



Guided Gingivectomy for Gummy Smile: Conventional versus Digital Approaches

Eslam Osama Mohamed Hashem¹, Abdallah Abdelnabi Aref¹, Doaa Adel-Khattab^{1*},
Mohamed Samy Zaki² and Ahmed Elsayed Hamed Amr¹

¹Department of Oral Medicine, Periodontology and Oral Diagnosis, Faculty of Dentistry, Ain Shams University, Cairo, Egypt

²Department of Fixed Prosthodontics, Faculty of Dentistry, Ain Shams University, Cairo, Egypt

***Corresponding Author:** Doaa Adel-Khattab, Department of Oral Medicine, Periodontology and Oral Diagnosis, Faculty of Dentistry, Ain Shams University, Cairo, Egypt.

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Doaa Adel-Khattab, *et al.*

Abstract

Excessive gingival display, commonly termed “gummy smile”, is a frequent esthetic concern that can adversely impact facial harmony and patient confidence. Etiologies range from altered passive eruption and dentoalveolar extrusion to hyperactive upper lip and vertical maxillary excess. Traditional free-hand and guided gingivectomy techniques have long been employed to address altered passive eruption; however, their predictability is limited by operator variability. With the advent of digital dentistry-including cone-beam computed tomography (CBCT), intraoral scanning, computer-aided design and manufacturing (CAD/CAM), and 3D printing-fully digital guided gingivectomy has emerged as a promising alternative. This review synthesizes current evidence comparing free-hand, conventional guided, and digital guided gingivectomy in managing gummy smile. Literature demonstrates that guided workflows-particularly digital-enhance precision, reduce operative time, and improve patient communication through virtual simulations. Clinical trials further indicate superior esthetic outcomes with digital methods, though equipment costs and training remain barriers. Conventional guided techniques retain relevance due to their simplicity and accessibility. Future research should emphasize long-term stability, cost-benefit analyses, and integration of artificial intelligence-driven smile design.

Keywords: Gummy smile; Gingivectomy; Digital dentistry; Surgical guide; Crown lengthening; Esthetic dentistry; Periodontal surgery

Introduction

A smile is a key component of facial esthetics and an important factor in social interaction, self-confidence, and psychological well-being [1]. The harmony between teeth, gingiva, and lips determines the attractiveness of a smile, and any imbalance can have profound psychosocial consequences [2]. One of the most common esthetic concerns encountered in dental practice is excessive gingival display (EGD), often referred to as a gummy smile. Defined as more than 3 mm of gingival exposure during smiling [3], this condition has been reported to affect between 10–29% of the general population, with a significantly higher prevalence in females [4].

Although gummy smile is not a pathological condition, it can negatively affect self-esteem and social interactions, prompting

many patients to seek correction. The etiology of EGD is diverse and includes dentoalveolar causes (altered passive eruption, gingival enlargement, dentoalveolar extrusion) and non-dentoalveolar causes (vertical maxillary excess, hypermobile upper lip, short lip, bimaxillary protrusion). Accurate diagnosis is therefore essential, as treatment must be etiology-specific to achieve predictable outcomes [5].

Among these etiologies, altered passive eruption (APE) is particularly significant. In APE, the gingival margin fails to migrate apically to the cemento-enamel junction (CEJ) during eruption, leaving short clinical crowns and excessive gingival display. Esthetic crown lengthening via gingivectomy with or without osseous contouring is the treatment of choice in such cases [6].

Historically, gingivectomy has been performed using free-hand techniques (scalpel, electrocautery, and lasers). While widely practiced, these approaches are operator-dependent with variable accuracy and esthetic predictability. Guided techniques initially conventional (wax-ups/vacuum stents) and now digital (CBCT, intraoral scanning, CAD/CAM, 3D printing) have improved precision, reproducibility, and patient communication. Digital workflows transfer virtual planning to the clinical setting with greater accuracy but require capital investment and training.

Etiology and diagnosis of gummy smile

Altered passive eruption (APE)

Altered passive eruption (APE) is a developmental condition in which the gingival margin fails to migrate apically to its correct anatomic position following tooth eruption. This incomplete migration leaves part of the anatomic crown covered by gingiva, creating short clinical crowns and excessive gingival display.

Coslet [7] classified APE into Types 1 and 2, each with A and B subtypes. In Type 1, a wide band of keratinized gingiva is present, and the gingival margin sits incisal to the CEJ. Type 1A shows the alveolar crest 1.5–2 mm apical to the CEJ, whereas Type 1B has the crest at the CEJ. In Type 2, the band of keratinized gingiva is nar-

row or normal while the margin still lies coronal to the CEJ. Type 2A presents with the crest 1.5–2 mm apical to the CEJ; Type 2B has the crest at the CEJ. This A vs B distinction is clinically important because a crest at/near the CEJ (Type B) directly affects biologic width and the surgical plan for crown lengthening.

