orthognathic Surgery

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Abstract

AIM: This narrative literature review aims to evaluate the treatment of botulinum toxin compared to Le Fort I orthognathic surgery in patients with a gummy smile.
METHODS: An electronic search was conducted via PubMed/Medline and Google Scholar using keywords such as "gummy smile", "excessive gingival display", "high smile line", "botulinum toxin treatment and correction", "botox usages" and "orthognathic surgery" for studies published until January 2015. After excluding unrelated items, the initial search yielded 84 articles. Following the exclusion of irrelevant articles based on abstract and title, the full texts of 60 articles were reviewed and included in this study.
RESULTS: Botulinum toxin treatment and Le Fort I osteotomy present distinct advantages and disadvantages. Botulinum toxin serves as an adjunct for correcting excessive gingival display and is gaining popularity due to its minimally invasive nature. However, Le Fort I osteotomy remains the gold standard for correcting vertical maxillary excess in gummy smile patients.
CONCLUSIONS: Both botulinum toxin treatment and Le Fort I osteotomy are essential for correcting different types of gummy smiles. Neither can completely replace the other in the correction of gummy smiles.

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1 Introduction

The concern regarding facial aesthetics has been growing in recent years. More and more people are becoming conscious of their appearances and are willing to undergo cosmetic and surgical treatments. Facial aesthetics encompass facial symmetry and proportion in both frontal and lateral views. A perfect smile, or an aesthetic smile, plays a crucial role in forming a favorable first impression of an individual.

A smile is the result of muscle group contraction in the middle of the lower third of the face, exposing the teeth and gums. The muscles involved in this group are the Levator labii superioris alaeque nasi (LLSAN), Levator labii superioris (LLS), Levator anguli oris (LAO), Zygomaticus major (ZM), Zygomaticus minor (Zm), Orbicularis oris (OO), Depressor septi nasi (DSN), and risorius.

The key components of an aesthetic smile include the proper proportion and arrangement of the lips framework, gingival scaffold, and teeth. Lips framework is determined by the lip line, smile arc, upper lip curvature, and smile symmetry. The dental component of an aesthetic smile comprises the size, color, shape, alignment, and angulation of the tooth crowns, midline, arch symmetry, and occlusal frontal plane. The gingival component encompasses the healthy color, contour, texture, and the height of the gingiva. Additionally, the amount of buccal corridor space also affects the overall aesthetics of the smile. An increase in the buccal corridor space diminishes the aesthetic quality of the smile.

A 'gummy smile' refers to the excessive exposure of the maxillary gingiva during smiling. It is also known as excessive gingival display, gingival smile, or a high smile line. Tjan and Miller (1984) categorized 454 adults into three groups: low smile line (less than 75% of the clinical crown height of the maxillary incisors is displayed), average smile line (75-100% of the clinical crown height is displayed), and high smile line (2mm of contiguous maxillary gingiva is visible). Peck et al. (1992) found that 26% of a sample of orthodontic patients exhibited 2mm or more of gingival display during smiling. Jensen et al. (1999) divided 733 people into four group categories: very high smile line (more than 2mm of apical display or gingival margin to the cemento-enamel junction within sound periodontium), high smile line (0-2mm of marginal gingival display or gingival margin apical to the cemento-enamel junction within sound periodontium), average smile line (gingival papillae is visible), and low smile line (gingival papillae and cemento-enamel junction are not visible).

These studies are difficult to compare due to the different methods used. However, it is generally agreed that a gummy smile is characterized by a continuous band of gingival display exceeding 3mm during spontaneous smiling, while normal gingival display ranges from 1-2mm (Vig and Brundo, 1978). Another study by Kokich et al. (1999), as cited by Vig and Brundo (1978), suggests that more than 4mm of gingival display is considered unattractive by both laypersons and general dentists.

The prevalence of a gummy smile is reported as 10% in the population of adults aged 20-30 years (Peck et al., 1992). It is more common in young females, with an incidence of 14%, compared to 7% in males. The prevalence of a gummy smile tends to decrease with age due to the sagging of the upper and lower lips, which results from a decrease in turgor (Vig and Brundo, 1978).

The etiology of a gummy smile can be categorized as skeletal, dentoalveolar, gingival, and lip-related factors. Vertical maxillary excess refers to the overgrowth of the maxilla in the vertical dimension and is often associated with the long face syndrome. Over-eruption of the maxillary anterior teeth leads to a more coronal positioning of the gingival margin and excessive gingival display. This condition is typically linked with an anterior deep bite

and may involve tooth wear of the anterior teeth. Hyperplasia of the gingiva, resulting from factors like dental plaque or medications such as phenytoin, cyclosporine, and calcium channel blockers, leads to the enlargement of gingival tissues, covering the clinical crown and creating a short clinical crown with a gummy smile. Delayed passive eruption of the gingiva occurs when the gingival margin fails to recede apically to the level of the cemento-enamel junction after tooth eruption, resulting in a gummy smile. A short upper lip, as measured from subnasale to the lower border of the upper lip, can also produce a gummy smile appearance. Finally, hyperactive upper lip muscles can increase the activity during smiling and are associated with excessive gingival display.

Accurate diagnosis of the gummy smile, based on its etiology, is crucial for determining the appropriate treatment. Multiple etiologies may be present simultaneously. Treatment options include orthognathic surgery for excessive vertical excess, orthodontic mechanics with temporary anchorage devices for overbite with anterior dentoalveolar extrusion, periodontal surgery such as gingivectomy, apical repositioning flap for excessive gingival overgrowth, and delayed passive eruption of the gingiva. Surgical lip repositioning and botulinum toxin treatment are considered for short and hyperactive lips. Orthognathic surgery for vertical maxillary excess typically involves Le Fort I osteotomy. The combined procedure of Le Fort I osteotomy with orthodontic treatment for maxillary repositioning has been well-documented and found to be a stable procedure since 1974 (Willmar, 1974). More recently, botulinum toxin treatment has gained popularity as a simple non-surgical alternative. This raises the question of whether botulinum toxin can replace orthognathic surgery as a possible treatment for gummy smile patients.

2 Methods

An online literature search was conducted via PubMed/Medline and Google Scholar to identify all relevant research and studies pertaining to the correction of gummy smile using botulinum toxin and orthognathic surgery. Data were collected from the year 1951 through the most recent available data up to 2015. The following search terms were employed: 'gummy smile', 'excessive gingival display', 'high smile line', 'botulinum toxin treatment and correction', 'Botox usage', and 'orthognathic surgery.'

The search was further expanded to encompass an evaluation of the advantages and disadvantages associated with botulinum toxin and orthognathic surgery. Various keywords, including 'Le Fort I osteotomy', 'vertical maxillary excess', 'long face syndrome', 'complications', 'hyperactive upper lip', 'hypermobile lip', 'hyperfunctioning lip', 'treatment cost of Le Fort I osteotomy', 'treatment cost', 'stability', and 'aesthetic smile' were used in combination with the logical operators 'AND' and 'OR.'

Subsequently, all titles and abstracts retrieved from the PubMed database were meticulously screened and reviewed. This inclusive review process encompassed randomized control trials, cohort studies, prospective and retrospective studies, case-control studies, and in vitro studies examining the etiology, diagnosis, and treatment of gummy smile, botulinum toxin treatment for gummy smile, and Le Fort I osteotomy. It should be noted that all these studies were required to be clearly written in English, and studies published in languages other than English were excluded from this analysis.

By implementing these rigorous search and selection criteria, we aimed to ensure the inclusion of high-quality research and studies that could provide valuable insights into the correction of gummy smile through botulinum toxin and orthognathic surgery, as well as

the associated advantages and disadvantages. This method allowed us to comprehensively assess the available literature on this topic.

2.1 Statistics

Descriptive statistics, frequency analysis and content analysis as a qualitative method for systematically analyzing the textual content of the included studies were used. Due to the narrative nature of this work regression or meta analysis were not applied.

3 Results

A total of 303 articles were initially identified and examined, of which 84 were deemed relevant and subsequently included for full text analysis. Following the exclusion of unrelated articles, a total of 60 studies remained for detailed analysis (see Figure 1).

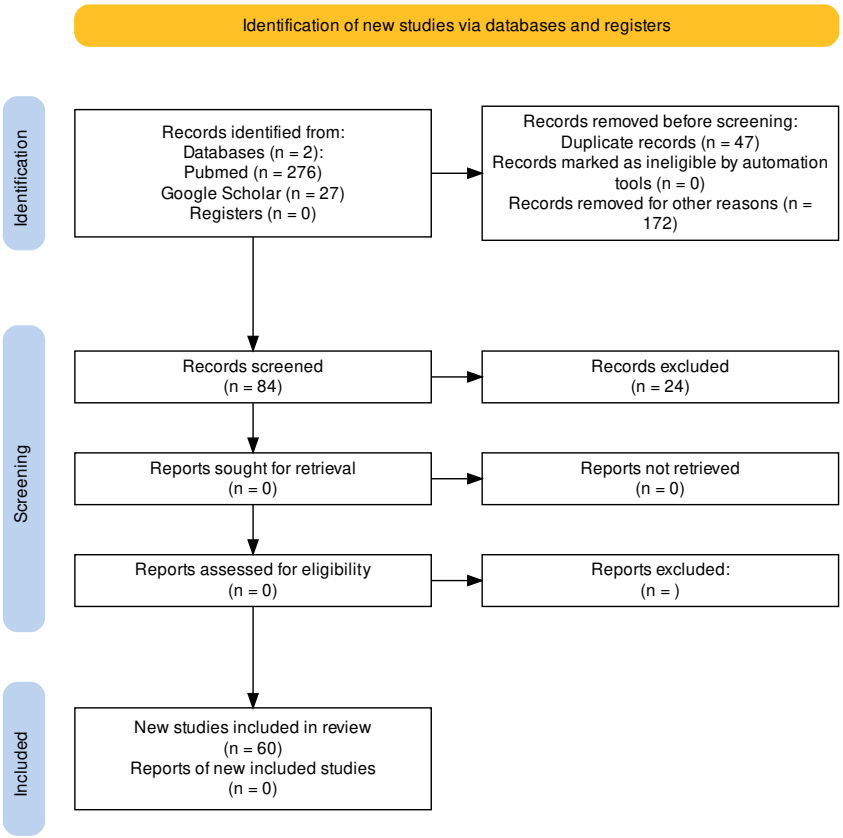

Figure 1. Flow diagramm of selection process.

