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Efficacy of combining clinical crown lengthening surgery and botulinum toxin A injection in gummy smile treatment

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Abstract

In many cases, the cause of a gummy smile is a combination of many simultaneously occurring factors. Therefore, a single method is certainly not effective in achieving the maximum aesthetic requirements. This study aims to evaluate the efficacy of combining clinical tooth crown lengthening surgery and subsequent BTX-A injection in gummy smile treatment using clinical and photographical assessment. 21 patients with an average length of excessive gingival display of at least 4 mm at maximum smiling point and with the height of keratinized gingiva ≥ 3 mm were recruited. Gingival exposure (GE) and clinical crown length (CCL) were measured at baseline (T0), two months after clinical crown lengthening surgery (T1), two weeks after BTX-A injection (T2), two months after BTX-A injection (T3). GE values at T1, T2 and T3 were significantly different ($p < 0.001$). CCL was significantly changed after gingivectomy surgery (T1) compared to preoperative value (T0) ($p < 0.001$). BTX-A could be considered a favorable adjunctive treatment for gummy smile patients after gingivectomy surgery.

Keywords: BTX-A, crown lengthening, smiling, injection

1. Introduction

A smile brings many benefits to oneself and makes everyone around feel better (1, 2). Because the mouth is the center of attention of one's face, the smile plays an essential role in facial aesthetics. Dentistry is a medical specialty most involved in smile improvement. However, the clinical assessment of dentists for a beautiful smile and smile cosmetic treatment planning remains challenging. Smile assessment criteria, which includes: the degree of gingival exposure, the proportion of anterior teeth, and the gum line, helps the dentist plan practical and effective treatment. According to recent studies, the maximum amount of gingival exposure allowed when smiling is 3 mm (3). Otherwise, it can be considered a gummy smile (GS), which is considered less aesthetic (4). According to a study in 2021 by Horn et al, the GS rate can be approximately 31% (5).

The demand for beauty is increasing in society as everyone is looking for cosmetic improvement, including gummy smile correction. Various methods have been proposed to correct gummy smiles, including orthodontic treatment, orthognathic surgery, bone resection, and gingivectomy.

While the orthodontic option is expensive and time-consuming, operations are also complex and invasive. Gingivectomy and smile line repositioning correct gummy smile cases when combined with passive erupted delay and when hyperactive lip muscles have been corrected (6, 7). However, both methods not only are invasive but also cause anxiety and pain after surgery. Botulinum Toxin A (BTX-A) has been adapted for other treatments and validated as a safe product in gummy smile treatment. In proper cases, excessive gum exposure can be adjusted by injecting BTX-A to reduce the contraction of the upper lip levator muscles, such as levator labii superioris (LLS), levator labii superioris alaeque nasi (LLSAN), zygomaticus major and minor (8, 9).

In many cases, the cause of a gummy smile is a combination of many factors acting simultaneously (10).

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Furthermore, the biomechanics of gummy smiles seem to involve the combined effects of teeth, gums, bones, and muscles. Therefore, no single method can reliably achieve the maximum aesthetic requirements for the patient. This study aims to evaluate the efficacy of a combination of clinical tooth crown lengthening surgery followed by BTX-A injection in gummy smile treatment based on clinical and photographic assessment.

2. Materials and Methods

2.1. Ethical statement

The study was approved by the UMPH ethical committee (approval number 20338-DHYD) in compliance with the Helsinki Declaration 2013. Informed consents were signed by each participant before enrolment in the study, after explanation of study objectives, intervention, risk, and potential benefits. Clinical trial registration: NCT05057286 at ClinicalTrials.gov.

2.2. Study design, setting, and participants

An uncontrolled longitudinal study was implemented at the Faculty of Odonto-Stomatology (FOS) of the University of Medicine and Pharmacy at Ho Chi Minh City (UMPH), Viet Nam, from August 2020 to May 2021.

Participants were recruited from patients with the chief complaint of excess gingival display at the Dental Clinic of FOS- UMPH. Study population included patients aged 18 and above with an average length of excessive gingival display ≥4 mm at maximum smiling (eight teeth counted, from the 14 to the 24 teeth) and height of keratinized gingiva ≥ 3 mm.

