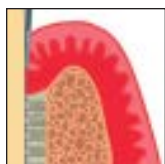# Efficacy of Adjunctive Er, Cr:YSGG Laser Application Following Scaling and Root Planing in Periodontally Diseased Patients

Vanessa Ruiz Magaz, DDS, PhD[1]
Antonio Santos Alemany, DDS, PhD[2]
Federico Hernández Alfaro, MD, DDS, PhD[2]
José Nart Molina, DDS, PhD[2]

The application of laser as a monotherapy has been shown to reduce probing pocket depths and increase clinical attachment levels after treatment of patients suffering from chronic periodontitis. Its controversial use as an adjunct to scaling and root planing (SRP) is discussed. The present study aimed to evaluate the efficacy of adjunctive Er, Cr:YSGG laser application following conventional SRP. A total of 30 patients with chronic periodontitis were enrolled in the study. The quadrants of each patient were allocated to either SRP or SRP + laser. A total of 3,654 sites with pocket depths ≥ 4 mm were treated and evaluated at 6 weeks and 6 months postoperatively with respect to attachment gain. Both therapies resulted in improved probing pocket depths and clinical attachment levels. The adjunctive application of Er, Cr:YSGG laser following SRP did not improve probing pocket depth or attachment level compared with SRP alone.

[1]Faculty of Dentistry, International University of Catalunya, Barcelona, Spain.
[2]Faculty of Dentistry, International University of Catalunya, Faculty of Dentistry, Barcelona, Spain.

Correspondence to: Dr Vanessa Ruiz Magaz, International University of Catalunya, Faculty of Dentistry, Calle Josep Trueta s/n, 08195 Sant Cugat del Vallès, Barcelona, Spain. Email: vanessaruizmagaz@gmail.com

Periodontal disease may cause several changes in the periodontium, such as pocket formation and irreversible attachment loss.[1] Thus, the primary goal of nonsurgical periodontal treatment is to arrest disease progression by elimination of the bacterial infection and to reduce soft tissue inflammation.[2] In terms of the clinical status, it means to create an environment that enables the patient to perform oral hygiene measures with ease.

Subgingival debridement aims to eliminate plaque, calculus, and bacterial deposits from the root surface. This is usually performed with hand- or power-driven instruments.[3] Both treatment modalities have been shown to be equally effective.[4] On the other hand, both are characterized by a limited access to sites such as furcations, concavities, grooves, and deep aspects of periodontal pockets.[5] As a consequence, remnants of calculus and bacteria with their toxins may be left on the root surface, negatively affecting the treatment outcome.[6,7]

Since the 1990s, the use of lasers has been proposed as an alternative or adjunct to conventional nonsurgical therapy due to its favorable hemostatic, bactericidal, and detoxification effects.[8] However, some laser systems are not suitable for periodontal therapy due to major thermal side effects that have been

described.[9,10] Based on their ability of hard and soft tissue ablation, Er:YAG (2.94-μm wavelength) and Er, Cr:YSGG (2.78-μm wavelength) lasers seem to be the most suitable for periodontal therapy.[8]

The benefits of laser application have been documented in several in vitro studies. They have been shown to create a biocompatible root surface enhancing soft tissue attachment.[11,12] Nevertheless, few clinical trials have been published comparing the application of Er:YAG and Er, Cr:YSGG lasers with conventional subgingival mechanical debridement.[13,14]

The aim of the present split-mouth randomized clinical trial was to evaluate the efficacy of two different nonsurgical approaches, scaling and root planing (SRP) and a combination of SRP with Er, Cr:YSGG laser (SRP + laser) at 6 weeks and 6 months, in patients suffering from moderate to advanced chronic periodontitis.

Materials and methods

Study design

The study was designed as a 6-month, split-mouth randomized clinical trial. It was conducted in the Department of Periodontology of the International University of Catalonia (Spain), and approved by the research ethics committee. All participants signed the informed consent form.