3.1 Smile

A smile is a facial expression that conveys joy and happiness. It typically involves a noticeable gleam in the eyes, an upward curvature at the corners of the lips, is typically not accompanied by sound emission, and exhibits less muscular distortion compared to laughter. The smile typically initiates at the commissure (the corner of the mouth) and extends laterally. The lips remain in contact, except in cases where individuals lack passive lip seal

or possess a shorter upper lip. As the smile expands, the lips move upward with curvature at the commissures, leading to the exposure of teeth. During this process, the jaws separate, creating a negative space, often characterized as the dark area between the upper and lower teeth.

Moreover, during a smile, the height of the upper lip decreases, while the width of the mouth increases by approximately 23% to 28% when compared to the relaxed, non-smiling position.

3.1.1 Smile formation

Smile formation comprises two distinct stages. The first stage, often referred to as the 'voluntary' or 'posed smile', involves the elevation of the upper lip to the nasolabial fold through the contraction of the levator muscles (Oliveira et al., 2013). The contraction of the medial muscle group raises the lip in the region of the anterior teeth, while the lateral muscle group elevates the lips in the vicinity of the posterior teeth. This action encounters resistance from the nasolabial fold, primarily due to the presence of cheek fat. The posed smile is highly reproducible and frequently serves as a reference position in orthodontic photography.

The second stage, known as the 'spontaneous smile' or 'unposed smile,' commences with a greater elevation of both the upper lip and the nasolabial groove. This elevation is brought about by the contraction of three muscle groups: the elevator of the upper lip, originating from the infraorbital area; the zygomatic major muscle; and the upper fibers of the buccinator muscle.

As the smile progresses to its final stage, the appearance of 'squinting' occurs as a result of the periocular muscle contracting to support maximal upper lip elevation through the fold. The association of eye squinting with the smile serves as a muscular cue on the face, activating centers in the anterior temporal area of the brain responsible for regulating the experience of positive emotions. Consequently, the final action of eye squinting serves as a diagnostic marker for the unposed smile (Peck et al., 1992).

3.1.2 Types of smile

According to Ruben (1974) as cited by Kane (2003) the smile can be classified into three distinct types (a) the 'Mona Lisa' smile (b) the canine smile and (c) the full denture smile. The 'Mona Lisa' smile is characterized by a wide grin with sharp elevations at the corners of the mouth, primarily attributed to the action of the ZM muscle. In contrast, the canine smile involves a pronounced elevation of the upper lip at the midline, largely driven by excessive contraction of the LLSAN muscle. Finally, the full denture smile is a substantial smile that exposes both upper and lower teeth, resulting from the coordinated contraction of the upper lip elevators and lower lip depressors muscles (Kane, 2003).

During a smile, the upper lip is elevated by approximately 80% of its original length, revealing approximately 10 mm of the upper incisors (Jorgen et al., 1999). Furthermore, it has been observed that women tend to exhibit 3.5% more lip elevation than men. On average, individuals experience a 7-8 mm upper lip elevation from the rest position to a full smile, with a variable range of 2-12 mm (Jorgen et al., 1999).

A gummy smile, also referred to as excessive gingival display, gingival smile, high smile line, full denture smile, and short upper lip, is characterized by the excessive exposure of maxillary gingival tissue during smiling. For the purpose of a precise definition, it is agreeable to classify a gummy smile as occurring when 3 mm or more of maxillary gingival

tissue is exposed during spontaneous smiling, as described by Garber and Salama (1996) and Allen (1988) as cited by Garber and Salama (1996).

In recent years, gummy smiles have gained increased attention from the dental community due to a heightened awareness among patients concerning aesthetic concerns. It is worth noting that the majority of individuals perceive a gummy smile as unattractive. According to Husley, the ideal smile line is defined by the gingival margin of the upper incisors. The normal range for gingival display is typically 1-2 mm (Peck et al., 1992; Tjan and Miller 1984).

3.1.3 Types of gummy smile

Recently, gummy smile were classified to 4 different types according to excessive gingival display areas by Muzzuco and Haxsel (2010). The classification based on the areas are the result from excessive contraction of different group muscles involve in smiling.

1. Anterior gummy smile: More than 3mm of excessive gingival display in the gingival area between maxillary canine teeth. Muscle of action- Levator labii superioris alaeque nasi (LLSAN).

2. Posterior gummy smile: More than 3mm of excessive gingival display in the gingival area posterior to maxillary canine teeth but normal gingival display (less than 3mm) in anterior area. Muscle of action- Zygomaticus minor and major muscles.

3. Mixed gummy smile: More than 3mm of excessive gingival display in both anterior and posterior area. Muscle of action – combination of both group of muscles (all the muscles of smiling).

4. Asymmetric gummy smile: More than 3mm of excessive gingival display on either one side. Muscle of action – asymmetric contraction of either LLSAN or Zygomaticus muscles.

3.1.4 Aetiology of the gummy smile

Females have a higher prevalence rate than males. Low smile lines were predominantly observed in males, with a ratio of 2.5 to 1, while high smile lines were more common in females, with a ratio of 2 to 1 (Tjan and Miller 1984). In spontaneous smiling, females exhibited a 1.5 mm greater upper lip line in a superior position compared to males (Peck et al., 1992). In the same study, males were found to have a longer upper lip than females, with a mean difference of 2.2 mm, and there was a 2.2 mm mean increase in vertical maxillary height in males compared to females. Patients with a gummy smile also demonstrated a minimum of 20% greater facial muscular capacity to lift the upper lip when smiling than individuals with a normal smile (Peck et al., 1992).

This is supported by Diamond (1996) as cited by Tjan and Miller (1984), where young females reported a higher prevalence of 14% compared to young males, who reported 7%. Similar findings were also reported in other studies by Vig and Brundo (1978). Females are twice as likely as men to display their maxillary anterior teeth.

The etiology of a gummy smile can be divided and classified into skeletal, dental, periodontal, and soft tissue (muscular) origins (Figure 2).

Vertical maxillary excess (VME) Vertical maxillary excess (VME) is characterized by the overgrowth of the maxilla in the vertical dimension. This condition is a typical presentation of long face syndrome, as described by Willmar in 1974. The key features of vertical maxillary excess include an increased lower facial height, incompetent lips with an increased interlabial gap, an increased incisor show at rest, a convex profile, and a high mandibular plane angle. In VME patients, the occlusal plane is situated lower than in

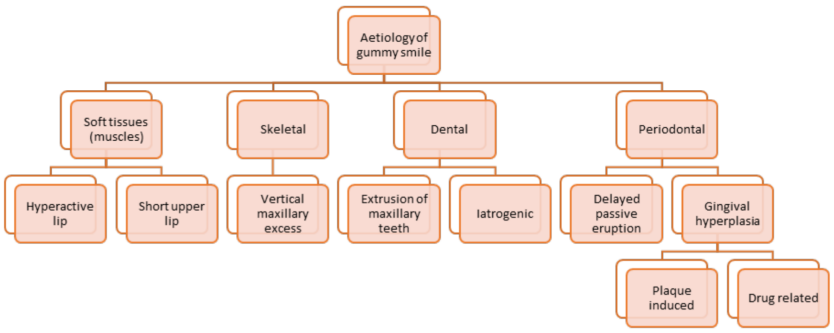

Figure 2. Aetiologies of the gummy smile.

normal individuals, resulting in a gummy smile. The distance between the palatal plane and the incisor edge of the maxillary teeth is typically 2 mm greater in VME patients compared to those with a gummy smile. While the upper lip's length is usually within the normal range, it may appear relatively short in individuals with VME. Garber and Salama (1996) proposed a classification system for VME, dividing it into three categories based on the amount of gingival exposure and treatment modalities (see Table 1).

Table 1. Vertical maxillary excess classification and treatment modalities based on Garber and Salama (1996). Gummy smile = amount of gingival display.

Degree	Gummy smile	Treatment
I	2-4 mm	(a) Orthodontic intrusion. (b) (a) + periodontal treatment. (c) (b) + restorative treatment (c)
II	4-8 mm	(d) Orthognathic surgery. Depeending on root/bone/crown relation.
III	More or equal to 8 mm	(d) + (a-c)

Anterior dentoalveolar extrusion The extrusion or over-eruption of upper incisors leads to the downward movement of the dentoalveolar complex. This results in increased exposure of the maxillary gingiva, which contributes to a gummy smile. Additionally, tooth wear and the development of an anterior deep bite on the upper anterior teeth may occur. When a deep bite is present, there is typically a step or discrepancy in the occlusal plane. This phenomenon is commonly observed in Class II division 2 malocclusions.

Delayed passive eruption Delayed passive eruption (DPE), also referred to as altered passive eruption, describes a condition where, under normal circumstances, the gingival margin would recede apically to the level of the cemento-enamel junction (CEJ) following the completion of tooth eruption (Table 2). However, in cases of DPE, the gingival margin fails to recede apically. Consequently, the affected teeth appear shorter and squarer, with the gingiva positioned more coronally to the CEJ. Patients with DPE exhibit a gummier appearance. DPE can affect multiple or single teeth, with a prevalence of 12% within the population. Given that DPE is a physiologic condition, it is essential to make a careful

diagnosis, as the gingiva continues to erupt into the third decade of life.

Table 2. Treatment of gummy smile for delayed passive eruption (DPE) or Vertical maxillary excess (VME) as cited by Garber and Salama (1996).

