

Case Report

Esthetic Crown Lengthening with Digital Workflow: Case Report and Bibliographic Review

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Abstract

Introduction: Crown lengthening is a surgical procedure commonly used for the treatment of altered passive eruption. It involves the removal of gingival tissue and bone to create a longer clinical crown and apically reposition the gingival margin, thereby addressing the presence of short clinical crowns.

The stability of the soft tissue margin after a crown lengthening procedure is a critical factor and may compromise the outcome of the treated areas. Gingival Margin (GM) rebound can lead to aesthetic compromise as well as disruption of periodontal health. Crown lengthening techniques include both conventional and guided approaches. A guided aesthetic crown lengthening procedure was performed on a 28-year-old female patient diagnosed with altered passive eruption type 1B. The guide was designed based on a digital smile design. Following the crown lengthening comprising gingivectomy, gingivoplasty and osseous resection-the patient was monitored at 30, 60, 90 and 180 days.

Results: The gingival margin remained stable 180 days after the surgical procedure, resulting in a high level of aesthetic satisfaction for the patient.

Conclusion: This clinical case demonstrates that the use of a surgical guide derived from a diagnostic wax-up allowed for successful crown lengthening. These findings support the feasibility of using such guides as an effective tool in crown lengthening procedures, particularly in clinical situations with high aesthetic demands.

Keywords: Crown Lengthening; Digital Workflow; Esthetic Dentistry; Case Report

Introduction

Crown lengthening is a surgical procedure commonly used in the treatment of altered passive eruption. It is part of periodontal plastic surgery and consists of removing gingival tissue and bone to create a longer clinical crown and apically reposition the gingival margin. This approach addresses the presence of short clinical crowns, irregular gingival margins or a gummy smile, all of which can negatively impact the aesthetic perception of a patient's smile. The procedure is performed without altering the biological width of attachment, which is based on the 3 mm dimensions proposed by Gargiulo in 1961 [1,2]. The main indications for the crown lengthening procedure include the treatment of subgingival caries, crown or root fractures, altered passive eruption, cervical root resorption and short prosthetic abutments [3-5]. Conventionally, this procedure involves a gingivectomy to remove keratinized gingiva, followed by flap elevation to allow direct visualization of the alveolar bone for osteotomy. This is done based on the biological width dimensions, typically around 3 mm. However, this is a standardized measurement that may not apply to every patient. As a result, new techniques have been developed to allow for more precise and personalized

tissue removal [6]. These include digital workflows that utilize computed tomography or digital wax-ups based on digital smile designs. Through specialized software, customized guides can be created to assist in the removal of hard and soft tissues, with the aim of reducing postoperative complications such as tissue rebound, where the gingival margin loses the stability achieved at the time of surgery [6-8]. Therefore, the objective of this study is to compare the stability of the gingival margin after crown lengthening using the conventional technique versus the digital workflow technique.

Dental Eruption

Dental eruption occurs in two phases. The first is known as active eruption, which refers to the emergence of the tooth into the oral cavity. The second is called the passive eruption phase, during which the gingival margin migrates apically and is positioned at the level of the Cementoenamel Junction (CEJ) [4]. However, in certain cases this second phase fails to occur in one or more teeth, resulting in a condition known as altered passive eruption, defined by Goldman and Cohen in 1968 as a situation in which the gingival margin in adults is not located at the CEJ of the tooth [4,9,10].

Classification of Altered Passive Eruption

Altered passive eruption was classified by Coslet, et al., in 1977 into two types based on the location of the mucogingival junction in relation to the alveolar bone crest. Each type is further subdivided into two subgroups according to the position of the alveolar bone crest in relation to the CEJ [4,8,11].

Types of Altered Passive Eruption

Type 1: The gingival margin is located incisal or occlusal to the CEJ, with a wider band of attached gingiva from the gingival margin to the mucogingival junction than the generally accepted average width of 3-4.2 mm in the maxilla and 2.5-2.6 mm in the mandible. In these cases, the mucogingival junction is usually apical to the alveolar crest (Fig. 1) [11].