Inclusion criteria included: gummy smile due to combined etiologies: a short clinical crown of teeth due to the altered passive tooth eruption and hyperactivity of upper lip muscles (maxillary lip generally translates more than 8mm from the repose position to the position achieved at a full smile), with a normal lip length (20-22mm in females and 22-24mm in males).

Exclusion criteria were pregnant or breastfeeding patients, gummy smiles due to maxillary bone overgrowth (maxillary hypertrophy) or vertical maxillary excess, neuromuscular disorder, gingival hyperplasia due to medications, supplements, or neuromuscular transmission inhibiting agents, systematic diseases that can affect the result of surgical treatment (such as diabetes, anticoagulant use, hematologic disorders, immunodeficiency diseases etc.), allergy to BTX-A or albumin, a history of taking BTX-A injection in the head-neck area, or any contraindication of surgery.

Study procedure consisted of recruitment, pre & post-operative photography, gingivoplasty, BTX-A injection, visits, data collecting and analysis.

2.3. Photographic protocol

All participants were photographed before surgery at T0. The shooting procedure was standardized to ensure reproducibility for post-surgical photographs at two months after clinical crown lengthening surgery (T1), two weeks (T2), and two months (T3) follow-up visits after BTX-A injection. Frontal view photos of the patient's natural smile and maximum smile (Fig. 1A, Fig. 1B) were taken. Distance between the subjects and the camera was at least 1 meter and constant in every shooting. Patients sat on a chair without headrest in a relaxed position. Patients' Frankfort occlusal plane was parallel to the floor. The camera lens was placed on the same level as patients' occlusal plane and focused on the contact point of their upper central incisors (11). Before shooting, patients removed all their jewelry, tied their hair to show the face clearly. The patients were informed to dress up appropriately to see their necks in full. Face proportion was controlled in every photo using a grid board on the camera. An acceptable photo clearly showed the patient's eyes, both sides of the mandible's inferior border, the center of his/her nose, and two auricles. The photography protocol would be repeated in each subsequent visit.

Fig 1. A. Front smile photo
B. Maximum smiling photo
C. Initial stage at baseline time (T0)
D. Measurement of the width of the upper middle incisors
E. Measerement of the future length of the central incisors
F. Creation of the bleeding
G. Placement of internal bevel incision
H. Placement of sulcular incision for full-thickness flap reflection
İ. Full-thickness flap reflection, white border: CEJ, black border: alvoler crest
J. Alveolar bone adjustment according to biological width
K. Shaping the outer alveolar bone shape
L. Alveolar bone contour after shaping
M. Double-checking the biological width
N. Suturing the flaps
O. Follow-up 2 months after the surgery

2.4. Preoperative protocol

The same doctor performed clinical examination, history taking, evaluating, and recording the GS level of all patients. The keratinized gingiva height and initial clinical crown length (iCCL) were measured in millimeters using a digital caliper and periodontal probe.

Postoperative clinical crown length (pCCL) of teeth was calculated as below:

A surgical guided splint/ surgical template was fabricated from a plaster cast of the upper arch impressed by alginate. Patients were asked to submit a blood test result to make sure they were not contraindicated for for surgery. Preoperative

photos were taken by the same cameramen following the protocol mentioned above.

2.5. Clinical dental crown lengthening surgery protocol (Fig. 1C – Fig.1O)

Patients were asked to rinse their mouths with 10 ml chlorhexidine gluconate 0.12% (KIN) for 2 minutes. Next, nurses prepared the extra and intraoral cavity with antiseptic solution povidine 10%. Patients were locally anesthetized using Lidocaine 2% and 1:200,000 epinephrine. Distance from gingival margin to bone crest was measured by bone sounding with periodontal probe UNC-15. Usually, it is 3 mm at the buccal and lingual surface, 4.5-5.0 mm at the proximal sides.

The surgeon re-evaluated the height of keratinized gingiva (must be ≥ 3 mm) (12-14) before marking the bleeding points with a socket probe and surgical template.

The first incision was at the internal bevel gingivectomy 450 apically to the tooth axis. Then, the second incision was performed along the gingival sulcus. The gingiva was removed from the root surface, then the remaining tissue attaching to the root was cleaned with periodontal curettes. A full-thickness flap was performed in the gingivectomy border to the mucogingival junction to expose the alveolar at least 4-5mm. Alveolar was adjusted by a 2 mm diameter carbide bur to establish the prober biologic width, which was 2.5 mm at least from anterior teeth at every position (from CEJ to the crest of bone). Finally, 5-0 polyamide non-resorbable sutures were used.

