# **Original Article**

# Laser-Aided Circumferential Supracrestal Fiberotomy and Low-Level Laser Therapy Effects on Relapse of Rotated Teeth in Beagles

Su-Jung Kim<sup>a</sup>; Joo-Hee Paek<sup>b</sup>; Ki-Ho Park<sup>c</sup>; Seung-Goo Kang<sup>d</sup>; Young-Guk Park<sup>e</sup>

## ABSTRACT

**Objective:** To investigate the effectiveness and periodontal side effects of laser circumferential supracrestal fiberotomy (CSF) and low-level laser therapy (LLLT) on orthodontically rotated teeth in beagles.

**Materials and Methods:** Eighteen mandibular incisors from nine dogs were divided into three groups by treatment (n = 6/group): A, orthodontic couple force application only (control); B, laser CSF following orthodontic couple force application; and C, LLLT following orthodontic couple force application. Both mandibular lateral incisors were rotated for 4 weeks, and the relapse tendency was observed for 4 weeks more without any retainers. The amount of relapse, sulcus depth, and gingival recession were measured at weeks 4 and 8. One-way analysis of variance (ANOVA) and Scheffé's post hoc test were used for data analysis. Tissue specimens were examined at week 8 under light microscopy after hematoxylin-eosin (H&E) and Masson's trichrome staining.

**Results:** The mean percentage of relapse was 41.29% in group A, 14.52% in group B, and 56.80% in group C (P < .001). Four weeks after laser CSF, the sulcus depth increased by 0.67 mm, but no gingival recession was observed. There was no significant difference between groups A and C in terms of sulcus depth and gingival recession.

**Conclusions:** Laser CSF is an effective procedure to decrease relapse after tooth rotation, causing no apparent damage to the supporting periodontal structures, whereas LLLT on orthodontically rotated teeth without retainers appears to increase the relapse tendency. (*Angle Orthod* 2010;80:385–390.)

KEY WORDS: Diode laser; Relapse; CSF; LLLT; Biostimulation

## INTRODUCTION

Stability of rotated teeth is a concern in orthodontic treatment. A significant cause of relapse is thought to be the gingival and transseptal fibers of the periodon-

<sup>c</sup> Research Fellow, Department of Orthodontics, Oral Biology Research Institute, College of Dentistry, Kyung-Hee University, Seoul, Korea.

<sup>d</sup> Assistant Professor and Chairman, Department of Orthodontics, Oral Biology Research Institute, College of Dentistry, Kyung-Hee University, Seoul, Korea.

<sup>o</sup> Professor, Department of Orthodontics, School of Dentistry, Kyung-Hee University, Seoul, Korea.

Corresponding author: Dr Young-Guk Park, Department of Orthodontics, School of Dentistry, Kyung-Hee University, 1 Hoegi-Dong, Dongdaemoon-Ku, Seoul 130-701, Korea (e-mail: ygpark@khu.ac.kr)

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tium, which are stretched and twisted as the tooth is rotated.  $^{\mbox{\tiny 1-3}}$ 

To relieve the rotated tooth from forces exerted by the stretched fibers, circumferential supracrestal fiberotomy (CSF) was introduced.<sup>4,5</sup> In simple CSF using a scalpel blade, intergingival, transgingival, transseptal, and semicircular fibers are transected. CSF appears to help the tissue remodel and decrease relapse of orthodontically rotated teeth. The literature indicates that periodontal problems such as pocket formation, loss of attached gingiva, and gingival recession do not occur after CSF.<sup>6</sup>

However, conventional CSF has some clinical drawbacks: poor patient acceptability as an invasive procedure, and it is feasible only on teeth with a healthy periodontium. This lack of patient acceptance despite its demonstrated advantage suggests that an alternative technique needs to be considered. In 1990, Frick and Rankine<sup>7</sup> demonstrated that electrosurgery is as effective as the conventional procedure for CSF, yet causes less bleeding and infection.

Laser offers numerous advantages compared with surgery. It offers biostimulatory effects, coagulates

<sup>&</sup>lt;sup>a</sup> Assistant Professor, Department of Orthodontics, Oral Biology Research Institute, College of Dentistry, Kyung-Hee University, Seoul, Korea.