Type 2: A narrow band of keratinized gingiva is present and the mucogingival junction is located coronal to the alveolar bone crest (Fig. 2) [11].

Subgroups

Subgroup A: The distance between the CEJ and the alveolar crest is 1.5-2 mm

Subgroup B: The CEJ and the alveolar crest are located at the same level [11]

Etiology of Altered Passive Eruption

Type 1 Altered Passive Eruption: This type may result from a failure in the passive eruption phase, leading to excessive gingival overlap of the anatomical crown, although the distance from the alveolar crest to the Cementoenamel Junction (CEJ) remains within normal limits [10,11].

Type 2 Altered Passive Eruption: This may be caused by a failure in the active eruption phase, resulting in insufficient emergence of the tooth from the alveolar bone. As a consequence, the CEJ is located in close proximity to the alveolar bone crest [10,11]. This altered eruption pattern may lead to the appearance of a "gummy smile," defined as the exposure of more than 4 mm of gingiva when smiling. When it affects only a few teeth, it can cause asymmetry in clinical crown length or the appearance of short and square-shaped crowns [7,11].

Diagnosis

To diagnose a patient with altered passive eruption, several clinical diagnostic tools are required, including intraoral and extraoral photographs for analyzing facial symmetry, smile and lip lines, lip length and mobility. Measuring clinical crown dimensions is also essential to determine whether the teeth exhibit short clinical crown [7,11,12]. Additionally, the assessment must be complemented with periodontal probing and radiographic analysis to determine the position of the alveolar bone crest in relation to the gingival margin. When the CEJ is not detectable within the sulcus, a diagnosis of altered passive eruption may be considered, followed by a crestal bone sounding. After anesthetizing the gingiva, probing depth is recorded. The probe is then gently advanced through the base of the sulcus until the alveolar crest is contacted and this measurement is recorded. Crestal bone sounding under anesthesia is the traditional technique used to differentiate between subtypes A and B of altered passive eruption:

- If transgingival probing reveals the CEJ located subgingivally, a diagnosis of altered passive eruption subtype A can be made
- If the alveolar bone crest is detected by the probe without identification of the CEJ, the diagnosis corresponds to subtype B [4,7,11]

This clinical condition, especially when present in the anterior region, may result in aesthetic concerns for patients, causing discomfort when speaking or smiling and may also affect self-perception, leading to decreased self-esteem. This gingival excess has been recognized by the American Academy of Periodontology as a mucogingival deformity around the teeth [4].

Treatment

Correction of altered passive eruption requires a surgical approach known as crown lengthening, a periodontal plastic surgical procedure that has been widely used to correct and prevent anatomical, aesthetic, developmental, functional, traumatic or biofilm-induced defects or conditions of the gingiva, alveolar bone or oral mucosa [8,13-16]. This procedure involves the removal of gingival tissue and bone to create a longer clinical crown and apically reposition the gingival margin, thus resolving the issue of short clinical crowns without altering the biological width of attachment [2,14,17-20].

Objectives of Crown Lengthening

The goal of aesthetic clinical crown lengthening is to promote harmony in gingival dimensions and to establish a normal anatomical relationship between the Cementoenamel Junction (CEJ) and the alveolar bone, without compromising the supracrestal tissue attachment. These measurements must be respected based on the dimensions established by Gargiulo in 1961 in order to avoid complications such as inflammation or recession in the surrounding tissues [1-3,17,21,22].

Other objectives include:

- Exposure of a sufficient amount of healthy tooth structure for caries removal
- Improved retention quality of restorations
- Proper placement of restoration margins without invading the biological width
- Enhanced aesthetics in patients with uneven gingival margins [5,14,23]

Surgical Approach

There are four surgical approaches to crown lengthening, aiming to restore appropriate positioning and anatomical relationships between hard and soft tissues [17,24-26]. Gingivectomy: Removal of excess gingival tissue with or without gingivoplasty (reshaping and recontouring of the gingival tissue).

Apical repositioning of the soft tissue without osseous resection.

Apical repositioning of soft tissues with osseous resection/recontouring.

