Journal of Dental Sciences 17 (2022) 89–95

Available online at www.sciencedirect.com

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journal homepage: www.e-jds.com

Journal of Dental Sciences

Original Article

Flapless Er,Cr:YSGG laser versus traditional flap in crown lengthening procedure

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Received 16 March 2021; Final revision received 8 May 2021
Available online 11 June 2021

KEYWORDS
Closed flap crown lengthening;
Crown lengthening;
Er,Cr:YSGG laser;
Flapless crown lengthening

Abstract *Background/purpose:* Laser technology and minimally invasive therapy has gained attention in many dentistry fields. Er,Cr:YSGG laser is the latest laser type that can be applied on both soft tissue and hard tissue. This study presents periodontal outcome of Er,Cr:YSGG laser flapless crown lengthening procedure compared with traditional technique.
Materials and methods: Twenty-five participants were divided into two groups: 13 patients were treated with the traditional method of crown lengthening and 12 patients were treated using a flapless Er,Cr:YSGG laser. Their periodontal status were measured and compared at baseline, immediately, one month, and three months after surgery.
Results: The results showed a significant increase in clinical crown length immediately after surgery in both groups. After a three-month follow-up, the gingival margin of the laser group remained at stable height with 0.17 ± 0.31 mm increase after surgery, while the gingival margin of traditional group showed both recession and rebounding by -0.13 ± 0.63 mm ($p > 0.05$) average.
Conclusion: The flapless Er,Cr:YSGG laser crown lengthening with its minimally invasive approach without flap reflection may be an alternative treatment for providing an adequate height of tooth for restoration.

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https://doi.org/10.1016/j.jds.2021.05.004
1991-7902/

Introduction

Crown lengthening is a procedure accomplished by scalpel and rotary instruments in a traditional approach. However, electrosurgery, piezoelectric devices, and lasers are alternative treatments to increase an adequate outcome in the present.[1–4]

Advantages of traditional crown lengthening are low cost, good visibility, and convenience to access the surgical field. However, it may lead to post-surgical complications including inflammation, excessive bleeding, and gingival margin alterations.[5–8]

The Er,Cr:YSGG laser, a new kind of erbium laser has an active medium of erbium, chromium, yttrium, scandium, gallium, and garnet ions with an emission wavelength of 2780 nm. This mid-infrared wavelength has high absorption in water and hydroxyapatite which makes its application appropriate when ablating soft tissue and hard tissue by thermomechanical ablation with minimal collateral thermal damage and tissue charring.[9] Er,Cr:YSGG laser offers a minimally invasive alternative with lower risks than the traditional technique owing to blood vessel sealing ability, less bleeding, less mechanical trauma, less postoperative discomfort, and shorter chair time.[10,11]

Furthermore, the flapless approach eliminates the need for flap reflection which diminishes swelling and omits the need for stitches. Suturing can cause irregular tissue positioning due to tissue contraction.[11]

Until now, there is no clinical controlled study comparing between flapless Er,Cr:YSGG laser crown lengthening and traditional approach. Only case reports and case series were published.

Materials and methods

Twenty-five periodontally healthy patients (aged 22–69 years) from Faculty of Dentistry, Srinakharinwirot University for pre-restorative crown lengthening surgery. This study protocol was approved by The Human Research Ethics Committee of Srinakharinwirot University [Bangkok] (Code: SWUEC 155/2562F). Each subject was informed and signed consent after accepting for risks and benefits of the study. The inclusion criteria were: 1) Probing depth (PD) $\leq$3 mm; 2) Treated teeth had adequate attached gingiva width and should maintain $\geq$2 mm after surgery; 3) not more than 1 degree of tooth mobility; 4) Treated teeth must have crown: root ratio less than 1:1 and must not cause furcation involvement post-surgery. Participant with systemic conditions that were contraindications to periodontal surgery or would affect tissue healing or bone metabolism, with previous surgery at the region to be treated, with exostosis, torus mandibularis, or infected lesions at the surgical sites were excluded.

Before surgery, patients received dental prophylaxis and oral hygiene instruction. The following clinical parameters were collected: 1) Relative gingival margin (RGM) is a distance from reference stent to the gingival margin); 2) Relative bone level (RBL) is a distance from reference stent to the alveolar bone crest (bone sounding) measured under local anesthesia; 3) plaque index (PI) according to Silness and Löe[12]; 4) gingival index (GI) according to Löe and Silness[13]; 5) biotype according to Frost et al.[14]; 6) Attached gingiva width was obtained by subtracting probing depth from keratinized gingiva width at the mid-facial aspect of treated tooth; 7) tooth mobility.