Diagnosis combines clinical and radiographic findings. Clinically, short crowns and excessive gingival display are evident. Bone sounding under local anesthesia measures the distance from gingival margin to CEJ and CEJ to alveolar crest, helping determine whether the crest is favorably positioned. Cone beam computed tomography (CBCT) found to be superior to bone sounding and conventional 2D radiography in the assessment of CEJ and bone morphology [8].

Other dentoalveolar etiologies

- **Gingival enlargement** can arise from inflammatory, drug-induced, or hereditary causes, all of which may produce pseudo-pockets and excessive gingival display. Inflammatory enlargement is typically plaque-mediated, presenting with erythema and edema; drug-induced enlargement is classically associated with phenytoin, cyclosporine, and calcium-channel blockers (e.g., nifedipine) and appears fibrotic; hereditary gingival fibromatosis, although rare, manifests as generalized fibrous overgrowth. These conditions often mask the anatomic crown and mimic APE [9].
- **Dentoalveolar extrusion** secondary to attrition is another contributor to EGD. With progressive tooth wear, the tooth and supporting periodontium may migrate coronally to maintain occlusal contacts, carrying the gingival margin coronally and increasing gingival display. This is common in bruxers and long-standing attrition. Diagnosis requires clinical and radiographic assessment, recognizing that the vertical dimension may be 'maintained' at the cost of gingival exposure [10].
- **Short tooth syndrome** encompasses teeth that appear shortened due to a combination of microdontia, severe attrition, and gingival coverage. Unlike isolated APE, crown height loss is not purely gingival but also due to reduced enamel/dentin height [11].

Non-dentoalveolar etiologies

- **Vertical maxillary excess (VME)** is a skeletal discrepancy characterized by increased lower facial height and excessive anterior maxillary gingival display. Severity is commonly categorized as mild (2–4 mm), moderate (4–8 mm), or severe (>8 mm). Clinical features of VME include a long-face pattern, lip incompetence at rest, and an inferiorly rotated palatal plane [12].
- **Lip morphology and dynamics** also play a central role. A short upper lip is typically defined as <20–22 mm (subnasale to inferior border of the upper lip at rest), while a hypermobile lip exhibits vertical excursion >8 mm during smiling. Both scenarios increase gingival exposure [3,13].
- **Bimaxillary protrusion** characterized by proclined incisors and protrusive lips can accentuate gingival display as the lips elevate further during smiling. Prevalence varies by ethnicity [14].

Treatment modalities

Available options for excessive gingival display, selected by etiology, are summarized sequentially:

- **Botulinum toxin** is a minimally invasive option for cases of gummy smile caused by hyperactive lip elevator muscles. By blocking acetylcholine release, it weakens the levator labii superioris complex and reduces gingival exposure during smiling. Improvement appears within days and lasts 3–6 months, after which reinjection is required. It is safe and well accepted, though its temporary effect and need for repeated sessions limit its use [15].
- **Hyaluronic acid fillers** can be used to reduce gingival display by adding lip volume and restricting lip elevation. The outcome is immediate and reversible, with results lasting 6–12 months. This approach is safe and minimally invasive, but its effect is variable and short term, and repeated treatment is usually necessary. Fillers are often considered as an adjunctive measure rather than a definitive therapy [16].
- **Surgical lip repositioning** has gained popularity as a simple and effective method to treat excessive gingival display caused by hypermobile upper lips. The technique involves excision of a strip of mucosa from the maxillary vestibule and advance-

ment of the lip mucosa to a lower position, which restricts the upward pull of the elevator muscles during smiling. This modification in lip dynamics reduces gingival exposure and improves smile harmony. The procedure can be performed under local anesthesia, is well accepted by patients, and provides longer-lasting outcomes than botulinum toxin injections (Rubinstein & Kostianovsky, 1973). Nevertheless, it has limitations, including potential relapse over time, scarring, and decreased vestibular depth, and is less effective in cases associated with significant vertical maxillary excess. Although the literature mainly consists of case reports and small observational studies, these have consistently demonstrated predictable short-term improvements in smile esthetics [17].

For patients with severe vertical maxillary excess, orthognathic surgery, most often in the form of Le Fort I osteotomy with superior repositioning of the maxilla, remains the definitive treatment. This approach directly addresses the underlying skeletal discrepancy and not only reduces gingival display but also improves facial harmony and occlusion. Orthognathic surgery offers stable long-term results and is often considered the gold standard in cases where gingival exposure exceeds 8 mm. However, it is an invasive procedure requiring general anesthesia, hospitalization, and lengthy postoperative recovery, and carries inherent surgical risks such as bleeding, infection, and neurosensory disturbances [18].