Gingivectomy/gingivoplasty with osseous recontouring [24].

Digital Workflow In Dentistry

In 1986, Charles Hull introduced the first Three-Dimensional (3D) printing technology and since then, various manufacturing technologies have been developed and applied across numerous fields [27]. Three-dimensional printing is an advanced manufacturing technology based on Computer-Aided Design (CAD) digital models. It uses standardized materials to create customized 3D objects through automated processes. Originally used for rapid prototyping, this technology has been widely implemented in industry, design, engineering and manufacturing for nearly 30 years [27,28]. In dentistry, its applications span prosthodontics, oral and maxillofacial surgery, oral implantology, orthodontics, endodontics and periodontology [27-31]. The workflow in restorative and surgical dentistry has significantly improved with the advent of Computer-Aided Design and Manufacturing (CAD/CAM). Digital technology provides major advantages for treatment planning and enables clinicians to visualize treatment outcomes before initiating therapy [32-36]. Compared to traditional wax-up techniques, 3D printing offers certain advantages. Due to its speed, high precision and ability to customize individual cases, complete dentures, implant-supported restorations and surgical guides are more easily produced [37-39]. Moreover, the application of 3D printing in dentistry can help provide patients with more personalized, cost-effective services and simplify the complex analog workflow [27,28,40]. Today, in addition to conventional techniques, CAD/CAM systems have revolutionized surgical planning in dentistry. By integrating hard and soft tissue imaging data, a 3D virtual patient can be created to simulate comprehensive treatment non-invasively. This data integration can, in turn, be used to guide and predict digital workflow treatments [40-42].

Digital Workflow in Aesthetic Crown Lengthening

The success of aesthetic crown lengthening surgery depends on the precise adjustment of the alveolar bone crest position according to the established treatment plan. According to several clinical reports, a fully digital workflow for this procedure allows for predictable outcomes over a follow-up period of at least six months [27,41,43]. Thanks to the integration of technologies such as Cone-Beam Computed Tomography (CBCT), CAD/CAM and 3D printing, periodontists can plan and perform aesthetic crown lengthening surgery using computer-generated surgical guides, relying on the precision of digital guidance [40,44-46]. Patients benefit from reduced surgical time, lower morbidity and more precise outcomes compared to conventional methods [47-49]. Digital Smile Design (DSD) is another useful software tool that facilitates diagnosis, planning and treatment in aesthetic cases and allows patients to visualize the outcome before beginning treatment [27,44,50,51]. By combining DSD, CAD/CAM and 3D printing technologies, a precise surgical guide can be created for aesthetic crown lengthening. Another technique for obtaining surgical guides involves using measurements obtained from CBCT during treatment planning to anticipate results-crucial in the anterior region, where soft tissue changes can greatly impact aesthetics [52,53]. Using digital workflow, it is possible to fabricate 3D-printed surgical guides with specialized software. These guides help plan the amount of hard and soft tissue to be removed during crown lengthening procedures. An additional advantage of using 3D-printed digital guides is their thinner profile compared to conventional vacuum-formed guides, which are often made from diagnostic wax-ups [40,44,51,53].

Postoperative Complications

Following the crown lengthening procedure, several postoperative complications may occur, including discomfort, pain, inflammation, soft tissue rebound, infection and improper gingival margin placement [4,8].

Soft Tissue Rebound

Among these complications, in terms of healing, patients with thick gingival biotypes are more likely to experience soft tissue rebound, whereas those with thinner gingival tissue are more prone to recession. It has been demonstrated that gingival margin rebound mainly occurs during the first three postoperative months. The stability of the soft tissue margin following a crown lengthening procedure is a critical factor that can compromise the outcome in the treated areas [7,8,54,55]. Gingival Margin (GM) rebound may lead to aesthetic compromise as well as alterations in periodontal health [56]. Thick phenotypes appear to be associated with greater GM rebound after aesthetic crown lengthening procedures compared to thin phenotypes [8,57,58]. Other factors that may influence the GM position after crown lengthening include individual variability in biological width, the amount of bone resection, postsurgical bone remodeling and clinical expertise [6,8,59].