Condition	Treatment options
DPE type 1-A	Gingivectomy
DPE type 1- B	Flap with osseous resection
VME - degree 1	Orthodontic treatment
	Orthodontic and periodontal treatment
	Periodontal treatment
VME - degree 2	Periodontal and restorative treatment
	Periodontal and restorative treatment
	Orthognathic surgery
VME - degree 3	Orthognathic surgery and periodontal and restorative treatment

Gingival Hyperplasia Gingival hyperplasia is the enlargement of gingival tissue due to the presence of inflammation caused by dental plaque and medications such as phenytoin, cyclosporine, and calcium channel blockers. Severe enlargement of the gingiva can result in the appearance of a gummy smile in patients, and the clinical crowns may appear shorter.

Hyperactive Lip Hyperactive lip, also referred to as a hypermobile lip or hyperfunctioning lip, is characterized by increased activity of the elevator muscles of the upper lip during smiling, which leads to a gummy smile. Normally, the upper lip translates 6-8mm from repose to spontaneous smile. A study conducted by Peck et al. (1992) demonstrated that individuals with a high lip line raise the upper lip by 1mm more than normal or 20% more than the control group during smiling.

Short Upper Lip The length of the upper lip is measured from the subnasale to the inferior border of the upper lip. In young adults, the normal lip length ranges from 20-24 mm. Females typically have a range of 20-22 mm, while males range from 22-24 mm (Robbins, 1999). A short upper lip in relation to commissure height results in an unaesthetic lip appearance and a reverse resting upper lip line.

Iatrogenic Factors Iatrogenic factors, such as upper incisor torque loss, especially in Class II Division I cases and other orthodontic retraction with poor torque control, can lead to a gummy smile. Canting of the occlusal plane due to the excessive and improper use of elastics may also result in an asymmetrical gummy smile. Furthermore, when diagnosing a gummy smile, care must be taken, as a combination of etiological factors may be present, such as patients with vertical maxillary excess (VME) who also have dentoalveolar protrusion (DPE).

3.1.5 Diagnosis of Gummy Smile

The first step in establishing a correct diagnosis of a gummy smile involves classifying the gingival level and considering variables such as gender, age, and periodontal health. Sub-

sequently, the etiology of the gummy smile is determined. Typically, this condition arises from a multifactorial interaction, characterized by excessive vertical maxillary growth, a short upper lip, maxillary teeth extrusion, excessive contraction of the upper lip, and disproportionate crown length and width of anterior teeth, which are commonly associated with excessive gingival display and hyperplasia or passive eruption.

The diagnostic process typically encompasses clinical examination, smile assessment through photography, cast model analysis, and radiographic examination, including lateral cephalometry. The extraoral examination of the facial profile from both frontal and lateral perspectives plays a crucial role in assessing the harmony among the face, lips, and teeth during rest, unposed, and posed smiles. Subsequently, intraoral examination involves the evaluation of clinical crown height, the presence of attrition, gingival status, and occlusion.

Photographic examination is crucial for assessing gingival visibility during natural and forced smiles. Patients often exhibit a cautious reaction in their natural smile, whereas forced smiling, which involves maximum lip contraction, can lead to a less aesthetically pleasing display of the gingiva. The use of filming is recommended, along with intensive and insightful observation of the patient's expressions during the initial consultation. A comprehensive evaluation of both natural and forced smiles is essential to determine the position of the smile line.

Step-by-Step Evaluation of a Gummy Smile The correct diagnosis and subsequent treatment of a gummy smile are contingent upon understanding its etiology and classification (Oliveira et al., 2013). To identify the etiologies of a gummy smile, a comprehensive smile evaluation and other clinical assessments are essential.

1. Evaluate the presence of a gummy smile, which includes an assessment of the upper lip smile line, the length of the upper lip in the resting position, the distance from the upper lip to the upper incisor edge in the resting position, the relationship between the upper lip and upper incisor edge during smiling, and the measurement of interlabial gaps. Interlabial gaps pertain to the vertical midline opening observed between the relaxed upper and lower lips with the mandible in the resting position.

2. Examine the occlusion, with a specific focus on the presence of an overbite, as well as characteristics related to the occlusal plane, including canting, the presence of a reverse curve of Spee, and the evaluation of the curve of Spee.

3. Assess the dimensions of the teeth, emphasizing crown width and height, and determine whether they exhibit normal dimensions or show signs of attrition. Additionally, evaluate gingival status, which encompasses the assessment of overall health or the presence of hyperplasia, along with the level of the cementoenamel junction (CEJ).

4. Conduct a skeletal or bone structure assessment through cephalometric analysis, specifically to evaluate vertical maxillary excess.

5. Perform muscle analysis, which involves checking for a short upper lip from a lateral view or photo, as well as evaluating muscle tone from a direct front view when the patient is at rest and smiling (indicative of a hyperactive lip).

Diagnosis of Hyperactive Lip Etiology The following criteria are assessed to determine the diagnosis of a gummy smile due to a hyperactive lip.

1. The presence of a gummy smile exceeding 3mm during both posed and unposed smiles.

2. Upper lip length may be normal or short.

3. Upper lip to upper incisor edge at rest position falls within the normal range of 3-4 mm for females and 2 mm for males (Vig and Brundo, 1978).

4. Clinical crowns exhibit a normal proportion.

5. Gingival condition is within the normal range.
6. Lower face height, as determined from cephalometric studies, is normal.
7. The occlusal plane is normal and typically lacks overbite.
8. Muscle tone of the upper lip is hyperactive during smiling.

Diagnosis of Vertical Maxillary Excess Etiology The following criteria are assessed to determine the diagnosis of a gummy smile due to vertical maxillary excess.

1. The presence of a gummy smile exceeding 3mm during both posed and unposed smiles.
2. Upper lip length is typically normal or slightly longer.
3. Upper lip to upper incisor edge at rest position displays more than 3-4mm of incisor exposure in females and 2 mm in males.
4. Clinical crowns exhibit a normal proportion.
5. Gingival condition is within the normal range.
6. Lower face height, as determined from cephalometric studies, is increased.
7. The occlusal plane is normal and typically includes overbite.
8. Muscle tone of the upper lip is normal during smiling.

Treatment of Gummy Smile The treatment of a gummy smile involves several approaches depending on its etiology (Figure 3).

1. Orthognathic Surgery: Le Fort I osteotomy is employed to correct gummy smiles of skeletal origin. This surgical procedure repositions the maxilla to achieve the desired aesthetic outcome.
2. Orthodontic Interventions: Orthodontic mechanics, often in combination with Temporary Anchorage Devices (TADs), are utilized to address cases with overbite issues, involving extrusion of the upper anterior teeth. This approach helps in achieving the desired dental alignment.
3. Periodontal Surgery: Periodontal surgical techniques, such as gingivectomy and apically repositioned flap procedures, are employed to remove excessive gingival tissue and reshape the underlying bone volume. These surgeries aim to enhance the harmony of the gingival display.
4. Muscular Tissue Surgery: For cases characterized by a short upper lip and hyperactive lip, surgical procedures targeting the muscular tissue are undertaken. These interventions can help adjust lip length and muscle tone to achieve a balanced smile.
5. Botulinum Toxin (Botox) Treatment: In cases involving hyperactivity of the elevator muscles of the upper lip, Botox injections may be considered as a non-surgical alternative. Botox can temporarily relax the hyperactive muscles, reducing excessive gingival display.

The choice of treatment method is contingent on the specific etiology of the gummy smile and should be determined through careful evaluation and diagnosis.

3.2 Botulinum toxin treatment

The term 'Botulinum' finds its origin in the Latin word 'botulus', meaning sausage. It was initially coined 'botulism' following a notorious incident of sausage poisoning, which resulted from the consumption of poorly prepared blood sausage. The earliest documented observations and descriptions of botulism were made by Justinus Kerner, a renowned figure from 1786 to 1862 (25. Yiannakopoulou, 2015). Subsequently, Professor Emile van Ermengem

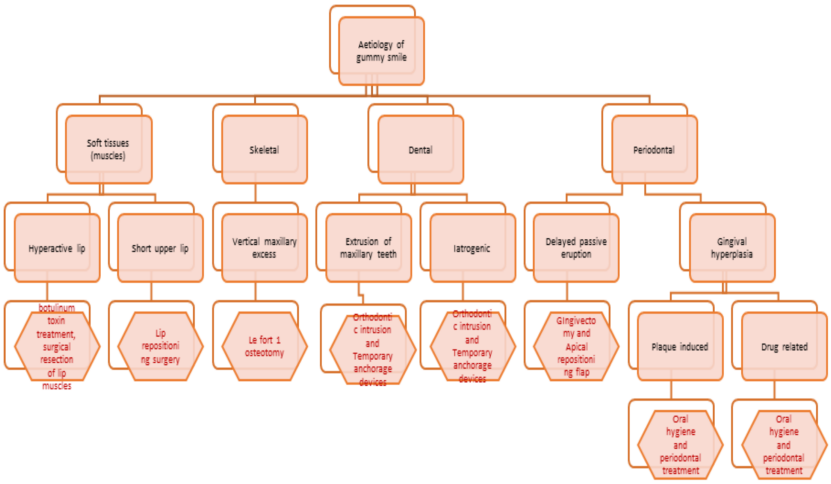

Figure 3. Summary chart of gummy smile etiology-based treatments.

identified the bacterium Clostridium botulinum and developed an antiserum for botulism in Belgium in 1897 (Yiannakopoulou, 2015). The first clinical trials involving humans were conducted by Dr. Alan Scott, an ophthalmologist at the Smith-Kettlewell Eye Research Foundation, in 1978. Dr. Michael Kane, a plastic surgeon, began employing Botulinum toxin injections for gummy smile correction in 1992 (Kane, 2003), while Dr. Niamtu adopted this technique in 1999. Notably, Mario Polo significantly contributed to the widespread use of Botulinum toxin for gummy smile treatment starting in 2005 (Polo, 2008).

Botulinum toxin is a protein and neurotoxin produced by the anaerobic, spore-forming bacterium Clostridium botulinum. These spores are heat-resistant and can germinate under conditions of low acidity, an absence of oxygen, and in liquid media, as often found in certain foods. Upon ingestion, the toxin is absorbed through the gastrointestinal tract and enters the systemic circulation (Patel et al., 2013).