<sup>&</sup>lt;sup>b</sup> Employee practitioner, Department of Orthodontics, YES dental hospital, Seoul, Korea.



Figure 1. Photographs of orthodontic buttons with elastic chains. (A) Occlusal view. (B) Frontal view.

blood vessels, seals lymphatics, and sterilizes the wound during ablation while maintaining a clear, clean, surgical field.<sup>8,9</sup> There is markedly less bleeding, minimal swelling, and less postoperative infection.<sup>10</sup> Laser CSF is expected to prevent relapse of orthodontically rotated teeth in addition to the advantages offered by the properties of laser.

Low-level laser therapy (LLLT) has biostimulatory effects such as stimulation of wound healing, collagen synthesis, and acceleration of bone remodeling during tooth movement.<sup>11–13</sup> However, its effects on the relapse tendency of orthodontically rotated teeth have not been fully characterized.

Therefore, this study was conducted to evaluate the effectiveness and periodontal side effects of laser CSF and LLLT on orthodontically rotated tooth. The specific aims were to compare the (1) amount of relapse, (2) sulcus depth, (3) gingival recession, and (4) connective tissue rearrangement.

## MATERIALS AND METHODS

Nine domestic male beagles, each weighing about 10–13 kg and aged 12–18 months were used. Eighteen mandibular lateral incisors were divided into three groups (n = 6/group), as follows: A, orthodontic couple force only (control); B, orthodontic couple force with laser CSF; and C, orthodontic couple force with LLLT. This project was approved by the Kyung Hee Medical Center Institutional Animal Care and Use Committee.

## **Experimental Tooth Movement**

Both mandibular lateral incisors were selected as the experimental teeth. Each dog was sedated with Zoletil 50 (Virbac Lab, France; 0.25 mg/kg, IM). A shallow groove was made on the facial enamel at the crest of the marginal gingiva as reference for measurement of the amount of gingival recession. Another groove was made on the incisal edge, and shallow pits were made on both second premolar cusp tips to measure the amount of rotation.

Orthodontic buttons (Ormco Corp, Orange, CA) were bonded to the labial and lingual surfaces of the experimental teeth and the labial surfaces of the mandibular canines with Superbond C&BR (Sun Medical Co, Moriyama, Japan). Elastic chains were engaged between buttons to create rotational couple forces (Figure 1). Each of these elastic chains exerted forces of around 50 gm. By grinding the incisal surfaces of the maxillary incisors, the experimental teeth were maintained out of occlusion. Rotational movement was accomplished within 4 weeks. The appliances were checked once a week to change the elastics.

After 4 weeks, the orthodontic couple forces were removed. No surgery was performed in group A, laser CSF was performed immediately after removing the orthodontic appliances in group B, and LLLT was carried out every 3 days for 4 weeks on group C. No retainer was used in any group. Rotational relapse of the experimental teeth were evaluated over a short observation period (4 weeks).

## Laser Supracrestal Fiberotomy

A gallium-aluminum-arsenide (Ga-Al-As) diode laser (SoftLase Pro; Zap Lasers, LLC, Pleasant Hill, Calif) with an 808-nm wavelength and 0.4-mm fiber diameter was used. Infiltration of 2% lidocaine (YuHan Co, Seoul, Korea) with 1:100,000 epinephrine provided local anesthesia during the procedure. Immediately before laser CSF was performed, the sulcus depth of each tooth was measured. The maximum depth of insertion of the fiber tip was determined to be the sum of the sulcus depth and biologic width (~2 mm).14,15 The laser tip was inserted into the gingival sulcus to the level of the alveolar bone crest, and the incision was extended around the tooth circumference with the system configured to the soft tissue cutting mode (continuous wave; 1.2 W). Postoperative care included gentamicin (Daesung Co, Seoul, Korea; 0.1 ml/kg) injection for one day.

## Low-Level Laser Therapy

The biostimulation mode (pulsed wave, 10 Hz, 763 mW, 4.63–6.47 J/cm<sup>2</sup>) was used for irradiation, with the fiber tip held 2–3 mm away from the gingiva. The coronal and apical thirds of the mesiobuccal, distobuccal, mesiolingual, and distolingual sides of the roots (totaling 8 regions) were irradiated every 3 days for 30 seconds each for 4 weeks.