Previous Research

Several studies have analyzed how flap position relative to the Alveolar Crest (AC) after crown lengthening affects the stability or rebound of the gingival margin. In a 2001 study conducted in Italy by Pontoriero, et al., 30 patients (84 teeth) underwent crown lengthening and were clinically evaluated at 1, 3, 6, 9 and 12 months to assess soft tissue stability. Results showed that during one year of healing after surgical crown lengthening, the marginal periodontal tissue tended to migrate coronally from the surgically established level. This coronal displacement of the gingival margin was more pronounced in patients with a "thick" periodontal biotype and appeared to be influenced by individual differences in healing response. However, this study did not specify the exact amount of tissue resection performed [58]. In another study conducted in India by Arora, et al., in 2013, it was observed that the "3 mm rule," which has traditionally dictated the amount of alveolar bone removal during crown lengthening surgery, does not account for variations in Supracrestal Gingival Tissue (SGT) dimensions. Therefore, osteotomy should be adapted to each patient's specific characteristics. This study included 64 patients requiring crown lengthening surgery on 64 teeth, with clinical parameters recorded on six surfaces of treated and adjacent teeth. The amount of osteotomy was determined based on the minimum dental structure needed for restorations and SGT dimensions at each site. Patients were reevaluated at 3 and 6 months. The authors observed a significant soft tissue rebound (0.77-0.58 mm) at 6 months post-surgery, which correlated significantly with periodontal biotype and flap position after suturing [60]. A 2019 study by Domínguez, et al., in Germany included 21 patients requiring aesthetic crown lengthening on anterior maxillary teeth. The aim was to evaluate Gingival Margin (GM) changes after submarginal incisions, buccal bone surgery and flap repositioning following a 6-month healing period. An individualized stent was fabricated to register GM position changes, with clinical measurements taken before surgery, immediately after and at days 42, 90 and 180. The authors demonstrated that crown lengthening where the flap is released to the mucogingival junction, maintaining a ≥ 3 mm distance between bone crest and gingival margin, can achieve stable GM position at 42, 90 and 180 days, provided adequate bone resection is performed [7]. Gingival rebound can negatively affect aesthetic and

functional outcomes by altering gingival margin harmony and potentially leading to false periodontal pocket formation. To ensure proper tissue resection, guides can be fabricated either analogically or via digital workflows based on Computed Tomography (CT) scans. For example, in Saudi Arabia, Saad, et al., conducted a clinical study in 2022 involving a single patient to demonstrate the advantages of digitally designed 3D surgical guides in periodontal surgery. Digital impressions and CT scans, along with Digital Smile Design (DSD), were used for treatment planning and to fabricate 3D-printed surgical guides. After one year of follow-up, clinical outcomes were accurate, surgeries were straightforward, procedure times were relatively short and optimal results with tissue stability were achieved, resulting in high patient satisfaction [40]. In a 2024 Vietnamese study by Cong, et al., a 30-year-old female patient required aesthetic crown lengthening to improve smile appearance. Based on the anatomical crown length, a smile design was created and cone-beam computed tomography was used to identify the cementoenamel junction, enabling treatment planning and fabrication of a 3D-printed surgical guide. During surgery, a full-thickness flap was raised in the maxilla, the surgical guide was positioned and osteotomy was performed accordingly. After 12 months, tissues remained stable and final results closely matched the preoperative Digital Smile Design simulation [44].

Case Report

A 28-year-old female patient, ASA I, with no history of chronic diseases or known allergies and no relevant personal medical history, presented to the Graduate Program in Periodontics and Implantology at the School of Dentistry of the Universidad Juárez del Estado de Durango seeking to improve her smile. A periodontal evaluation was performed to determine the feasibility of an aesthetic procedure involving the upper right canine to the upper left canine.

Intraoral photographs were taken (Fig. 1), as well as a periodontal probing using a North Carolina millimeter probe (Fig. 2) and a full-mouth radiographic series was obtained (Fig. 3). After a thorough clinical examination, the patient was diagnosed with short clinical crowns caused by altered passive eruption type 1B and a thick, scalloped gingival phenotype.