There are seven recognized serotypes of botulinum neurotoxin (A, B, C1, D, E, F, and G) (Polo, 2005). More recently, an eighth serotype has been identified. Despite its lethality, botulinum toxin is harnessed as an effective and potent therapeutic agent. Commercially, there are three types of botulinum toxin type A (Botox, Dysport, and Xeomin) and one type of botulinum toxin type B (MyoBloc) available in the market for both cosmetic and medical applications (Nayyar et al., 2014). Botulinum toxin type A is the most potent and is commonly employed in clinical practice for gummy smile correction. It is now referred to as Onabotulinumtoxin A.

3.2.1 Mechanism of Action of Botulinum Toxin

Botulinum toxin inhibits the transmission of nerve impulses to the targeted muscle by selectively preventing the release of the neurotransmitter acetylcholine (ACh) at the neuromuscular junction of motor or sympathetic nerves. This temporary inhibition of muscle contraction can also prevent the release of pain-stimulating neuropeptides in peripheral nerves. It is important to note that once botulinum toxin is administered, its paralytic effects are irreversible. Various approaches, such as active and passive immunization, can be employed to neutralize toxin circulation; however, antibodies cannot penetrate nerves to counteract internalized toxin. Recovery from botulinum toxin effects occurs spontaneously.

Phase 1 Action

1. **Binding:** The heavy chain of Botulinum toxin type-A binds to the cell membrane of the motor nerve, facilitating efficient uptake. This high-affinity binding action ensures selective and targeted treatment at the injection site.

2. **Internalization:** Following binding, the Botulinum toxin type-A protein molecule enters the motor nerve's cytoplasm through a process known as endocytosis. This leads to the activation of the enzymatic component (light chain) of the BOTOX protein molecule.

3. **Blocking:** The light chain of the Botulinum toxin type-A protein molecule cleaves the SNAP25 protein, preventing vesicles from fusing with the membrane and releasing acetylcholine into the neuromuscular junction. This blockage of nerve impulses results in reduced muscle activity. Cleaving of SNAP25 also hinders the release of neuropeptides responsible for transmitting painful sensations, including substance P, glutamate, and calcitonin gene-related peptide (CGRP), leading to decreased pain sensitization in peripheral nerves.

Phase II Action

1. **Nerve Sprouting:** New nerve endings begin to sprout and reconnect to the muscle after approximately 3 to 4 weeks following a single injection of Botulinum toxin type-A. This renewal of nerve connections restores the ability of the nerve to initiate muscle contractions.

2. **Re-establishment of Original Nerve Connection:** Ultimately, the new nerve sprouts retract, and the original nerve endings regain their normal function, resulting in the restoration of muscle function (Kanhu et al., 2012).

3.2.2 Indications

Botulinum toxin has been employed to treat excessive muscle contraction associated with various conditions since 1970. It has demonstrated efficacy in addressing strabismus, cervical dystonia, blepharospasm, hemifacial spasm, hyperfunctional larynx, juvenile cerebral palsy spasticity, pain and headache, occupational dystonia, and writer's cramp. The Food and Drug Administration (FDA) has approved Botox as a safe and effective therapy for these indications. Since 1987, it has also found widespread use in cosmetic treatments for hyperactive facial lines. In 1990, the National Institutes of Health Consensus Conference further recognized botulinum toxin as a safe and effective therapy for various unlabelled uses (Yiannakopoulou, 2015; Nayyar et al., 2014).

In the field of dentistry, recent suggestions for use encompass temporomandibular disorders, masseteric hypertrophy, hemifacial spasm, gummy smile correction, myofacial pain, bruxism, trismus, sialorrhea, retraining muscles during orthodontic therapy for patients with robust musculature, aiding patients in adapting to new dentures, especially for individuals with irregular muscle contractions due to prolonged edentulism and old dentures. Additionally, botulinum toxin is utilized for jawline recontouring, involving the injection of the masseter muscle to weaken it and reduce muscle bulk, resulting in a more tapered jawline (Nayyar et al., 2014).

Indications of Botulinum Toxin for Gummy Smile Correction Botulinum toxin is employed for the correction of gummy smiles, particularly in cases of hyperactive lip and short upper lip. This treatment is suitable for patients undergoing orthodontic treatment or those who decline orthodontic intervention but desire gummy smile correction. Mario Polo introduced the injection of Botox into the levator muscles of the upper lip during smiling to address excessive gingival display (Polo, 2005). Subsequently, Hwang et al. (2008) proposed an injection point for botulinum toxin-A to correct gummy smiles (Hwang et al., 2009).

In summary, botulinum toxin treatment is a viable option for correcting gummy smiles in patients who wish to mask excessive gingival display, especially if they are reluctant to undergo orthognathic surgery and prefer temporary correction before making a decision about surgical intervention to impact the maxilla. It is also effective in the treatment of iatrogenic gummy smiles caused by excessive detorquing and extrusion of upper incisors.

Hyperactive Lip Hyperactive, hyperfunctional, or hypertonic muscles exhibit excessive activity, with a contractile potential exceeding the norm. Hyperactive upper lips are typically characterized by a lack of vertical dimension and reduced upper lip length at the philtrum. The posture of the lips and the shape of the mouth are governed by a complex three-dimensional arrangement of muscular slips. While most attribute gummy smiles to excessive exposure of the anterior gingiva due to contraction of the levator labii superioris alaeque nasi (LLSAN) muscle, it's important to recognize that all muscles involved in elevating the upper lip play a role in gingival display during smiling. These muscles include LLSAN, levator labii superioris (LLS), zygomaticus major (ZM), zygomaticus minor (Zm), levator anguli oris (LAO), orbicularis oris (OO), and risorius muscles (Polo, 2005).

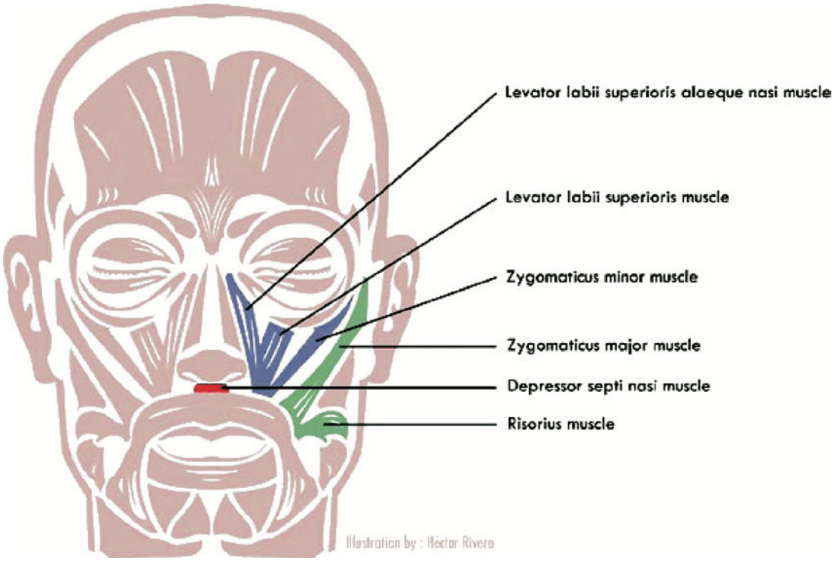

Figure 4. All muscles involved in smiling. Source: Polo (2008).

3.2.3 Clinical application

Botulinum toxin is supplied in a vacuum powder form that tends to clump at the bottom of the vial. Before using a needle syringe for reconstitution, it is essential to wipe the rubber seal on the vial with an alcohol swab (Kanhu, 2012). Typically, a 1.0 mL tuberculin syringe

is preferred for reconstitution, and the needle gauge used for injection falls within the range of 26 to 30 (Kanhu, 2012). During reconstitution, it is advisable to inject the diluent slowly into the vial while gently rotating it to aid reconstitution. It is crucial to avoid agitating the solution during transport, as this can denature the toxin and reduce its duration of action.

Reconstituted botulinum toxin should be administered within four hours. During this period, it should be stored in a refrigerator (2° to 8°C) and should remain clear, colorless, and free of particulate matter (Kanhu, 2012). Skin preparation involves using alcohol wipes and then drying with sterile gauze sponges. Before injection, it is recommended to aspirate to prevent toxin deposition into the facial arteries. Botulinum toxin provides immediate results in a single appointment. All injections are intramuscular, and local anesthesia is typically not used, although topical local anesthesia can be considered to alleviate injection pain if necessary.

A safe and reproducible injection technique for Botulinum toxin A, targeting the convergence area of three muscles, has been proposed and demonstrated to be effective in clinical practice. Proper training is essential for dentists to perform these injections. The results achieved with Botulinum Toxin A are close to immediate, but they are not permanent and generally last for approximately 6 months, with a range of 4 to 8 months. Botulinum Toxin typically requires re-administration 2-3 times a year, depending on the decline in its effects. A follow-up visit at 1-2 weeks post-injection is necessary to evaluate the effectiveness of the treatment. The therapeutic effects of Botulinum toxin A become noticeable within 1 to 3 days, peak at 1 to 4 weeks, and diminish after 3 to 4 months. To minimize the risk of antibody formation against the protein, which would impede the effectiveness of botulinum toxin in subsequent treatments, repeated injections should be administered with a minimum interval of three months (Nayyar et al., 2014). Hands-on training is crucial to master the proper administration techniques.

3.2.4 Site of injection and dosage

The injection sites were determined by muscle animation during smiling and also by palpation of muscle contraction to locate the precise muscle location. Multiple studies have shown different dosage and almost similar injection site targeting LLSAN, LLS and Zm muscles. The botulinum toxin action spreads in a halo of 1-2cm around the injection point. The dilution and the depth of injection determined the diameter of halo.

There are two groups of authors suggesting different dosage of botulinum toxin for gummy smile correction. The first group suggested multiple injection sites to each muscle animation in smiling and the dosage are high around 4-12 U. Then the second group only targeted one injection site which the estimated area of overlapping of muscles animation in smiling and the dosage is usually small around 1.95- 3U. The two groups are show below.