Esthetic crown lengthening by gingivectomy, with or without osseous contouring, remains the primary approach for managing altered passive eruption. It is a prevalent procedure in periodontal practice that aim to expose the anatomical crown and to create or reestablish the proper “biologic width” dimensions apical to the CEJ while maintaining an adequate gingival width [13]. In Type A cases, soft tissue gingivectomy alone is sufficient, while in Type B cases, osseous resection is required to re-establish the biologic width. Free-hand methods using scalpel, electrocautery, or lasers have been widely employed and can produce acceptable outcomes in skilled hands. However, their accuracy is operator-dependent, and achieving symmetrical gingival margins across multiple anterior teeth is unpredictable [19]. These limitations have driven the evolution toward guided techniques, which provide superior precision and esthetic predictability.

Free-hand gingivectomy techniques

Scalpel gingivectomy remains the most familiar approach, typically using Kirkland/Orban knives or #15C blades. It affords excellent tactile feedback and precise incision placement in experienced hands. Disadvantages include intraoperative bleeding, possible need for suturing, and limited visualization. Healing generally proceeds by secondary intention over ~4-6 weeks, with stable long-term esthetics in well-selected cases [20].

Electrocautery uses high-frequency current for soft-tissue excision. Advantages include hemostasis and shorter operative time than scalpel methods; some studies report reduced postoperative discomfort. However, collateral thermal injury to adjacent tissues (including enamel and bone) is a concern, and histology has shown delayed healing when parameters or technique are suboptimal. Accordingly, electrosurgery is better reserved for limited procedures and thick biotypes, with caution around thin tissues [21].

Laser gingivectomy (CO₂, diode, Er:YAG, Nd:YAG) enables precise ablation with minimal bleeding and a bactericidal effect on the wound surface. Patients often experience reduced postoperative pain and faster early healing relative to scalpel. Device cost, learning curve, and laser-tissue interaction differences are practical limitations; for example, Er:YAG exhibits shallow thermal penetration while Nd:YAG penetrates more deeply. Randomized trials suggest that long-term gingival margin stability is comparable to scalpel when biologic width is respected [22].

Overall, free-hand gingivectomy is effective but operator-dependent. Variability in gingival margin levels across multiple anterior teeth and the risk of biologic width violation remain key drawbacks, which has driven the adoption of guided approaches [19].

Guided gingivectomy techniques

Guided approaches, particularly digital workflows, represent the most significant advancement in esthetic crown lengthening. Conventional guides based on diagnostic wax-ups and vacuum stents improved outcomes compared to free-hand techniques but often lacked precision and failed to incorporate bone anatomy.

Digital techniques integrate CBCT, intraoral scanning, and CAD/CAM to produce 3D-printed guides that respect both soft and hard tissue landmarks. These allow highly accurate incisions, predictable biologic width preservation, and reproducible esthetic results. Dual-guide protocols further enhance accuracy by separately guiding gingivectomy and osteotomy. Beyond precision, digital workflows also improve patient communication through virtual smile design and reduce surgical time. Although cost and the need for advanced training remain barriers, evidence increasingly supports digital guided gingivectomy as the gold standard for esthetic crown lengthening, offering greater predictability and long-term stability than free-hand or conventional methods. Compared to conventional guides, which rely on physical wax-ups and vacuum stents, digital guides incorporate CBCT and intraoral scans to create CAD/CAM-based surgical templates. These digital guides offer superior precision by integrating both soft and hard tissue landmarks, enabling more accurate incisions and biologic width preservation. Clinical studies have shown that digital workflows reduce operative time, enhance esthetic outcomes, and improve patient understanding through virtual simulations. In contrast, conventional guides, while more accessible and cost-effective, may lack anatomical fidelity and are prone to fit discrepancies [23].

Future Perspectives

Future research should focus on multi-center randomized controlled trials comparing long-term outcomes of digital versus conventional guided gingivectomy. Integration of artificial intelligence for automated smile design and surgical planning could further enhance precision and efficiency. Cost-effectiveness analyses and studies on accessibility in resource-limited settings are also warranted to broaden the applicability of digital workflows.

Conclusion

Digital guided gingivectomy has transformed the management of gummy smile, offering superior precision and predictability compared with free-hand methods. Conventional guides remain useful where resources are limited. Technique selection should reflect etiology, periodontal biotype, clinician experience, and patient preference, with careful preservation of biologic width.

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