Figure 1: Initial situation of the patient. A) Frontal view; B) Right lateral view; C) Left lateral view.

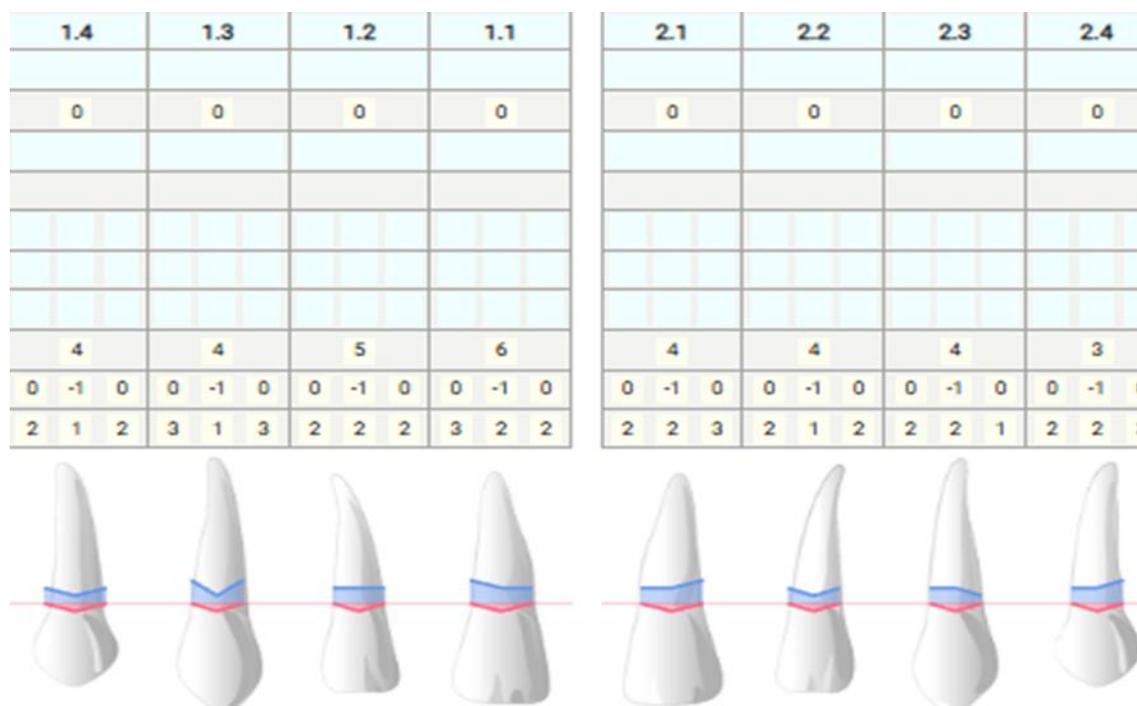


Figure 2: Periodontal chart.