Multiple injection sites The concept of multiple injection sites with varying dosages of botulinum toxin was first introduced by Polo (2005). In his study, five women with excessive gingival display received injections at three different sites, with each site receiving 1.25 U of botulinum toxin. The injection sites included both right and left LLSAN muscles, LLS muscles, and the overlapping areas of the LLS and Zm muscles. These injections were repeated in a second phase of the study one month later, with 0.625 U administered at LLS/Zm and 1.25 U or 0.625 U at LLS, followed by a 2.5 U injection in a third phase. Additionally, those who exhibited the greatest amount of elevation near the philtrum received injections at the origin of the depressor septi nasi muscle near the orbicularis oris muscle, positioned 2-3 mm

inferior to the nostrils and 2-3 mm from the midline at each phase of the study.

Mazzuco and Hexsel (2010) proposed a classification of gummy smiles into anterior, posterior, mixed, and asymmetric types, and tailored the dosage of botulinum toxin according to the specific gummy smile type. Abobotulinumtoxin A (Dysport) was used in place of Botox. For the anterior gummy smile type, 2.5 or 5 U of botulinum toxin were administered, depending on the degree of gingival exposure, at 1 cm lateral and below the nasal ala to relax the LLSAN muscle. In cases of posterior gummy smile, 2.5 U were injected at each point along the nasolabial fold where the most lateral contraction occurred during smiling, and 2 cm lateral to the first point at the level of the tragus. In the case of the mixed gummy smile type, three injection points, similar to those for anterior and posterior gummy smile types, were used, but the dosage was reduced to 50% at the point near the nasal ala.

Suber et al. (2014) injected 4-6 U of onabotulinumtoxin A into three sites targeting the LLS and LLSAN muscles. The superficial facial landmarks used for the injection sites included positions 2 mm lateral to the alar-facial groove at the level of the nasal passage, 2 mm lateral to the first injection site in the same horizontal plane, and the last injection site positioned 2 mm inferior and between the first two sites, forming an inverted triangle.

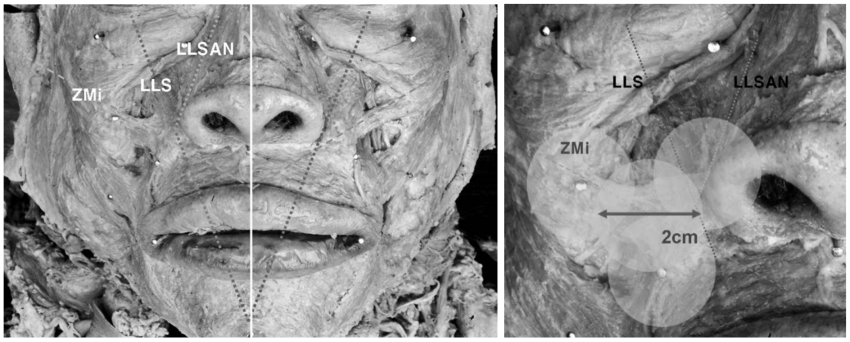

Figure 5. Left: Dissected specimen with vectors indicating the direction of the muscle fibers. Right: Circles with a 1 cm radius (2 cm diameter) have been drawn on each photograph to illustrate the effective range of botulinum toxin. Source: Hwang et al. (2009).

Single injection site In 2008, Mario Polo recommended injecting 2.5 U of botulinum toxin A into both sides of the levator labii superioris alaeque nasi (LLSAN), levator labii superioris (LLS), and the overlap area between LLS and zygomaticus minor (Zm) muscles, totaling 5 U per side (Polo, 2008).

In another study conducted by Hwang et al. in 2009, a single injection point for botulinum toxin was proposed, known as the 'Yonsei point'. This point is situated at the center of the triangle formed by the LLS, LLSAN, and Zm muscles. A recommended dosage of 3 U was suggested for each injection at the Yonsei point. The horizontal distance from the ala to the Yonsei point was found to be 10.4 mm for males and 10.3 mm for females, while the vertical distance from the lip line to the Yonsei point was measured at 32.3 mm for males and 31.5 mm for females, based on dissection results from 50 cadavers. This approach contrasts with previous studies that recommended multiple injections into each of the levator muscles involved in smiling (Hwang et al., 2009).

Sucupira et al. in 2012 employed onabotulinum toxin A, using 1.95 U per side, with injection points positioned 3 to 5 mm lateral to each nostril. The injections targeted the

levator labii superioris alaeque nasi muscle and were administered independently of the type of smile (Sucupira et al., 2012).

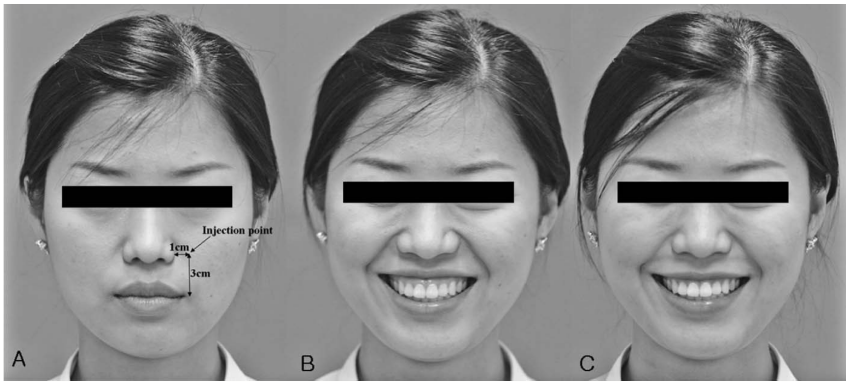

Figure 6. Injection points for the facial muscels including the levator labii superioris alaeque nasi and the levator labii superioris. Images illustrating before and after injection. Source: Hwang et al. (2009).

3.2.5 Results and Maintenance

In a study conducted by Polo in 2005, results were observed 14 days after injection, with an average decrease of 4.2 mm in gingival exposure during an unposed smile (Polo, 2005). Improvement in gummy smile was noticeable approximately 10 days after injection, and there was an increase in lip length to a mean of 124.5%. This effect was reversible and typically lasted for 3 to 6 months. Importantly, all patients reported satisfaction with the results, and no side effects were reported or observed (Polo, 2005).

Subsequently, in 2007, Polo reported an average lip drop of 5.1 mm at 2 weeks post-injection. Gingival display gradually increased from 2 weeks to 24 weeks. It was observed that gingival display did not return to the baseline value until 30-32 weeks post-injection (Polo, 2008).

Hwang documented a 3 mm reduction in gingival display, decreasing from 5 mm, just one week after injection, in a case study (Hwang et al., 2009). Mazzuco and Hexsel reported a significant reduction of about 75.09% in the degree of gingival display. The duration of action of abobotulinumtoxin A was found to be 3 to 5 months (Mazzuco and Hexsel, 2010).

Suber's study showed an average reduction of 4.14 mm over the central incisors and 3.51 mm over the canines for the correction of gingival display. The baseline gingival display ranged from 3-7 mm at incisors and 1-5 mm at canines (Suber et al., 2014).

In a further study the average gingival display was 3.62 mm before treatment, which was reduced to 0.58 mm after treatment with botulinum toxin A (Sucupira and Abramovitz 2012). Patients with gummy smiles reported a change in smiling within a range of 1 to 7 days, with a mean of 2.5 days (Polo, 2008).

All these studies consistently demonstrated a significant reduction in gingival display with botulinum toxin treatment, with the maximum effect observed at 2 weeks post-injection (Table 3). The effect of botulinum toxin typically lasted for at least 3 months and, in some cases, up to a maximum of 32 weeks before returning to the baseline level of gummy smile.

Adverse effect The botulinum toxin treatment was well tolerated, and the adverse effects were of limited duration, with localized action.

Table 3. Dose and effect of botulinum toxin application for reduction of gummy smiles. LLSAN = Levator labii superioris alaeque nasi. LLS = Levator labii superioris. Zm = Zygomaticus minor. n.s. = not specified. Dosage in units. GD = Gingival display (rounded) in [mm]. GR = Reduction in gingival display (rounded) in [mm]. T = Duration of action in [month].

Author	Dosage	Site	GD	GR	T	Side effect
Polo, 2005	9.0 - 11.8	LLSAN, LLS	5	4	3 - 6	Pain
Mazzuco, 2010	2.5 - 7.5	n.s.	n.s.	n.s.	3 - 5	Asym. smile
Suber, 2014	4.0 - 6.0	LLSAN, LLS	3 - 7	4	3	n.s.
Polo, 2007	5.0	LLSAN, LLS, Zm	5.2	5	7	Pain
Hwang, 2008	3.0	Yonsei point	5	3	5	n.s.
Sucupira, 2012	2.0	LLSAN	3.6	3	3	No side effect

1. Common occurrences with any percutaneous injection include mild stinging, burning, or pain at the injection site, edema around the injection site, erythema around the injection site, and mild headaches.

2. Excessive paralysis of the muscles surrounding the injection site of botulinum toxin can lead to adverse effects, such as an asymmetric smile and difficulties in smiling, moving the lips when speaking or eating. These adverse effects are mostly technique-dependent and vary with the clinician. A sad smile may result from the lowering of the angles of the mouth, caused by the hyperactivity of the depressor anguli oris muscles. This can be easily treated with the injection of botulinum toxin into these muscles (as shown in the photograph below) (18).

3. Rarely, numbness, paresthesia, focal tonic movements (twitching), mild nausea, occasional vomiting, mild malaise, and myalgias may occur.

4. Adverse effects of longer duration that can be serious and are not technique-dependent include immediate hypersensitivity reactions, urticaria, dyspnea, soft tissue edema, and anaphylaxis.

Contraindication Caution should be taken in the following circumstances.

1. Pregnancy or breastfeeding.

2. Presence of inflammation or infection at the site of the proposed injection.

3. Hypersensitivity or allergies to any component of botulinum toxin, such as human albumin, Botox toxin, lactose, or saline solution.

4. Motor neuropathy and neuromuscular disorders, including amyotrophic lateral sclerosis, myasthenia gravis, Lambert-Eaton Syndrome, muscular dystrophy, and multiple sclerosis.