2.6. Post-operation protocol

Patients were all prescribed antibiotics (Amoxicilline 500mg, three times a day in 7 days), anti-inflammatory drugs (Ibuprofen 400 mg, three times a day in 5 days), analgesics (paracetamol 500mg, three times a day in 5 days), and antiseptic mouthwash (15ml Chlorhexidine gluconate 0.12% (KIN), twice a day in two weeks). Patients were instructed to brush their teeth slightly with a soft toothbrush, to return to oral hygiene practice after two weeks, and to revisit every week within two months. The sutures were removed 14 days after surgery.

2.7. Botulinum Toxin A injection

One hundred units (U) of botulinum toxin were diluted with 2.5ml of sterile saline solution without shaking. 1 mm syringe with a 30-gauge needle was used to get 0.25ml BTX-A for four-point injection, or 0.6ml in case injection of 6 points. The anatomy points were located for BTX-A injection as in Fig. 2A. Cold compress was applied extraoral 5 minutes at injection site before injection. After local anesthesia, the doctor administered slowly 2,5 IU of diluted BTX-A at each point until white cellulite appeared. Patients were recalled two weeks (T2), and two months (T3) after injection.

2.8. Clinical outcomes

Another assessor determined, measured, and recorded clinical parameters at baseline T0, two months after performing clinical crown lengthening surgery (T1), two weeks after BTX-A injection (T2), two months after BTX-A injection (T3).

2.9. Measurements on photos

On frontal view photo, two types of parameters, including the highest point of the gingival margin (A) and the mesial-distal dimension (L0) (Fig. 2B), were measure for each of the eight maxillary anterior teeth. Photo scaling was performed using superimpose method with a given reference dimension (clinical L0). After synchronizing the clinical L0 with photo L0, the digital ruler on the software would be used to measure the study dimensions. All photos were processed using Keynote software version 9.2 (Fig. 2C – 2F).

Five selected photos were framed for each patient to focus on maximum smiles and named by numerical code in chronological order (For example, P1Tx) (Fig. 3). Photo scaling was performed using superimpose method with a given reference dimension (clinical L0). After synchronizing the clinical L0 with photo L0, the digital ruler on the software would be used to measure the study dimensions.

The tooth-axis parallel line (d line) was drawn from the A point vertically to meet the lower edge of the upper lip at B point. Thus, the clinical degree of gingival exposure (N0) was the length AB.

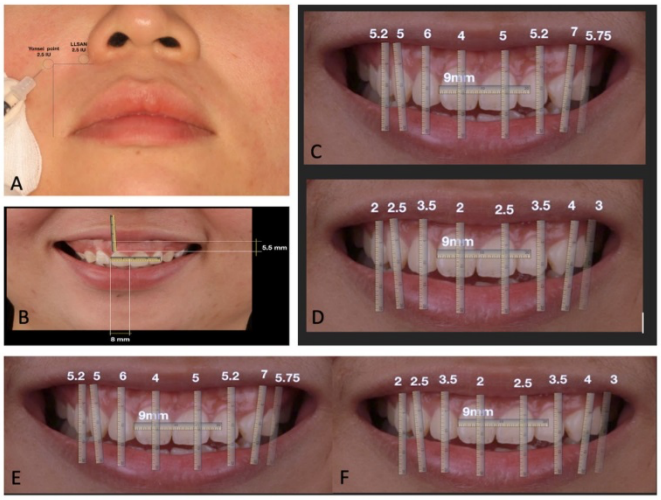

Fig 2.