**Figure 2.** The cast was placed on a prosthetic surveyor and photographed on a Kaiser copy stand. (A) Kaiser copy stand. (B) Prosthetic surveyor with dental cast.

#### Amount of Relapse

We took alginate (GC Co, Tokyo, Japan) impressions on day 1, and at weeks 4 and 8. On the original, rotational, and relapse casts, a sharp pencil line was drawn on the groove of the incisal edge of the experimental tooth, and dots were marked in the shallow pits of the mandibular second premolar cusp tips. The line linking both these cusp tips was used as the reference line.

Each cast was placed on a prosthetic surveyor (the posterior occlusal plane and the incisal plane were positioned parallel to the floor) and photographed with constant magnification on a Kaiser copy stand (Kaiser Fototechnik, Boston, Mass) (Figure 2). From the photographs, the original, rotational, and relapse angles were measured by using lines superimposed on the reference line and incisal edge line (Figure 3). Double-determination measurements were performed by two investigators independently.

#### **Pocket Depth and Gingival Recession**

A periodontal probe was used to measure the pocket depth and gingival height on day 1, and at weeks 4 and 8. The pocket depths were recorded on the mesiolingual, lingual, distolingual, mesiolabial, labial, and distolabial surfaces of the experimental teeth. The amount of gingival recession was measured from the shallow horizontal groove in the facial enamel, corresponding to the preoperative level of the free gingival margin.

#### **Histologic Examination**

All experimental animals were euthanized by direct injection of Zoletil 50 (50 mg/kg) (Virbac Laboratories, Carros France) into the heart at week 8. Tissue blocks were fixed in 10% neutral buffered formalin and decalcified in 10% ethylenediaminetetraacetic acid (EDTA) solution. Paraffin blocks were sectioned



Figure 3. Photographs of the dental casts. (A) Day 1. (B) Week 4.

perpendicular to the long axis of the experimental teeth, and the specimens were examined under light microscopy following hematoxylin-eosin (H&E) and Masson's trichrome staining.

#### **Statistical Analysis**

Data analysis was conducted using one-way analysis of variance (ANOVA) and Scheffé's post hoc test. A *P* value less than 0.05 was considered statistically significant.

## RESULTS

The degree of initial rotation and relapse, and rate of relapse are shown in Table 1. The mean (± SD) degree of rotation after 4 weeks was  $15.42^{\circ} \pm 2.60^{\circ}$  in group A,  $18^{\circ} \pm 4.98^{\circ}$  in group B, and  $17.25^{\circ} \pm 3.37^{\circ}$  in group C, without statistically significant differences (*P* < .05). The mean degree of relapse was  $6.42^{\circ} \pm 1.72^{\circ}$  in group A,  $2.58^{\circ} \pm 0.86^{\circ}$  in group B, and  $9.75^{\circ} \pm 2.44^{\circ}$  in group C. The mean percentages of relapse were  $41.29^{\circ} \pm 5.65\%$ ,  $14.52^{\circ} \pm 3.59\%$ , and  $56.80^{\circ} \pm 10.98\%$  in groups A, B, and C, respectively (Figure 4). The mean degree and mean percentage of relapse were statistically different (*P* < .001).

Figure 5 shows the average sulcus depth. All groups showed increased sulcus depth at week 4, which tended to decrease at week 8. In group B, the initial mean sulcus depth of 1.97 mm increased, reaching 3.14 mm at week 4, subsequently decreasing to

**Table 1.** The Means of Rotational Movement of Teeth in EachGroup Tested by One-Way ANOVA and Scheffé's Post HocComparison

	Degree of Rotation, $^{\circ}$	Degree of Relapse, $^{\circ}$	Relapse, %
Control Laser CSF LLLT F	15.42 ± 2.60 18.00 ± 4.98 17.25 ± 3.37 .741*	$\begin{array}{l} 6.42  \pm  1.72 \ \text{b} \\ 2.58  \pm  0.86 \ \text{c} \\ 9.75  \pm  2.44 \ \text{a} \\ 23.969^{***} \end{array}$	41.29 ± 5.65 <sup>b</sup> 14.52 ± 3.59° 56.80 ± 10.98° 49.742***

CSF, circumferential supracretal fiberotomy; LLLT, low-level laser therapy; F, degree of freedom.