All measurements were performed by one examiner using UNC-15 periodontal probe (Hu-Friedy, Chicago, IL, USA). Furthermore, the RGM and RBL were measured at 6 sites around each tooth using UNC-15 periodontal probe (Hu-Friedy) beyond a customized clear acrylic stent with vertical grooves at appropriate sites to standardize probe placement and angulation (Fig. 1). The RGM, RBL, and attached gingiva width were rounded off to the nearest millimeter. Calibration exercises to achieve $\geq$95% intra-examiner reproducibility of measurements were conducted before the study started; the assessment was made by an independent source.

Surgical procedure

Traditional technique: The scalpels were used to perform internal beveled and sulcular incisions and gingival tissue removal. In cases with inadequate attached gingiva (<3 mm) sulcular incision with apically positioned flap would be performed instead. A full-thickness mucoperiosteal flap was reflected to remove and recontour alveolar bone as necessary, using rotary instruments until a distance of 3 mm from the alveolar bone crest to the future restoration margin was achieved. The gingival margin was sutured at the future restoration margin position. Coe-Pak™ (GC America, Alsip, IL, USA) was applied.

Flapless Er,Cr:YSGG laser: Er,Cr:YSGG laser (Waterlase C100, Biolase, Irvine, CA, USA) with a setting of 1.5 W, 7% water, and 11% air and G6 laser tip (0.6 mm in diameter, 6 mm in length) were used to perform internal beveled and laser troughing to remove gingival tissue. The tip was placed parallel to the root surface and moved from side to side,[11] keeping the gingival margin at the future restoration margin. The alveolar bone was removed and recontoured until a 3-mm distance between the alveolar crest and the future restoration margin was achieved via incisions without flap elevation using Er,Cr:YSGG laser with a setting of 3.5 W, 50% water, and 40% air and G6 laser tip. The tip was placed

Figure 1 Representative photograph with the clear acrylic stent when collecting data.

parallel to the root surface, perpendicular to the alveolar crest and moved from side to side,[11] then slight tilted the tip away from the root surface to recontour the buccal and/or lingual cortical plate to prevent vertical bone defects or bony ledges.[15] The bone ablation relied on tactile sense without an open-flap procedure. The amount of bone removal was guided by applying a periodontal probe periodically. Control of bleeding and tissue adaptation were performed by pressing the wound with moist gauze. No sutures and periodontal dressing were used.

All treatments were performed by a single periodontist and started after local anesthesia. The numerical rating scale of pain (NRS) was obtained through patient 1 day after surgery by phone call (patients assessed pain severity using numerical scores ranging from zero to ten). The sutures of the traditional group were removed after 7 days. Figs. 2 and 3 demonstrate both surgical techniques and their clinical results.

The PI, and GI were recorded at baseline, 1 month, and 3 months post-surgery. While, RGM was recorded at baseline, immediately post-surgery, 1 month, and 3 months post-surgery. The RBL was recorded at baseline, immediately post-surgery, and 3 months post-surgery. The attached gingiva width and tooth mobility were recorded at baseline and 3 months post-surgery.

Figure 2 Traditional techniques and clinical results (tooth number 14). (A—B: Baseline, C—D: 7 day post-surgery (stitched off visit), E—F: 1 month post-surgery, G—H: 3 months post-surgery).