A. The BTX-A injection site and dosage in gummy smile treatment
B. Mesial-distal tooth dimension and the clinical level of gingival exposure were measured with a digital caliper
C. Photos were processed using Keynote software version 9.2
D. Photos were processed using Keynote software version 9.2
E. Photos were processed using Keynote software version 9.2
F. All photos were processed using Keynote software version 9.2

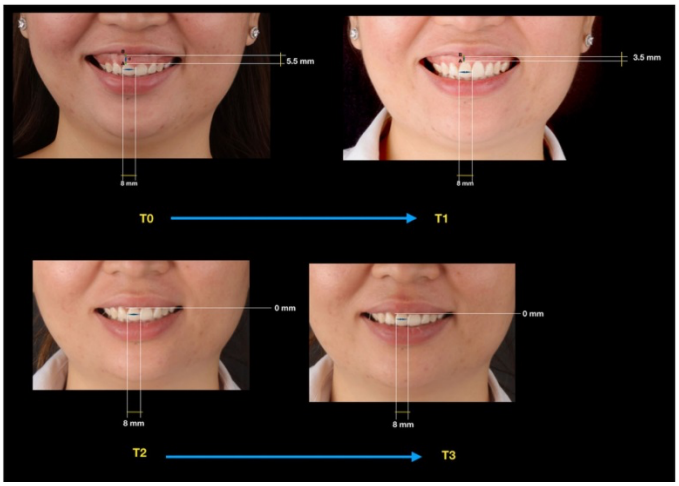

Fig 3. Processing smile photos with computer software.

2.10. Statistical analysis

Descriptive statistics were mean ± standard deviation values given for the numerical variables.

Analysis was performed to determine the difference between the clinical degree of gingival exposure before and after clinical crown lengthening surgery. Also, gingival exposure before and after the BTX-A injection was compared. Data were reviewed and analyzed using SPSS software (version 20.0; SPSS, Chicago, III). Student paired t-test was applied if variables were normally distributed. Otherwise, the Wilcoxon test was used for pair comparison.

It was considered statistically significant when p value < 0.05.

3. Results

Twenty-one patients (20 females and one male) aged 24.67 ± 3.44 visited the Dental Clinic of FOS-UMPH from August 2020 to May 2021 with the chief complaint of gummy smile. Among them, one patient dropped out of the study due to intermittent participation. After gingivectomy, the patient felt satisfied that she did not want to continue with the BTX-A injection. Thus, 20 patients (19 females and one male) at an average age of 24 years old completed all study requirements. Each patient had four photos taken at T0, T1, T2, and T3.

Average gingival exposure in each tooth and overall of one participant was shown in Table 1, Fig. 4A, B, and Table 2. The average gingival display at baseline was 5.35 ± 0.97 mm and 1.14 ± 0.79 mm at T3.

Gingival exposure in individual teeth after crown lengthening surgery (T1) and BTX-A injection after two weeks (T2) and two months (T3) were significantly different (p <0.001). Additionally, Mean gingival exposure change after crown lengthening surgery (T1) and BTX-A injection at two weeks (T2) and two months (T3) were statistically different (p <0.001) (Fig. 4C).

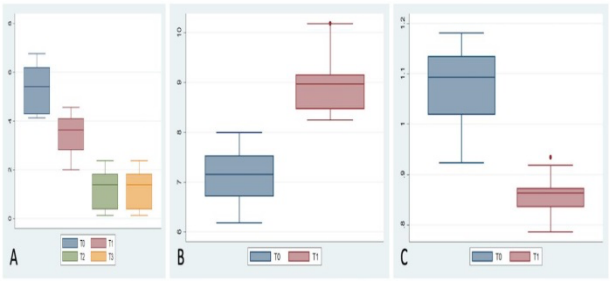

Fig 4.

A. Comparison of mean gingival exposure change after crown lengthening surgery (T1) and BTX-A injection at 2 weeks (T2) and 2 months (T3)
B. The mean clinical crown length change after crown lengthening surgery (T1)
C. Change of crown width/length ratio in individual teeth after crown lengthening

Clinical crown length was significantly changed after gingivectomy surgery (T1) compared to preoperative (T0), p <0.001 (Table 3). Differences of gingival exposure were 1.86 mm at T1, 4.20 mm at T2, and 4.21 mm at T3, compared to T0.

Width/length ratio of CCL also altered significantly, p < 0.001 (Table 4). No complication from BTX-A was noted.