5. Usage of aminoglycoside antibiotics (aminoglycosides may interfere with neuromuscular transmission and potentiate the effect of botulinum toxin).

6. Users of calcium channel blockers, penicillamine, and quinine (Kanhu et al., 2012; Nayyar et al., 2014).

3.3 Orthognathic surgery – Le Fort I Osteotomy

Orthognathic surgery is defined as the surgical repositioning of the dentoalveolar segments of the maxilla and mandible. Orthognathic surgery patients typically cannot be ideally treated with orthodontic therapy alone, as they present with malocclusions resulting from skeletal discrepancies secondary to congenital anomalies or trauma. Orthognathic surgery primarily involves the basal bone and is limited to the alveolar bone (Bell, 1975).

Le Fort I osteotomy is a surgical technique within orthognathic surgery used to address vertical maxillary excess. This technique is employed to treat patients with a long face by repositioning the maxillary segment upward following an osteotomy (Bell and McBride, 1977).

The orthognathic surgery of the maxilla was first introduced by von Langenbeck in 1859 for the removal of nasopharyngeal polyps (Bauer and Ochs, 2014). Subsequently, in 1901, the French physician Rene Le Fort introduced classifications for midface fractures (Cortese, 2012).

In 1921, Herman Wassmund performed a Le Fort I osteotomy for the correction of dentofacial deformities without intraoperative mobilization, with orthopedic traction applied postoperatively (Bauer and Ochs, 2014).

Total mobilization of the maxilla with immediate repositioning was accomplished by Axhausen in 1934, and the separation of the pterygomaxillary junction was introduced by Schuchardt in 1942. Obwegeser introduced complete mobilization of the maxilla for repositioning with tension in 1965. The usage of rigid fixation in maxillary osteotomies was first described by Michelet in 1973, Horster in 1980, Drommer and Luhr in 1981, and Luyk and Ward-Booth in 1985 (Cortese, 2012).

3.3.1 Procedure of the Le Fort I osteotomy

The clinical diagnosis and preoperative evaluation are crucial for ensuring the success of Le Fort I osteotomy. The diagnosis aims to determine the nature, position, severity, and possible etiology of the dentofacial deformity. The patient's general medical history should be considered to rule out systemic conditions that may compromise the surgical procedure. Special attention should be given to the patient's overall dental health, including an evaluation of the muscles of mastication and the temporomandibular joint. Periodontal and pulpal problems should be addressed before any surgical intervention. Additionally, patients should be assessed to determine their expectations for treatment outcomes and their motivation towards surgery (Bell, 1975).

A comprehensive radiographic examination, including lateral and frontal cephalograms, an orthopantomogram (OPG), and hand-wrist radiographs, is necessary before surgical intervention. Le Fort I osteotomy is typically indicated after the active growth period to ensure stability. However, Washburn et al. (1982) have suggested that maxilla impaction with Le Fort I osteotomy is not affected by later growth (West and Epker, 1972; Wolford and Epkler, 1975; Schendel et al., 1976; Fish et al., 1978; Epker and Schendel, 1980; Epker, 1981).

Preoperative photographs, both extraoral facial photographs and intraoral photographs, are essential for documenting the pre-treatment profile. The temporomandibular joint should be evaluated through inspection, palpation, auscultation, and radiographic examination to assess joint movements and the presence of pathology. Muscles of mastication should be inspected and palpated (Boyd et al., 1989).

Model surgery is a valuable guide for immediate preoperative surgical simulation and

splint construction. The assessment of clinical examination, model surgery, and cephalometric analysis is essential for the proper planning of Le Fort I osteotomy. Le Fort I osteotomy can be performed as a single-piece procedure or as a multiple-piece surgery, such as segmental Le Fort I osteotomy (Ho et al., 2011). Pre-operative orthodontic procedures, including leveling and aligning of teeth to achieve the best aesthetic incisor position, should be completed before surgery, followed by the preparation of model surgery.

The surgical procedure for Le Fort I involves a vestibular incision from the first molar on the right to the first molar on the left. The osteotomy is performed at least 5mm above the apices of the teeth. The first anterior osteotomy cut is made 4-5 mm from the apices of the canines to the midline, followed by the vertical cut at the zygomatic buttress region. After that, the posterior cut is made 4-5 mm above the molar apices (Author, Year). The osteotomy of the lateral nasal wall and septum is performed, followed by the separation of the pterygomaxillary junction with a curved osteotome. Lastly, the downward fracture of the maxilla is achieved using Rowe's disimpaction forceps or by digital pressure (Bell et al., 1977).

An adequate amount of bone is removed with a saw or bur from the lateral piriform rim to the posterolateral sinus wall, in accordance with the planned maxillary impaction to correct the gummy smile. Osteotomy of the vomer, nasal septum, lateral nasal wall, and floor, as well as the inferior turbinate, is removed if an excessive amount of maxillary impaction is indicated.

Maxillary segmentation at the midline is performed to expand the maxilla and achieve anteroposterior correction, while horseshoe osteotomy is used for excessive vertical maxillary impaction. Multiple maxillary segmentations should be limited to three or four pieces to maintain the vascular supply to the maxillary bones, as excessive segmentation may increase the risk of necrosis. The maxillomandibular complex is stabilized with the constructed splint and repositioned to the centric condylar position in the glenoid fossa.

Maxillary fixation is achieved with rigid osteosynthesis, using four mini plates and screws at the piriform rim and zygomatic buttress. Interarch elastics are often used for accurate and complete mandibular closure within the splint post-surgically. The suspension wires are loosened, and the occlusal splint is removed after three weeks postoperatively. Typically, after achieving sufficient stability in the maxilla, final orthodontic treatment can commence. The initial loading of mobilization is usually initiated four to six weeks postoperatively.

3.3.2 Le Fort I osteotomy and vertical maxillary excess

Le Fort I osteotomy can generally be used to treat a gummy smile with skeletal discrepancy of vertical maxillary excess (VME) origin in patients. Vertical maxillary excess is clinically manifested by a gummy smile, upper teeth exposure, incompetent lips, increased lower facial height, mentalis strain, and an increased mandibular plane angle (Epker and Schendel, 1980).

The clinical characteristics of VME from a profile view include an increased total face height due to increased lower facial height, a downward and backward rotation of the mandible, an increased interlabial distance greater than 4mm (Chu et al., 2009), increased upper incisor exposure at rest, sunken cheeks, and a well-developed and excessively curled lower lip. From a frontal view, the characteristics are a narrow alar base width, gummy smile, increased interlabial distance, increased vermillion exposure on the lower lip, an increased lower third of face height, gummy smile, and depressed paranasal areas with flat cheeks. VME often presents with or without an anterior open bite and a high-arched palate with an increased distance from the root apex to the nasal floor (Fish et al., 1978). The mandible

of VME patients is rotated downward and backward due to excessive vertical growth of the maxilla. Excessive vertical height on the maxilla indicates the need for surgical impaction of the maxilla through Le Fort I osteotomy with or without segmental osteotomies.

One-piece Le Fort I osteotomy is indicated for VME without open bite deformity (Epker and Schendel, 1980). Differential maxillary intrusion on the anterior and posterior with segmental Le Fort I osteotomy is indicated for the treatment of anterior open bite with different amounts of anterior and posterior gummy smile. Segmental maxillary osteotomies after Le Fort I osteotomy are usually performed to correct remaining step deformities in the curve of Spee, and the posterior segments can also be split for better arch coordination to correct a narrow maxilla and anteroposterior discrepancies.

The horseshoe osteotomy, leaving the palate intact, is the surgical procedure of choice for vertical impaction of the maxilla greater than 5 mm, as it does not compromise the nasal airway and provides better vascular supply to the individual segments (Shimo et al., 2013). Bilateral sagittal split osteotomy (BSSO) can be added to advance or setback the mandible, and chinplasty can be performed to reposition the chin (Chu et al., 2009). Assessment and diagnosis of each individual case are needed to determine the type of orthognathic surgery required.

The treatment for VME involves impacting the maxilla to achieve the proper incisor exposure with the lips at rest (Epker, 1981). Skeletal contraction occurs when impacting the maxilla, so anterior repositioning of the jaws must be considered to compensate for the adverse soft-tissue effects. As a result, the mandible rotates counterclockwise to maintain occlusion as the maxilla is impacted, leading to mandibular autorotation due to the more forward position of the chin.

Clinical application The amount of maxillary impaction is crucial, as moving the maxilla too far upward can have a more detrimental effect on facial aesthetics than leaving a gummy smile untreated. Factors to be considered when planning the amount of impaction of the maxilla include:

1. Patients with shorter upper lips tend to show more teeth than those with longer upper lips.

2. Age plays a significant role, as younger individuals can tolerate a greater amount of impaction than older individuals due to the natural lengthening of the upper lip with age.

3. There should be at least 2-3 mm of incisor show at rest after the impaction of the maxilla. Care should be taken not to over-impact the maxilla, as this can result in an aged appearance for the patient. In general, a planned 4 mm incisor show is aimed for after surgery (Bell et al., 1977).

4. Excessive impaction of the maxilla may lead to the widening of the alar base of the nose and an upward tipping of the nose tip (Bell et al., 1977).

5. The upper lip tends to shorten and thin as upward impaction of the maxilla occurs (Bell et al., 1977).

6. Surgery should be postponed until the growth of the maxilla and mandible has stabilized, as recommended by Vig and Turvey (1980). However, according to Washburn et al. (1982) maxillary superior repositioning surgery can be performed in adolescents to take advantage of continued maxillary growth. Epker's study included a total of

12 patients aged 10-16 years who underwent superior repositioning of the maxilla, and most patients exhibited a counterclockwise growth pattern, which is contrary to the normal clockwise growth pattern observed in long-faced patients. Further growth tended to shorten the face, and patients with a vertical growth pattern could benefit from this approach.