 $M \pm SD; *P < .05; ***P < .001.$ 

a,b,c Order of mean value: a > b > c.



**Figure 4.** Percentage of relapse in the control, laser CSF, and LLLT groups. Asterisk indicates a significant difference between groups (P < .001). Values are mean  $\pm$  SD.

2.64 mm at week 8. Only in group B, pocket depth increased by 0.67 mm at week 8 compared with the initial level. No gingival recession was observed in any group (Figure 6). All groups showed gingival swelling due to wearing the orthodontic appliances for 4 weeks. However, after debonding, gingivitis subsided and the gingival height returned to its original level by week 8.

#### **Histologic Findings**

Supracrestal fibers of the experimental teeth in group A had a fiber pattern similar in density and arrangement to comparable areas of the nonrotated central incisors (Figure 7), showing mild waviness and then constant thickness.

Slight infiltration of inflammatory cells was observed in group B. Histological studies failed to show bone necrosis, sequestration, or destruction. Rearrangement of the fibrous structures was observed: the organizational pattern resembled that of the nonrotated teeth, in which large fiber bundles were seen interconnected with thin fibers (Figure 8).

Group C specimens showed no differences from group A specimens (Figure 9). As tooth relapse is a progressive condition, the diurnal changes and thickness of the fiber bundles, as well as the phase of the



Figure 5. Graph of the changes of gingival sulcus depth.

blood vessels, were similar to those of the control group.

#### DISCUSSION

The results of this study indicate that laser CSF alleviates the relapse of orthodontically rotated teeth. Four weeks after surgery, the supracrestal fibers had already healed and were rearranged regularly. There was no sign of gingival recession, although the periodontal pocket depth increased by about 0.67 mm. The approximate 1-mm increase in periodontal pocket depth at week 4 could have been caused by temporary hyperplastic gingivitis.

A short-wavelength laser (500 nm-1000 nm) is absorbed by pigmented tissue or blood elements but less absorbed by water or hydroxyapatite. Because light energy from the diode laser (810-830 nm) is highly absorbed by the soft tissues and poorly absorbed by teeth and bone, hard tissue damage is avoided.<sup>16</sup> In this study, we were able to confirm the safety of the diode laser CSF procedure because there was no particular injury to teeth or bone.

Basically, by stimulating thrombocyte activation and blood vessel congealment, a laser can provide a sense of relief to both doctor and patient, as there is less



Figure 6. Graph of the changes of gingival height.



**Figure 7.** Group A. Supracrestal fibers disclosed a fiber pattern with the nonrotated central incisors. (A) H&E staining,  $100 \times$ , (B) Masson's Trichrome staining,  $40 \times$ , (C)  $200 \times$ ; R, experimental tooth root; S, supracrestal fiber; N, nonrotated tooth.

blood loss during and after surgery. It can also reduce tissue swelling by sealing the lymphatic vessels.<sup>9</sup> For example, laser gingivectomy has advantages such as minimal bleeding and postoperative pain and no swelling.<sup>17</sup> Surgical lasers typically have (1) a central zone of carbonization surrounded by, (2) a zone of vaporization, coagulation, and protein denaturation, and (3) a stimulating zone. This may be one reason for the improved healing with laser surgery compared with traditional scalpel surgery. During laser curettage, sufficient hemostasis and significant reduction of the initial levels of periodontal pathogens are achieved.17 Although the procedures mentioned in the preceding are not identical to laser CSF, the treated part is composed of the same gingival fibers. In this experiment, gingival bleeding was sufficiently insignificant to be controlled with sterile gauze during laser CSF. It certainly seems that the bactericidal effect transferred by the laser within the periodontal pocket can reduce the risk of infection. However, for confirmation, further histologic or cytologic studies are needed.

Because a laser beam is irradiated from the end of a 0.4-mm-diameter laser tip, the sides of the tip cannot be used for transection; therefore, an up-and-down stroking movement was initially required. As the diode laser tip is made of relatively low-strength fiber, the tip can occasionally break.