4. Discussion

Our clinical trial suggested that a combination of gingivectomy surgery and botulinum toxin A injection effectively improved the esthetics of gummy smiles. The average age of our population was 24.67 ± 3.44. This age group has reached stabilization of craniofacial structures and has not been affected by physiological tooth wear. In

Table 1. Comparison of changes in gingival exposure in individual teeth after crown lengthening surgery (T1) and at two weeks (T2) and two months (T3) after BTX-A injection

Tooth	TO		T1		T2		T3		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	p value
14	5.58	1.51	3.88	1.04	1.33	1.24	1.28	1.19	
13	5.28	1.61	3.30	1.52	1.10	1.21	1.10	1.21	
12	6.30	0.99	4.15	1.08	1.80	1.01	1.80	1.01	
11	4.76	1.22	2.95	1.16	0.83	1.07	0.83	1.07	<0.001
21	4.85	1.51	3.03	1.21	0.83	1.07	0.83	1.07	
22	5.90	1.40	3.98	1.21	1.45	1.39	1.43	1.35	
23	5.43	1.29	3.58	1.31	0.93	0.89	0.93	0.89	
24	4.75	1.64	3.10	1.40	0.98	0.73	0.93	0.77	

Table 2. Comparison of mean gingival exposure change after crown lengthening surgery (T1) and at two weeks (T2) and two months (T3) after BTX-A injection

	Mean	SD	p value
T0	5.35	0.97	<0.001
T1	3.49	0.83	
T2	1.15	0.80	
T3	1.14	0.79	

Table 3. The clinical crown length change in individual teeth after crown lengthening surgery

Tooth	TO		T1		p value
	Mean	SD	Mean	SD	
14	6.25	1.01	7.65	0.84	< 0.001
13	7.50	0.71	9.28	0.83	
12	6.60	0.42	8.70	0.55	
11	7.88	0.79	9.93	0.52	
21	7.88	0.74	9.93	0.52	
22	6.95	0.54	8.80	0.44	
23	7.35	0.96	9.45	0.83	
24	6.48	0.88	7.70	0.73	

Table 4. Change of crown width/length ratio in individual teeth after crown lengthening surgery (T1)

Tooth	T0		T1		p value
	Mean	SD	Mean	SD	
14	1.15	0.16	0.93	0.08	< 0.001
13	1.06	0.09	0.85	0.07	
12	1.04	0.09	0.79	0.07	
11	1.06	0.14	0.84	0.06	
21	1.06	0.11	0.84	0.06	
22	1.01	0.10	0.80	0.09	
23	1.06	0.11	0.81	0.06	
24	1.16	0.15	0.98	0.07	

addition, the patients' smile lines and soft tissues have not changed significantly due to aging

Gender distribution in this study was 92, 86 % female and 7, 14% male, so the difference in the gender ratio was statistically significant (p <0.001). Hagai Miron et al. (15) studied subjects from 20 to 40 years old showed that the prevalence of gummy smiles in women was 2.5 times higher than in men. Thus there is a concordance in the gummy smile prevalence reported in literature (5). In addition, the percentage of women interested in smile esthetic is higher than that of men, which also contributes to the severe discrepancy in gender distribution. However, all comparisons were performed in the same group at different timelines so that sexual distribution did not affect the result.

The study sample was carefully selected at baseline to ensure that the average gummy smile calculated from teeth 14 to 24 was at least 4 mm (Table 1). Focused subjects were patients with gummy smiles caused by a combination of variable passive eruption and hyperactive upper lip muscles (the maxillary lip generally translates more than 8 mm from the repose position to the position achieved at a full smile). Other etiologies of gummy smiles, such as maxillary bone overgrowth or vertical maxillary excess or neuromuscular disorders, were not included in this study.

Literature has indicated the effectiveness of gingivectomy in gummy smile correction in mild and moderate cases (*). Consistently, our result reported that the gingival display level was statistically significantly reduced by about 1.8 mm ($p < 0.001$) after clinical crown lengthening surgery. Therefore, surgical treatment of gummy smiles is effective for patients with altered passive eruption. In addition, the decrease of gum exposure after the surgery from the upper incisors to the upper premolars was statistically significant. Therefore, clinical crown lengthening surgery should be indicated in aesthetics cases or before the restorations for subgingival decayed, broken teeth.

Furthermore, this surgical procedure helped reestablish the correct clinical crown and adjust gingival asymmetry (16) . However, it is still a challenge for clinicians to treat gummy smiles. A large amount of bone reduction can lead to gingival recession, while recurrence may occur with insufficient bone grinding.