A cinch suturing to control the alar base width and V-Y closure or mucosal resection to create lip lengthening and prevent thinning of upper lip (Ellis, 1965). There is no literature on the maximum amount of maxillary impaction found. Although 10 mm impaction is reported by Bell et al. (1977). The amount of gummy smile correction with Le Fort I osteotomy is dependent to the anatomy of the patient such as the amount of the excess vertical bone height of the maxilla to the canine apices and the position of infraorbital nerves. Long canine teeth will give less impaction of maxilla and less gummy smile correction.

The vertical reduction of the nasal floor and anterior nasal spine need to be considered to prevent deviation of nasal septum. The reduction of the bone height is correspondent to the amount of planned maxillary impaction. If more than 5 mm of vertical reduction of maxilla or gummy smile is planned, flattening of inferior turbinates is recommended (Bell et al., 1977).

3.3.3 Stability of treatment and maintenance

Multiple studies on the stability of the Le Fort I osteotomy have shown that the procedure is relatively stable. The stability results of vertical maxillary excess correction with Le Fort I osteotomy was studied by Stoker and Epker (1974), Schendel et al. (1976) and Washburn et al. (1982). The studies reported maxillary impaction surgery is extremely stable operation with small relapse tendency as the maxilla tends to move superiorly.

Willmar reported on stability of markers and occlusion for l-year observation period with an insignificant 10% upward relapse on at the anterior marker for Le Fort I osteotomy in 106 patients (Bishara et al., 1988).

Then Schendel et al. (1976) showed excellent stability in a sample of 30 patients who were reviewed for an average of 13.8 months post-surgical procedures (11 total maxillary osteotomies and 19 combined anterior and posterior maxillary osteotomies) by resulting. There were minimal changes in the vertical maxillary excess group and A point and ANS changed more than maxillary incisors and molars. The relapse was found to be the same direction as that of the surgical movement.

Bell and McBride (1977) reported stability without relapse in 41 patients with vertical maxillary excess who had maxillary superior repositioning by Le Fort I osteotomy.

Bishara et al. (1988) concluded that the maxilla continued to move superiorly on the initial surgical superior repositioning and the upward movement of maxilla happened during fixation. The anterior part of the maxilla is twice more likely to move upward than the posterior part of the maxilla. Dental movement is more than skeletal movement upward for maxilla. This result is contrasting with result of Schendel (1976). This is may be due to the excessive suspension wire tightening or elastic extrusive forces. However, the skeletal movement exceeded dental movement horizontally. Profitt et al. (2007) stated that superior repositioning or the impaction of the maxilla is the most stable category of orthognathic surgery (Figure 8).

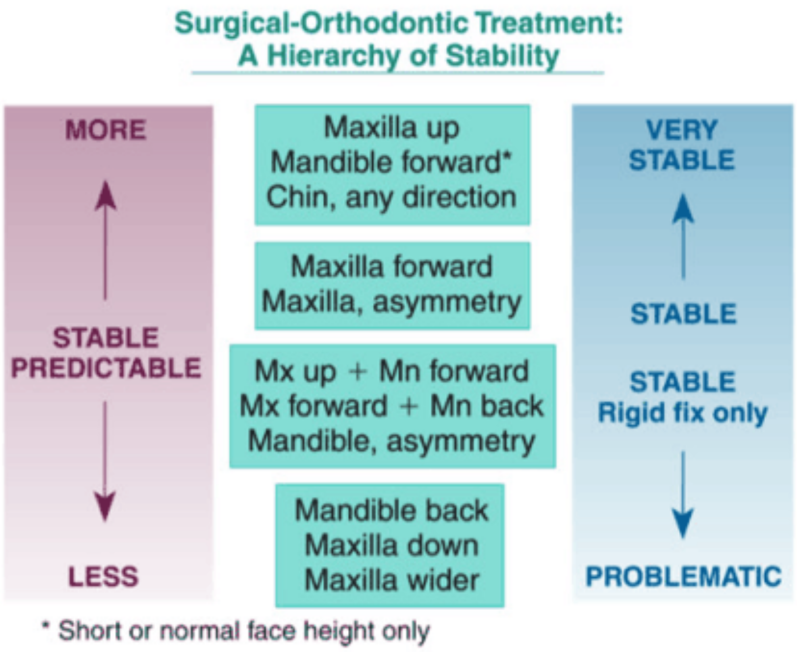

Figure 7. A hierarchy of stability in surgical orthodontic treatment. Source: Profitt et al. (2007)

3.3.4 Complication and morbidity

Complications have been reported with a low incidence of occurrence such as swelling, haemorrhage, infections, nerve injuries, non-union of bone, bone necrosis, excessive blood loss, nasal bleeding, TMJ problems, periodontal disease, ophthalmic and middle ear disorders, dysphagia and psychological problems (Ho et al., 2011)

Le fort I osteotomy post-operative infections such as maxillary sinusitis have been reported in literature to be around 1.1%. Maxillary sinusitis is due to breach sinus membrane during the osteotomy and is treated with antibiotics. The incidence of non- unions is reported to be 0.33 to 0.8% in literature (Robl et al., 2014). A non- union is usually associated with osteosynthesis instability, occlusal instability and situations with postoperative infections. Assessment of maxillary mobility is the important for adequate union of the osteotomies bone.

The result from the inadequate nasal septum removal will cause deviated nasal septum and unfavourable aesthetic result from the poor planning and operative procedure. Direct trauma to the vessels due to the blind nature of the osteotomy in the maxillary posterior area will cause vascular complications such as haemorrhage, swelling and hematoma postoperatively. The most often traumatized vessel during Le Fort I osteotomy is the descending palatine artery. The maxillary artery and its terminal branches, the pterygoid venous plexus, the internal carotid artery, and internal jugular vein may be injured but usually very rare.

The close proximity to the dental roots during osteotomy may cause pulp necrosis. Mostly, dental damage happened due to Le Fort I segmental osteotomy which to close interdental cuts to the roots. Therefore, horizontal Le Fort I osteotomy is positioned minimal 5mm from the apical of maxillary canine to minimise vascular compromised to the teeth. The temporary loss of tooth sensitivity for 6 - 12 months. It was reported usually around 5% permanent damage following Le Fort I osteotomy and the direct damage to teeth will

heal completely in approx. 90% of cases (Robl et al., 2014).

The aseptic necrosis of the mucosal membrane and bone are due to local circulatory disorders that are disrupted such as major and minor palatal arteries, main branches of the superior alveolar artery, palatal branches of the ascending pharyngeal artery and the facial artery. The overextension and tearing of palatal mucous membrane interrupting blood supply to mucosal membrane and bone will also case bone necrosis. Extensive bony segmentation and transverse palatal expansion in extensive maxilla impaction cases will increased risk of mucosal membrane and bone necrosis.

The facial nerve may be traumatised in extra oral approach surgery but very rare in intra oral approach surgery and trigeminal nerve injury is usually reversible in the infra-orbital foramen. Nerve injuries will cause paraesthesia at surrounding nerve supply areas. Complication of unwanted fracture lines during operative may extend to the pterygopalatine fossa, skull base and to the orbit. Reports on ophthalmic complications such as blindness, diplopia and ocular palsy are usually due to atypical fractures at the pterygoid extending to the orbital apex and the base of the skull.

A case report on cerebrospinal fluid (CSF) leak is reported by Bhaskaran (2010). The untreated CSF leak is due to trauma resulted from bad split of the pterygomaxillary dysjunction or removal of bone at the posterior and pterygoid region during impaction of maxilla. This may lead to meningitis if untreated. As a conclusion of Le Fort I osteotomy, no major problems arise maxillary osteotomies and life- threatening complications are usually very rare (Acebal-Bianco et al., 2000).

3.3.5 Contraindication

Individuals with bone disorders such as osteogenesis imperfecta, Paget's disease and others are contraindicated to undergo Le Fort I osteotomy as would impaired the operator's ability to achieve a good fracture. Healing process is impaired as well. Any medical condition which is prohibiting surgical intervention is contraindicated. If the repose incisors show is normal 2-3mm but patient had gummy smile with vertical maxilla excess, Le Fort I osteotomy will risk making patient looked aged (Ellis, 1965). Surgical limitations in extreme large discrepancies in vertical maxilla excess that compromising vascular supply to the maxilla and risk necrotising maxilla and surrounding soft tissues. Horse-shoe osteotomy, a modification of Le fort I osteotomy is recommended for extreme vertical maxilla correction.

3.3.6 Side effects

Nasal The effects of maxillary impaction on the nasal airway and nasal soft tissues is that nasal airway resistance decreases in the majority of patients. The hypothesized reason for decreased nasal airway resistance is an increase in the cross-sectional area in the region of the nasal valve (Ellis, 1965). Therefore, impacting the maxilla while maintaining the width of the alar bases by alar cinch procedure could then increase nasal airway resistance. The combined effect of reducing the size of the nasal cavity (by impacting the nasal floor) and preventing the usual increase in cross-sectional area of the nasal valve will increase the nasal resistance. However, there is no data available to support the impaction of the total maxilla affect nasal airway resistance if the alar bases were held constant. Thus, the real effect of impacting the nasal floor into the nasal cavity is difficult to evaluate.

The "bunching" of the nasal and paranasal soft tissues as a result of superior repositioning of maxilla without removing extra bone from piriform areas. The elimination of excessive

alveolar bone in the area of the pyriform fossa to prevent this pillar of bone from being intruded into the anterior nasal fossa (Bell et al., 1977).

The nasal tip moved a little upward with maxillary intrusion and forward a little with a combination of maxillary intrusion and protraction. The nasal tip moved superiorly 1 mm for every 6 mm of superior movement of upper incisors (Radney and Jacobs 1981). The nasal septum maybe deviated if nasal floor is not trimmed and removed in excessive VME cases.

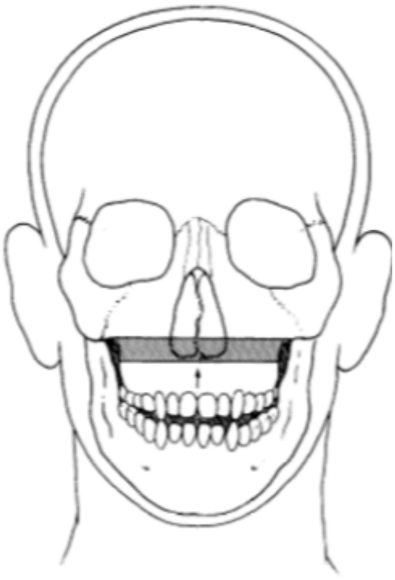

Figure 8. The reduce intranasal dimension with impaction of Le Fort I osteotomy. Source: Guenthner (1984).