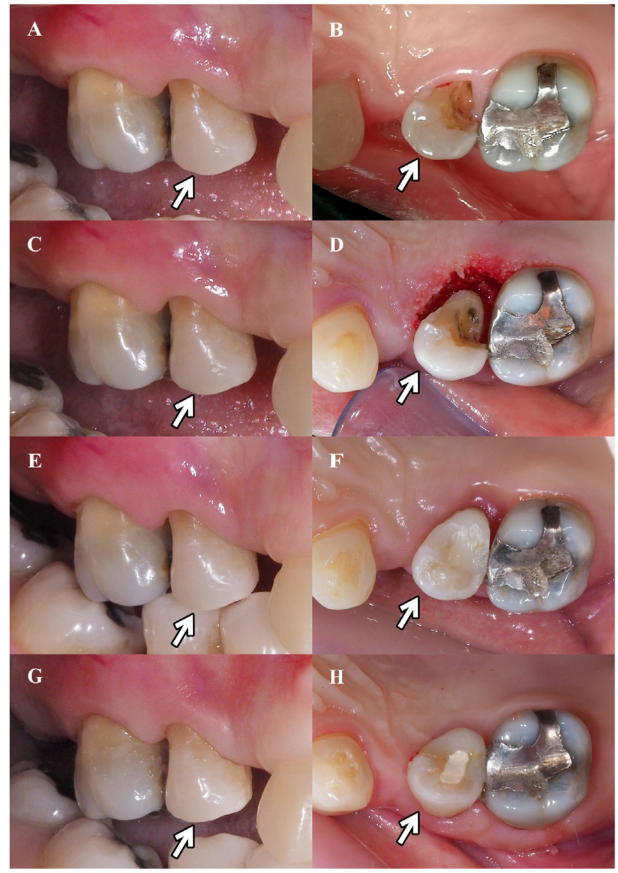

Figure 3 Flapless Er,Cr:YSGG laser techniques and clinical results (tooth number 15). (A—B: Baseline, C—D: immediately post-surgery, E—F: 1 month post-surgery, G—H: 3 months post-surgery).

Data analysis

The primary outcome was mean change in the gingival margin. Secondary outcomes included the additional clinical parameters and NRS scores of pain. Statistical analysis was performed employing the SPSS® software version 25. Datas were examined for normality by the Shapiro—Wilk test. The clinical parameters were computed separately for treated and adjacent teeth of traditional and laser groups. Differences (Δ) of RGM and RBL were calculated for both groups. The One-way repeated-measures ANOVA was used to detect RGM and RBL of treated teeth and RBL of adjacent teeth differences between time points. The Friedman test and Bonferroni correction were used to compared PI, GI, ΔRGM of both treated and adjacent teeth, and RGM of adjacent teeth differences between time points. The Wilcoxon test was used to compare ΔRBL and attached gingiva width of treated teeth and ΔRBL of adjacent teeth differences between time points. RBL of adjacent teeth differences between groups were compared using the unpaired sample t-test. The Mann—Whitney U test was used to compare PI, GI, RGM, ΔRGM, RBL, and ΔRBL of treated teeth, PI, GI, RGM, ΔRGM, and ΔRBL of adjacent teeth, attached gingiva width, and NRS scores of pain differences between groups. The level of significance was set at 0.05 for all analyses.

Results

The 25 patients completed 3 months evaluation period. No post-surgical complications were observed. There were no significant differences in patient characteristics between the laser and traditional groups (Table 1).

Treated teeth

Relative gingival margin (RGM) and difference of relative gingival margin (ΔRGM)

The RGM means increased significantly at all time points for both groups (Table 2). However, there was no statistically significant differences between groups (Table 3). At 3 months compared to immediately post-surgery, the ΔRGM had a mean change in gingival margin of 0.13 ± 0.63 mm (negative values indicating tissue rebound) in the traditional group and 0.17 ± 0.31 mm in the laser group (Table 4 and Fig. 4).

Relative bone level (RBL) and difference of relative bone level (ΔRBL)

The RBL significantly increased in both groups from baseline to immediately post-surgery and 3 months (Table 2). And at 3 months, the RBL in the traditional group also significantly increased compared to immediately post-surgery. While at this time the RBL in the laser group is no change from immediately post-surgery. The ΔRBL from baseline to immediately post-surgery increased by 1.53 ± 0.68 mm in the traditional group and 1.43 ± 0.60 mm in the laser group. There was no significant difference found (Table 3).

Tooth mobility

At 3 months compared to baseline, the percentage of treated teeth with an increase in tooth mobility were 30.77% in the traditional group and 16.67% in the laser group (Table 3).