To design an effective treatment plan for gummy smile cases, it is necessary to carefully analyze both the white aesthetic and the pink aesthetic. Gingivectomy surgery improves tooth height, bringing teeth to a favorable golden ratio. However, it is also essential to calculate the future width/length ratio of the teeth (17). A minimum of 2 to 5 mm of keratinized gingiva was required in clinical crown lengthening to maintain the periodontal tissue health (16).

Preserving interdental papillae is very important anatomically and esthetically. The alveolar bone crest at the gingival papillae should be carefully removed to ensure anatomical structure maintenance and establishment of reattachment after flap elevation, and the distance from the bone crest to the contact point must be sufficient (about 5 mm or less) (18). Bone should be removed carefully, respecting the minimum space for biological width. Reports showed that at least 3 mm of gingiva would remodel coronal after six months when the flap was sutured at bone crest (18). In the present study, the flap was repositioned at least 2.04 mm away from the bone crest, which is the minimum space for biologic width, to prevent recurrence.

On the other hand, clinical crown length after two months was significantly improved (about 1.82 mm), compared to the initial tooth position. Furthermore, gingival display level reduced significantly from T1 (2 months after the surgery) to T2 (2 weeks after BTX-A injection) with $p < 0.05$ (1.86 mm and 4.20 mm, respectively). Hence, BTX-A was effective in reducing gingival display level 3 days after injection. It is consistent with the study by Ahmet (2020) (19). The same dermatologist performed the BTX injection procedure with standardized doses and anatomical marks to eliminate confounding factors.

At two weeks post-injection (T2), BTX-A reached its peak effect (9, 20). Mean gingival display at T2 was 1.41 mm, while it reached 3.54 mm before the injection of BTX – A (T1). No complication from BTX-A was noted. This result was similar to a previous study by Polo (20), reporting that the average gingival exposure when smiling was 5.2 mm at the baseline and 0.09 mm after 15 days of BTX - A injection. Likewise, Suber et al. (21) showed that mean gingival display was 4.89 mm and only 0.75 mm at baseline and 15 days after BTX injection, respectively. There is a difference in the level of reduction of gingival display among studies, which may be due to the different sample sizes, inter-surgeon variation, and possible differences in metabolism among races, living in various geographical regions. However, we could safely conclude that BTX-A effectively reduced gingival exposure in mild gummy smile patients.

Although BTX-A injection is the least invasive treatment, results are temporary. BTX-A efficacy will fade away slowly after 3-6 months. If the patient wants to maintain that result, he/she has to re-inject BTX-A. Another common disadvantage of BTX injection is ptosis, Joker-like smiles, and difficulty functioning chewing function. This effect is common, caused by f BTX overdose or poor injection technique. Therefore, BTX-A injection should be performed by an experienced dermatologist. In 2010, Rosemarie M et al. (22) divided GS into four types dependent on excessive contraction of specific muscles, including gingival exposure more than 3mm at only six upper anterior teeth, gingival exposure more than 3mm at only upper posterior teeth, gingival exposure more than 3mm at both of upper anterior and posterior teeth with bilateral symmetry and gingival exposure more than 3mm at both of upper anterior and posterior teeth with bilateral asymmetry. Therefore, the position and dosage of BTX-A applied were different among GS types.

We recommended oral hygiene after clinical crown lengthening to achieve the best tissue healing outcome. The subjects were instructed to rinse their mouth with 15ml chlorhexidine gluconate 0.12% after surgery, twice a day (within two weeks), brush their teeth gently with a soft-bristle toothbrush. Oral instruction was repeated every visit. These may enhance the outcomes of gummy smiles (23).

Clinical crown lengthening surgery reduced gingival exposure significantly when smiling by increasing the crown height and adjusting the width: length ratio of the clinical crown to a proper aesthetical standard. The results were enhanced by BTX-A injection, proven by observations at three days, two weeks, and two months post-injection. There were no complications or side effects in the present study. Safe injection sites were levator labii superioris, levator labii superioris alaque nasi, zygomaticus minor and zygomaticus major muscle. From our findings, we suggest that BTX-A is a favorable adjunctive treatment for gummy smile patients after gingivectomy surgery.

Conflict of interest

The authors declared no conflict of interest.

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