Muscle Boyd et al. (1989) investigated on mastication function by masseter muscles and found that postoperative muscle fibres were not atrophy and no muscles pathology after Le fort 1 surgery. Therefore, mandibular mobility and bite force were unchanged by maxillary surgery. Zarrinkelk et al. (1995, 1996) reported masseter muscles mechanical advantage was lower in patients undergoing impaction of maxilla than control in both before and after surgery. Other biomechanical measurement were reported normal. The mandibular were hypomobility for first 6 weeks and returned to normal after surgery then after 6-12 months postoperative. The bite forces increased after surgery and approaching normal values within 2 years but less than control group. Patient's muscle activity per unit bite force is decreased compared to control group (Zarrinkelk et al., 1995, 1996). Thus, mastication function of masseter muscle and bite force is decreased after impaction of Le fort 1 surgery but returned to near normal range 2 years after surgery.

Lip The lower border of the upper lip (Stomion) moved upward with intrusion of maxilla in a ratio of 1 to 0.40 (Radney and Jacobs 1981). The ratio must be used preoperatively to plan for the proper amount of maxillary intrusion to achieve a proper lip-to-tooth relationship postoperatively. This upward movement of stomion will cause thinning and lengthening effect of upper lip. The vertical lip thinning is due to both intrusion of the anterior maxilla and intrusion of the posterior maxilla. In prominent upper lip patient, these complement

the facial aesthetic but thin upper lips patient will appeared unattractive. However, the change in the lower lip in response to maxillary intrusion was unpredictable due to possibly because of differences in muscular tone. The lower lip fell inside the arc of rotation of the mandible and thus did not rotate in a 1: 1 basis with autorotation of mandible (Radney and Jacobs 1981).

Mandible and chin In the one jaw surgery to correcting gummy smile, the mandible will need to rotate upward to be in occlusion with the maxilla. Therefore, the chin point will move upward and forward or rotates counter clockwise direction. This effect of this mandibular repositioning can be beneficial to patients with mandibular deficiency, as patients will looked less retrusive. But, this will worsened the class III skeletal patients. Therefore, a different intrusion of anterior and posterior maxilla with clockwise rotation of the occlusal plane and with a BSSO setback must be planned to prevent this unwanted effect in patients with class III skeletal problems. Differential maxillary intrusion needed to provide treatment for an anterior open bite as well. The soft-tissue of chin responded to posterior maxillary intrusion by autorotating together with the bony chin on a 1: 1 ratio (Chu et al., 2009).

Growth Patient indicated for maxillary impaction tend to show a clockwise rotation of the mandible. The clockwise rotation of the mandible (vertical growth pattern) will decreased the chin prominence and increase the mandibular plane angle with subsequent growth (Epker, 1981). The effects of early maxillary impaction correction with Le fort 1 osteotomy on subsequent growth evaluation of 12 individuals from age 10 to 16 years was studied by Washburn et al. (1982) as reported by Epker (1981). The result shown counter clockwise growth pattern in the group. This was contrasting with the usual growth pattern in vertical excess patients without surgical correction. Further growth in these individual will shorten the face rather than lengthen it.

4 Discussion

Recently current trend in facial aesthetic is catching up in dentistry. Patients are coming to dental clinic requesting for botox treatment aka botulinum toxin treatment for gummy smile correction. They are more aware of the botulinum toxin treatment as there plenteous information available in the internet. However, Le Fort I osteotomy has been the golden standard of gummy smile correction from the early 1972 (West and Epker, 1972). Thus, the question is can botulinum toxin treatment supersede Le Fort I osteotomy in gummy smile correction.

From the result, both botulinum toxin treatment and Le Fort I osteotomy are individualised treatment of gummy smile dependent on its aetiology factor. The most significant difference is botulinum toxin is the treatment of choice for gummy smile due to its ease and proven safety application, inexpensive repeated doses, fast onset of action, low complication and adverse effect and lastly reversible result of gummy smile. While Le Fort I osteotomy is the treatment of gummy smile when skeletal origin gummy smile or in VME patients.

Botulinum toxin is the treatment of gummy smile for muscular origin aetiology that is hyperactive lip and also as an adjunct treatment when excessive gummy smile that cannot be corrected with Orthognathic surgery alone or in patient who refuse Orthognathic surgery. Normally, botulinum toxin treatment can be used without any orthodontic treatment to correct gummy smile while Le for 1 osteotomy need before or after orthodontic treatment to correct the existing malocclusion.

Botulinum toxin treatment is indicated for more than 3mm of gummy smile patient and up to maximum of 7mm gummy smile correction. If more than 7mm of gummy smile need to be corrected, the result might not be promising as patients will still have residual gingival display. Most cases reported show average of 3-5mm of gummy smile correction depending on the dosage, site of injections and also skills of clinician. However, at least 4-8mm of gummy smile correction is reported for Le Fort I osteotomy for gummy smile correction. More than 8mm of gummy smile correction or impaction of maxilla can be done but there is increase risks with morbidity. Large discrepancies will have their surgical limitations. Horse-shoe osteotomy, a modification of Le fort I osteotomy has been described in literature to impact maxilla upwards in large discrepancy VME (40). Therefore, more amount of gummy smile correction can be achieved with Le Fort I osteotomy if surgeon is skilful than botulinum toxin treatment.

There is no age restriction of patients indicated for botulinum toxin treatment of gummy smile but for Le Fort I osteotomy patient's need to wait till no growth as patient might need two jaw surgery. Although one jaw surgery of impaction of maxilla can be done during adolescents but most surgeons prefer to wait till no growth in patients.

Both of botulinum toxin treatment and Le Fort I osteotomy need trained clinician and skilful surgeon to provide an aesthetic smile. All patients of Le Fort I osteotomy should be informed of possibility of upper lip lengthening and lip thinning, deepening of nasolabial folds, and widening of the nasal base after surgery. The soft tissue sagging will be more apparent with aging. The widening of the nasal base can be overcome with ala cinch suturing to control the alar base width and V-Y closure or mucosal resection to create lip lengthening and prevent thinning of upper lip.

Therefore, careful planning of Le Fort I osteotomy to leave at least 4 mm of incisor show at rest is a must to prevent aging the patients. In the other hand, botulinum toxin treatment will decreases nasolabial fold. This crease correction will make patient looked younger and this is a plus factor for gummy smile correction patients. Most reported adverse effect of botulinum toxin treatment are asymmetric smile, joker like smile, sad smile , difficulty in smiling, talking and eating. This are mild and transient side effects compared to surgical complication of Le Fort I osteotomy such as swelling, haemorrhage, infections, nerve injuries, non-union of bone, bone necrosis, excessive blood loss, nasal bleeding, TMJ problems, periodontal disease, ophthalmic and middle ear disorders, dysphagia and psychological problems.

Bite force and eating function for botulinum toxin treatment of gummy smile correction is not affected compared to Le Fort I osteotomy. Bite force in Le Fort I osteotomy patient is altered and decreased. However, bite force will recover and be almost normal after two years post-surgery. It was reported that eating function was not disturbed. Literatures had shown botulinum toxin treatment is a safe and stable procedure compared to Le Fort I osteotomy. Even though, Le Fort I osteotomy is a surgery procedure but is the most stable surgical procedure among the hierarchy of surgery and the relapse is low.

Patients undergoing botulinum toxin treatment for gummy smile correction need to go for repeated maintenance injection every 3-6 months when the effect of botulinum toxin wear down. This reversible effect is good for patient with gummy smile who not keen on permanent correction of gummy smile or those who is indecisive of gummy smile correction. Le Fort I osteotomy is a one-time surgical procedure for gummy smile correction and the relapse is low. No maintenance needed.

The disadvantages of botulinum toxin treatment for gummy smile patient is contraindicated and cannot be used in patients allergic to any component of botulinum toxin such as

human albumin, Botox toxin, lactose or saline solution. As for Le Fort I osteotomy, patients need to be medically fit for surgery and contraindicated in bony disorder patients.

For those patient who refuse surgery or phobia to surgical procedure, botulinum toxin treatment would be the treatment of choice. Therefore, botulinum toxin treatment is a minimal invasive treatment for gummy smile compared to Le Fort I osteotomy. Lastly, botulinum toxin is least expensive compared to Le Fort I osteotomy for gummy smile correction. Botulinum toxin treatment patient need not to advance large amount of fees upfront as surgical patient does.

5 Conclusions

The diagnosis of etiology is essential for determining the type of a gummy smile in order to plan gummy smile treatment. Gummy smiles need to be corrected based on smile assessment and the underlying etiology. Botulinum toxin treatment and Le Fort I osteotomy each possess distinct advantages and disadvantages. Both botulinum toxin treatment and Le Fort I osteotomy are necessary for correcting different types of gummy smiles, and neither can entirely replace the other in the context of gummy smile correction. However, botulinum toxin can serve as an adjunct to address excessive gum exposure in severe VME patients, reducing the morbidity and complications associated with an excessive maxillary impaction in Le Fort I osteotomy. Botulinum toxin treatment is gaining popularity due to its minimally invasive nature. As botulinum toxin is a relatively recent treatment for gummy smiles, more research and further studies are needed to optimize its efficacy in gummy smile correction.

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Ethical approval

No ethical approval was required for this study as it did not involve human participants, animal subjects, or sensitive data. This study falls under the category of data collection without participant identification.

Consent for publication

Not applicable.

Authors' contributions

The author(s) declare that all the criteria for authorship designated by the International Committee of Medical Journal Editors have been met. More specifically, these are: (a) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (b) Drafting the work or revising it critically for important intellectual content; AND (c) Final approval of the version to be published; AND (d) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Competing interests

The author(s) declare that there are no competing interests related to this work.

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