Adjacent teeth

Relative gingival margin (RGM) and difference of relative gingival margin (ΔRGM)

At immediately post-surgery, the RGM of both groups were not statistically significantly different from baseline (Table 2). However, after 1 month and 3 months the RGM of both groups showed a significant increase compared to baseline. The ΔRGM from baseline to immediately post-surgery were 0.40 ± 0.36 mm in the traditional group and 0.17 ± 0.22 mm in the laser group (Table 3). The ΔRGM from baseline to 1 month and 3 months post-surgery in the traditional group showed statistically significant differences compared to the

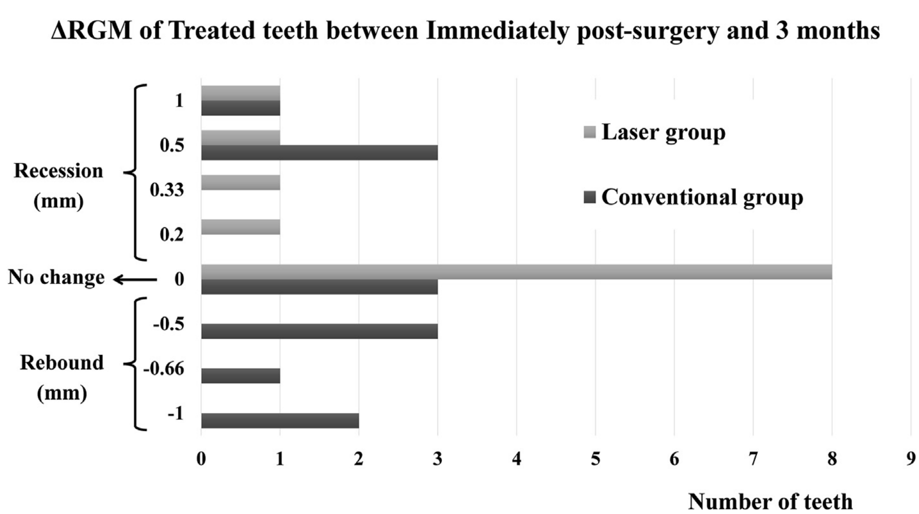

Figure 4 Distribution of the frequency of treated teeth that has changed of relative gingival margin (ΔRGM) from immediately post-surgery to 3 months.

Table 1 Demographic characteristics.

	Traditional group	Laser group	p-value
Number of teeth	13	12	
Number of adjacent teeth	22	18	
Sex (male: female)	2 : 11	2 : 10	0.930
Age	43.10 ± 15.67	46.74 ± 13.58	0.543
Biotype (thin: thick)	3 : 10	3 : 9	0.910
Tooth types (anterior: premolar: molar)	4 : 5: 4	4 : 3: 5	0.751

No differences between groups for any parameters [Age: Unpaired t-test ($p < 0.05$), Sex, Biotype, and Tooth types: Chi–Square test ($p < 0.05$)].

Table 2 Mean (±SD) of the parameters of treated teeth and adjacent teeth.

Parameters	Treated teeth				Adjacent teeth			
	Baseline	Immediately post-surgery	1 month	3 months	Baseline	Immediately post-surgery	1 month	3 months
Plaque index (PI)								
Traditional	0.42 ± 0.26	–	0.25 ± 0.18	0.35 ± 0.16	0.35 ± 0.22	–	0.28 ± 0.14	0.33 ± 0.21
Laser	0.31 ± 0.11	–	0.29 ± 0.41	0.33 ± 0.16	0.34 ± 0.11	–	0.27 ± 0.19	0.36 ± 0.19
Gingival index (GI)								
Traditional	0.31 ± 0.23	–	0.35 ± 0.19	0.37 ± 0.24	0.26 ± 0.16	–	0.31 ± 0.12	0.27 ± 0.16
Laser	0.33 ± 0.12	–	0.33 ± 0.48	0.33 ± 0.22	0.35 ± 0.11	–	0.30 ± 0.17	0.35 ± 0.18
Relative gingival margin (RGM)								
Traditional	3.99 ± 1.63	5.73 ± 1.75[b]	5.67 ± 1.78[b]	5.60 ± 1.71[b]	4.43 ± 1.38	4.83 ± 1.57	4.99 ± 1.57[a]	4.95 ± 1.45[a]
Laser	3.80 ± 0.89	5.28 ± 0.96[b]	5.45 ± 0.94[b]	5.45 ± 0.94[b]	3.86 ± 0.87	4.03 ± 0.91	4.06 ± 0.92[a]	4.07 ± 0.92[a]
Relative bone level (RBL)								
Traditional	7.38 ± 1.42	8.91 ± 1.27[b]	–	9.13 ± 1.34[b,c]	7.67 ± 1.32	8.05 ± 1.27[b]	–	8.24 ± 1.37[b,c]
Laser	7.43 ± 0.94	8.86 ± 1.02[b]	–	8.86 ± 1.02[b]	7.37 ± 0.69	7.58 ± 0.70	–	7.58 ± 0.70

[a] Significant differences from baseline (Friedman's two-way analysis of variance by ranks and Bonferroni correction; p-value< 0.05).
[b] Significant differences from baseline (One-way ANOVA and Bonferroni correction; p-value<0.05).
[c] Significant differences from immediately post-surgery (One-way ANOVA and Bonferroni correction; p-value<0.05).