LLLT of orthodontically rotated teeth without retainers increased the rotational relapse of the teeth in group C compared with those in the control group. There was no significant difference between groups A and C in terms of the orientation and extent of stretching of the supracrestal fibers and the distribution of blood vessels.

The coherence of electromagnetic laser energy plays a role in biostimulation efficacy. The coherent



**Figure 8.** Group B. Rearrangement of fibrous structures had taken place. (A) H&E staining,  $100 \times$ , (B) Masson's Trichrome staining,  $40 \times$ , (C)  $200 \times$ ; R, experimental tooth root; S, supracrestal fiber.



**Figure 9.** Group C. Thickness of the fiber bundle and the phase of blood vessels are arranged similarly to the control group. (A) H&E staining,  $100\times$ , (B) Masson's Trichrome staining,  $40\times$ , (C)  $200\times$ ; R, experimental tooth root; S, supracrestal fiber.

character of diode laser light is not lost after tissue penetration but is split into small, coherent and polarized islands called *speckles*. With these features, the energy can penetrate deep into the tissues, resulting in advantageous biostimulation effects.<sup>18</sup> Published data indicate that low-level irradiation can enhance collagen production,<sup>19</sup> as well as increase the proliferation rate<sup>20</sup> and alter locomotor characteristics in connective tissue cells.<sup>21</sup> These findings are true for skin and embryonic fibroblasts, but little is known about the effects on oral fibroblasts and particularly on human gingival fibroblasts.

The reason for orthodontic relapse of rotated teeth is poorly understood, but it is often related to the presence of the supragingival fiber group. Based on the results obtained from light microscopic studies by Edwards,<sup>2</sup> we assume that rotational movements are brought about by stretching of collagen fibers. Hitherto, relapse was considered to be the effect of orthodontically stretched gingival collagen fibers, which pull the tooth toward its pretreatment position. However, using scanning and transmission electron microscopy, Redlich et al<sup>22</sup> reported that the stretched gingival fibers were torn, ripped, disorganized, and laterally spaced; an increased number of elastic fibers were also seen near the torn collagen fibers. This study suggests that relapse may not be due to the stretched collagen fibers but rather it originates in changed elastic properties.

The fact that prolonged orthodontic retention or surgical excision of supracrestal fibers is required suggests that these fibers have low collagen-turnover activity and may be remodeled very slowly. Minkoff and Engstrom<sup>23</sup> and Rippin<sup>24</sup> stated that fibroblast activity is lower in dentogingival regions than in dentoalveolar regions. However, Deporter et al<sup>25</sup> and Proye and Polson<sup>26</sup> have suggested that collagen turnover in the transseptal region is at least as high as, and possibly higher than, that in the periodontal ligament.

As the histological and cytological causes of relapse are unclear, it is difficult to analyze the role of LLLT in the increased rate of relapse found in this study. We focused on the amount of relapse occurring on orthodontically rotated teeth, and could not observe the histological and cytological changes in more detail during laser irradiation. To find a more plausible explanation for the effect of LLLT on relapse tendency, further studies at the molecular level are needed.

## CONCLUSIONS

- Laser CSF is an effective procedure to decrease relapse following tooth rotation, causing no apparent damage to the supporting periodontal structures.
- LLLT of orthodontically rotated teeth without retainers appears to increase the relapse tendency.

## ACKNOWLEDGMENT

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## REFERENCES

- 1. Thompson HE. Orthodontic relapses analyzed in a study of connective tissue fibers. *Am J Orthod*. 1959;45:93–109.
- Edwards JG. A study of the periodontium during orthodontic rotation of teeth. Am J Orthod. 1968;54:441–461.
- 3. Wiser GM. Resection of the supra-alveolar fibers and the retention of orthodontically rotated teeth. *Am J Orthod.* 1996;52:855.
- 4. Edwards JG. A surgical procedure to eliminate rotational relapse. *Am J Orthod*. 1970;57:35–46.
- Crum RE, Andreason GF. The effect of gingival fiber surgery on the retention of rotated teeth. *Am J Orthod.* 1974;65: 626–638.
- Block RW, Kerns DG, Regennitter FJ, Kerns LL. The circumferential supracrestal fiberotomy. *General Dent.* 1998;55:48–54.
- Frick LL, Rankine CA. Comparison of electrosurgery with conventional fiberotomies on rotational relapse and gingival tissue in the dog. *Am J Orthod Dentofacial Orthop.* 1990;97: 405–412.
- Sarver DM, Yanosky M. Principles of cosmetic dentistry in orthodontics: part 2. Soft tissue laser technology and cosmetic gingival contouring. *Am J Orthod Dentofacial Orthop.* 2005;127:85–90.
- 9. Hall RR. The healing of soft tissues incised by a carbon dioxide laser. *Br J Surg.* 1971;58:222–225.
- 10. Moritz A. *Oral Laser Application*. Chicago, III: Quintessence; 2006.
- 11. Youssef M, Ashkar S, Hamade E, Gutknecht N, Lampert F, Mir M. The effect of low-level laser therapy during