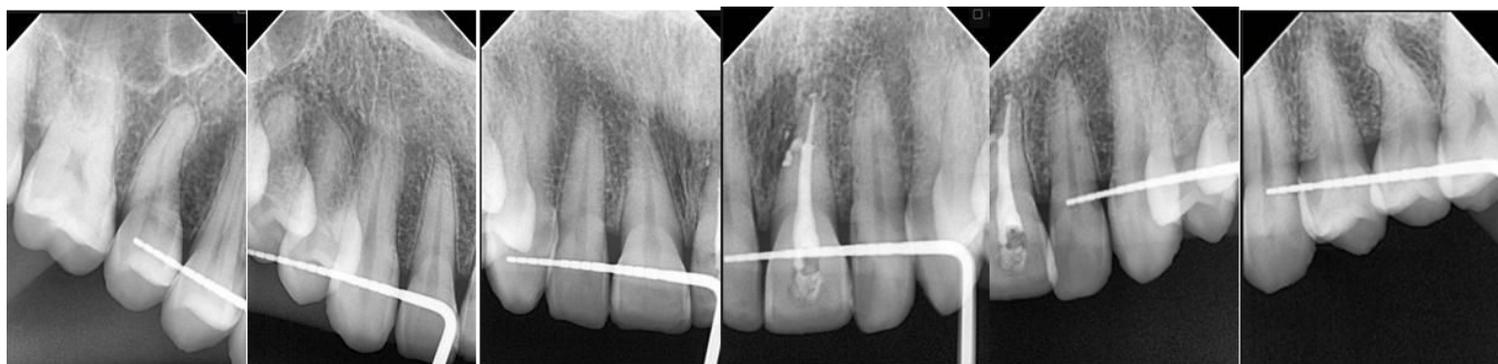


Figure 3: Radiographic series using a millimeter-marked Hu-Friedy® UNC periodontal probe to indicate the position of the gingival margin.

Procedure

An intraoral scan was performed using a Medit i600® scanner (Fig. 4). Once the patient's models were digitized, a digital smile design was created through a digital wax-up using Exocad® software (Fig. 5). After completing the digital wax-up, the surgical guide was designed by following the cervical margins of the teeth generated from the digital smile design. The guide was then 3D printed using biocompatible LeafDental® resin (Fig. 6).

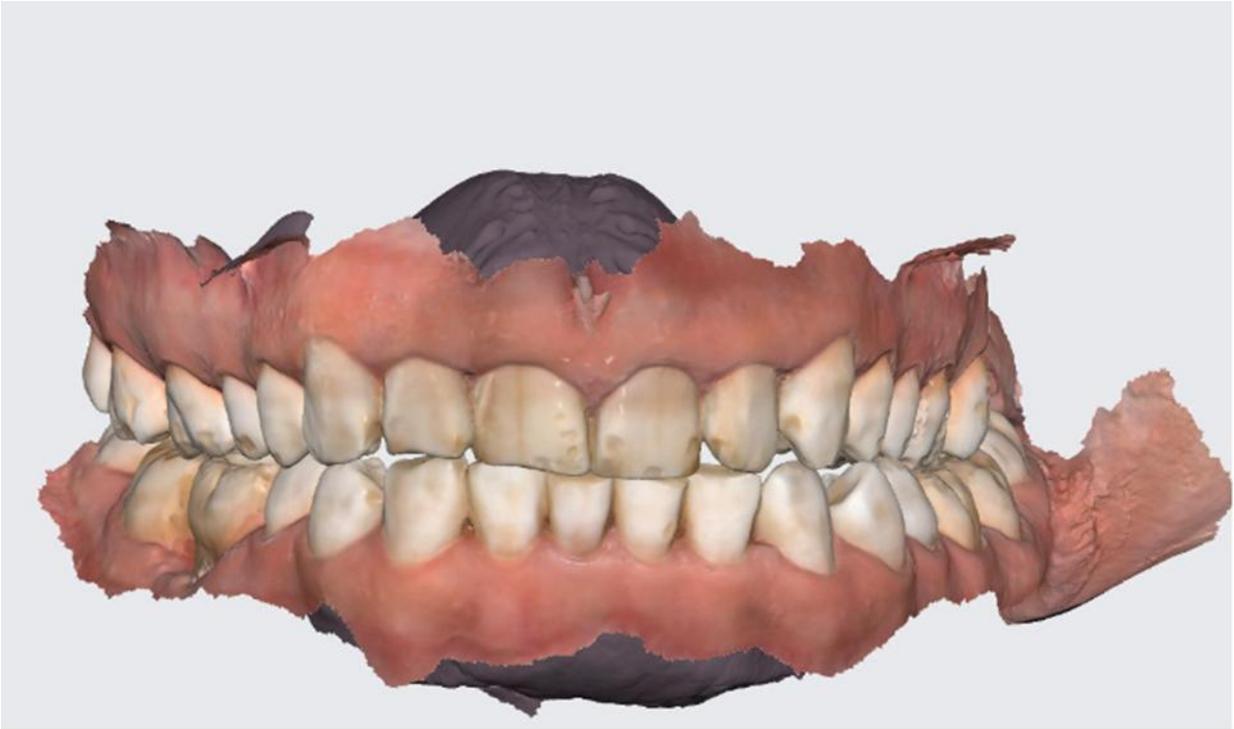


Figure 4: Intraoral scan using Medit i600® scanner.