Table 3 Difference (Δ) of the parameters of treated teeth and adjacent teeth.

Parameters	Treated teeth				Adjacent teeth			
	Baseline to immediately post-surgery	Baseline to 1 month	Baseline to 3 months		Baseline to immediately post-surgery	Baseline to 1 month	Baseline to 3 months	
ΔRelative gingival margin (ΔRGM)								
Traditional	1.74 ± 0.74	1.68 ± 0.58	1.61 ± 0.57		0.40 ± 0.36	0.56 ± 0.34[a,c]	0.52 ± 0.26[c]	
Laser	1.48 ± 0.52	1.65 ± 0.43	1.65 ± 0.43		0.17 ± 0.22	0.21 ± 0.24	0.22 ± 0.25	
ΔRelative bone level (ΔRBL)								
Traditional	1.53 ± 0.68	–	1.74 ± 0.67[b]		0.38 ± 0.31	–	0.57 ± 0.31[b,c]	
Laser	1.43 ± 0.60	–	1.43 ± 0.60		0.21 ± 0.32	–	0.21 ± 0.32	
ΔMobility			No change	Increase of 1°			No change	Increase of 1°
Traditional	–	–	69.23%	30.77%	–	–	100%	0%
Laser	–	–	83.33%	16.67%	–	–	100%	0%

[a] Significant differences from baseline to immediately post-surgery (Friedman's two-way analysis of variance by ranks and Bonferroni correction; p-value<0.05).
[b] Significant differences from baseline to immediately post-surgery (Wilcoxon signed-rank test; p-value<0.05).
[c] Significant differences between groups (Mann—Whitney U test; p-value<0.05).

laser group. At 3 months compared to immediately post-surgery, the ΔRGM had a mean change in gingival margin of 0.11 ± 0.33 mm in the traditional group and 0.03 ± 0.05 mm in the laser group (Table 4).

Relative bone level (RBL) and difference of relative bone level (ΔRBL)

At 3 months, the RBL in the traditional group significantly increased compared to immediately post-surgery. Meanwhile, the RBL in the laser group did not change (Table 2).

Tooth mobility

Tooth mobilities of both groups were unchanged after surgery (Table 3).

Attached gingiva width

Before surgery, attached gingiva widths were 3.38 ± 1.76 mm in the traditional group and 5.25 ± 1.54 mm in the laser group, and were significantly different between groups. At 3 months, the laser group had significantly lower attached gingiva width than the traditional group (Table 5).

Numerical rating scale of pain

The pain severity of 1 day post-surgery reported by the laser group (0.92 ± 1.78) was significantly lower than that of the traditional group (3.77 ± 1.17) (Table 6).

Table 4 Difference of relative gingival margin (ΔRGM), % site recess, rebound and without changed of treated teeth and adjacent teeth.

Parameter	Treated teeth				Adjacent teeth			
	Immediately post-surgery to 3 months				Immediately post-surgery to 3 months			
ΔRGM	Mean (±SD)	Recession	Rebound	No change	Mean (±SD)	Recession	Rebound	No change
Traditional	-0.13 ± 0.63	30.77%	46.15%	23.08%	0.11 ± 0.33	61.54%	23.08%	15.38%
Laser	0.17 ± 0.31	33.33%	0%	66.67%	0.03 ± 0.05	33.33%	0%	66.67%

No differences between groups (Mann–Whitney U test; p-value >0.05).

Table 5 Mean (± SD) and % site with ≤2 mm and >2 mm of attached gingiva width at baseline and 3 months.

	Baseline		3 months		p-value
Attached gingiva width					
Traditional	3.38 ± 1.76[b]		3.15 ± 1.53[b]		0.063
Laser	5.25 ± 1.54		4.58 ± 1.24[a]		0.011
% site	≤2 mm	>2 mm	≤2 mm	>2 mm	
Traditional	46.2%	53.8%	46.2%	53.8%	
Laser	0%	100%	0%	100%	

[a] Significant differences from baseline (Wilcoxon signed-rank test; p-value<0.05).
[b] Significant differences between groups (Mann–Whitney U test; p-value<0.05).