orthodontic movement: a preliminary study. *Lasers Med Sci.* 2008;23:27–33.

- Mester E, Mester AF, Mester A. The biomedical effects of laser application. *Lasers Surg Med.* 1985;5:31–39.
- Balboni GC, Brandi ML, Zonefrati L, Repice F. Effect of laser irradiation on collagen production by fibroblasts in vitro. *Bull Assoc Anat.* 1985;69:15–18.
- Tal H, Soldinger M, Dreiangel A, Pitaru S. Periodontal response to long-term abuse of the gingival by supracrestal amalgam restorations. *J Clin Periodontol.* 1989;16:654–659.
- Berglundh T, Marinello CP, Lindhe J, Thilander B, Liljenberg B. Periodontal tissue reactions to orthodontic extrusion. *J Clin Periodontol.* 1991;18:330–336.
- Kravitz ND, Kusnoto B. Soft-tissue lasers in orthodontics: an overview. Am J Orthod Dentofacial Orthop. 2008;133:S110– S114.
- Lioubavina-Hack N. Lasers in dentistry. 5. The use of lasers in periodontology. *Ned Tijdschr Tandheelkd*. 2002;109:286– 292.
- Saito S, Shimizu N. Stimulatory effects of low-power laser irradiation on bone regeneration in midpalatal suture during expansion in the rat. *Am J Orthod Dentofacial Orthop.* 1997; 111:525–532.
- Dortbudak O, Haas R, Mallath-Pokorny G. Biostimulation of bone marrow cells with a diode soft laser. *Clin Oral Implants Res.* 2000;11:540–545.
- 20. Medrado AR, Pugliese LS, Reis SR, Andrade ZA. Influence of low level laser therapy on wound healing and its biological action upon myofibroblasts. *Lasers Surg Med.* 2003;32: 239–244.
- Luger EJ, Rochkind S, Wollman Y, Kogan G. Effect of lowpower laser irradiation on the mechanical properties of bone fracture healing in rats. *Lasers Surg Med.* 1998;22:97–102.
- Redlich M, Rahamim E, Gaft A, Shoshan S. The response of supraalveolar gingival collagen to orthodontic rotation movement in dogs. *Am J Orthod Dentofacial Orthop*. 1996;110:247–255.
- 23. Minkoff R, Engstrom TG. A long-term comparison of protein turnover in subcrestal vs. supracrestal fibers tracts in the mouse periodontium. *Arch Oral Biol.* 1979;24:817–824.
- 24. Rippin JW. Collagen turnover of the periodontal ligament under normal and altered functional forces. I. Young rat molars. *J Period Res.* 1976;11:101–107.
- 25. Deporter DA, Svoboda EL, Howley TP, Shiga A. A quantitative comparison of collagen phagocytosis in periodontal ligament and transseptal ligament of the rat periodontium. *Am J Orthod.* 1984;85:519–522.
- Proye MP, Polson AM. Repair in different zones of the periodontium after tooth reimplantation. *J Periodontol*. 1982; 53:379–389.

## Erratum

Please see correction for: Laser-Aided Circumferential Supracrestal Fiberotomy and Low-Level Laser Therapy Effects on Relapse of Rotated Teeth in Beagles" 2010;80(2)385–390.

Demographic information for Dr. Joo-Hee Paek should read:

Student, Program of Medical Engineering, Kyung Hee University, Seoul, Korea