Figure 5: Digital wax-up created with Exocad® software.



Figure 6: (a) Surgical guide design using EXOCAD software; (b) 3D-printed guide.

Once the guide was tested in the mouth, antiseptics were performed using 0.12% chlorhexidine, followed by local anesthesia with 2% lidocaine with epinephrine (Zeyco®). The surgical guide was then positioned and primary incisions were made following the guide's contour with an internal bevel using a #15c scalpel blade. A second intrasulcular incision was performed (Fig. 6). The surgical guide was removed and the gingival collar was eliminated using a Gracey 1/2 curette (Hu-Friedy®). A full-thickness flap was elevated using a P20 periosteal elevator (Hu-Friedy®) and osteotomy and osteoplasty were carried out with a #4 carbide round bur (Fig. 7).



Figure 7: Primary internal bevel incision following the margin of the surgical guide.

Once the desired bone architecture was achieved, the flap was repositioned and sutured using vertical mattress sutures with 5-0 nylon (Fig. 8).



Figure 8: Immediate postoperative situation: flap repositioning and suturing with 5-0 nylon in a vertical mattress technique.

Sutures were removed after 15 days and the patient was followed up at 30, 60, 90 and 180 days (Fig. 9).



Figure 9: Follow-up at 180 days.

Discussion

The evidence obtained in this clinical case suggests that using an approach different from the conventional one for clinical crown lengthening allows for more predictable aesthetic outcomes, at least during a six-month follow-up period. This predictability is especially relevant in the anterior region, where even minimal alterations in soft tissues can significantly compromise the final aesthetic result [7,8,19,21]. One of the most notable aspects of this case is the application of a diagnostic overlay as a tool to validate the treatment plan alongside the patient. This strategy not only facilitates better clinician-patient communication but also enables the design and use of a precise surgical guide, leading to a considerable reduction in operative time. The integration of digital tools into the surgical workflow represents an important advancement in personalized treatment and in minimizing intraoperative errors [17-20]. A fully digital workflow for crown lengthening procedures, based on the use of a single surgical guide, requires the prior acquisition of a Cone-Beam Computed Tomography (CBCT) scan and the guide is designed based on the planned bone resection. However, it must be noted that this type of planning does not consider future aesthetic restorations, which could represent a limitation in terms of the functional and aesthetic integration of the overall treatment. Additionally, the need for a CBCT scan increases the cost of the procedure, which may pose a financial barrier for some patients [22,23,33]. Despite these considerations, the results obtained in this case support the effectiveness of designing and fabricating surgical guides based on a Digital Smile Design (DSD). This approach allows for the incorporation of planned restorations from the diagnostic phase, facilitating a more controlled surgical intervention focused on the desired final outcome. As a result, it increases the precision in gingival margin placement and reduces the risk of postoperative gingival rebound, a common complication in patients with thick gingival phenotypes [24,25,32,34]. Altogether, this clinical case supports the implementation of digital technologies as a key tool in the planning and execution of clinical crown lengthening. Despite the higher technical and financial requirements, the benefits in terms of precision, reduced surgical time and improved patient communication justify their application, especially in procedures with high aesthetic demands [7,8,19,21,22,33,34]. Nevertheless, some inherent limitations of this approach must be

considered. As this is an isolated clinical case, the findings should be interpreted with caution and not generalized without controlled clinical studies to support these results. Future work should focus on comparing, through controlled trials and longitudinal follow-up, tissue stability between conventional techniques and digital workflows assisted by DSD.

Conclusion

This clinical case demonstrates that the use of a surgical guide derived from a diagnostic wax-up enabled a successful crown lengthening procedure. These findings support the feasibility of using such a guide as an effective tool in crown lengthening procedures, particularly in clinical situations with high aesthetic demands.

Conflict of Interest

There are no potential conflicts of interest to declare in this systematic review.

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Author Contributions

All authors contributed equally for this paper.

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