Table 6 Numerical rating scale (NRS) of pain 1 day post-surgery.

	Traditional	Laser	p-value
NRS	3.77 ± 1.17	0.92 ± 1.78	0.000[a]

[a] Significant differences between groups (Mann–Whitney U test; p-value<0.05).

Discussion

This study is the first study to compare the clinical results of flapless Er,Cr:YSGG laser and traditional flap crown lengthening. Both methods have been successful in increasing the clinical crown, which can perform on all tooth types without any complications. The Er,Cr:YSGG laser, with proper setting and technique, could ablate both gingival and alveolar bone and provide favorable and uneventful wound healing without damaging nearby tissues. That is consistent with previous studies, including the results of Perussi et al.[16] which revealed that soft tissue incisions produced by the Er,Cr:YSGG laser showed similar wound healing to those produced by the scalpel, and the results of Kimura et al.[17] which revealed that the Er,Cr:YSGG laser is efficient in precisely bone ablation and causing minimal thermal damage to nearby tissues.

The alveolar bone is blindly resected in the flapless Er,Cr:YSGG laser method. A periodontal probe is used to check its integrity. However, the flapless Er,Cr:YSGG laser technique is easy to perform, and less time consuming due to minimal bleeding during the surgery and no stitches or periodontal dressing required that is consistent with previous studies.[18–21]

The gingival margin in the laser group appeared to be more stable than the traditional group after 3 months (see Fig. 4). The findings of this study are consistent with Farista et al.[22] (which showed minimal tissue placement after performing the closed flap osseous crown lengthening procedure using Er,Cr:YSGG lasers) and other prior studies (which demonstrated that a tissue rebound was often present after traditional crown lengthening,[5–7] and may occur largely during the first three postoperative months.[23]).

The traditional flap technique was suitable for the limited attached gingiva width that can be preserved by sulcular incision and apically-positioned flap technique, while the flapless technique is a contraindication in cases with limited attached gingiva because of gingivectomy procedure. After surgery, the attached gingiva width was not less than 2 mm in both groups as recommended by Maynard et al. and Lang et al.[24,25]

This present study also found significantly greater bone resorption of treated teeth in the traditional group at 3 months compared to immediately post-surgery whereas treated teeth in the flapless laser group showed no bone resorption. This is an interesting issue but there is insufficient research in this area. Therefore, further studies should be undertaken.

The periodontium of adjacent teeth in the traditional group was more prone to damage than the laser group because of flap reflection. Therefore, the gingival margin position of adjacent teeth post-surgery in the laser group tended to be more stable than in the traditional group. Moreover, bone resorption was not observed post-surgery in the laser group and greater bone resorption was observed in the traditional group at 3 months post-surgery. This is consistent with previous studies that investigated bone resorption after full-thickness flap procedure.[26–29]

The severity of pain 1 day post-surgery in the laser group was much less than that of the traditional group. This outcome is consistent with previous studies including Ribeiro et al. and Fekrazad et al.[20,30] Furthermore, proper usage of Er,Cr:YSGG laser is associated with reduction in complications experienced by traditional crown lengthening, reduction in bleeding and inflammatory response while performing surgery, faster wound healing time, and lower postoperative discomfort.[10,18] The flapless Er,Cr:YSGG laser technique is therefore an adequate alternative to crown lengthening procedure, especially for patients who are afraid of surgery.

However, the Er,Cr:YSGG laser machine including laser tips and its maintenance costs are very expensive, causing the cost of treatment to be high as well. The clinical procedures are technique sensitive. Therefore, clinicians must be skillful and perform the tasks with caution. Moreover, laser emisssion can cause ocular injury, protective laser spectacles should be employed by patients and staffs for eye protection.[31]

The main limitations of the current study were, first, a small sample size. Second, our study included both participants with sufficient and insufficient attached gingiva. Hence, a randomized controlled trial could not be conducted because the Er,Cr:YSGG laser flapless technique is a contraindication in cases with insufficient attached gingiva.

This study concluded that the flapless Er,Cr:YSGG laser crown lengthening technique could be a minimally invasive approach for providing adequate height of tooth and allowing accurate estimate of the final gingival margin position after the surgery.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Acknowledgments

This study was supported by research fund of faculty of dentistry, Srinakharinwirot University.

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