Patients

After a screening visit including a full-mouth periodontal evaluation, all patients fulfilling the following inclusion criteria were asked to participate:

- Age ≥ 18 years
- No systemic diseases
- No pregnancy
- No active periodontal treatment or systemic antibiotic therapy in the last 6 months
- Presence of at least one incisor, one premolar, and one molar in each quadrant
- Diagnosis of moderate chronic periodontitis and the presence of at least two teeth with at least one site with a probing pocket depth (PPD) between 4 and 9 mm in each quadrant with bleeding on probing (BoP).

Clinical measurements and data collection

The following parameters were recorded at baseline and at 6 weeks and 6 months thereafter: Plaque Index (PI),[15] bleeding on probing (BoP), probing pocket depth (PPD), gingival recession (GR), and clinical attachment level (CAL). All measurements were taken by the same calibrated examiner, who was blinded to the treatment and was different from the clinician performing the periodontal treatment.

PPD was measured from the gingival margin with a pressure-sensitive plastic periodontal probe standardized at 0.25 N (Vivacare TPS, Ivoclar Vivadent). GR was measured from the cementoenamel junction (CEJ) to the gingival margin. CAL was calculated by adding the GR and PPD measurements. All measurements were taken at six sites per tooth: mesiovestibular (mv), central-vestibular (cv), distovestibular (dv), mesiolingual (ml), central-lingual (cl), and distolingual (dl).

Treatment

Two contralateral quadrants per patient, one in the maxilla and one in the mandible, were randomly assigned to the SRP (control) and two quadrants to the SRP + laser (test) group by tossing a coin for the first quadrant.

Two weeks prior to treatment, all patients were scheduled for oral hygiene instruction and professional supragingival debridement according to individual needs. Supragingival plaque was recorded at baseline, and the patient's ability to maintain optimal oral hygiene standards was checked.

In the control group, the subgingival mechanical instrumentation was performed with 1/2, 7/8, 11/12, and 13/14 Gracey Mini Five curettes (Hu-Friedy, Chicago) and the end point of mechanical debridement was achieved when the clinician was unable to detect any remnants of calculus on the treated root surfaces. During treatment, inspection of the treated sites was carried out periodically with a periodontal probe (PCP-UNC 15, Hu-Friedy).

In the test group, SRP was followed by laser application. An Er,

Fig 1 *Er, Cr:YSGG laser handpiece with a Z6 series tip of 600 μm in diameter and 9 mm in length.*

Fig 2 (a) *Laser tip is applied on root surfaces from coronal to apical aspects of the pocket. (b) The fiber-optic tip needs to be placed in parallel paths with an inclination of 5 to 15 degrees toward the root surface.*
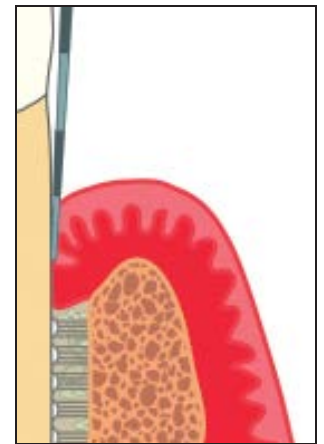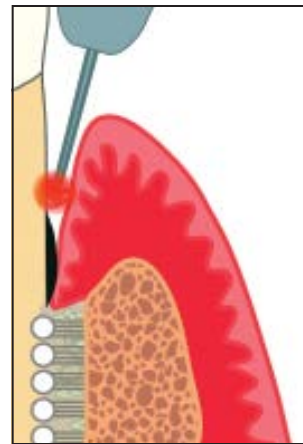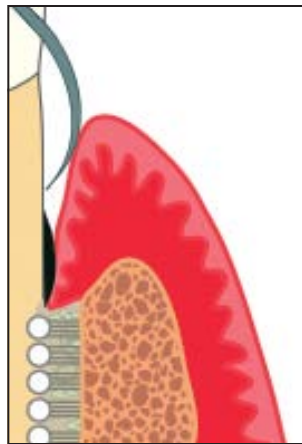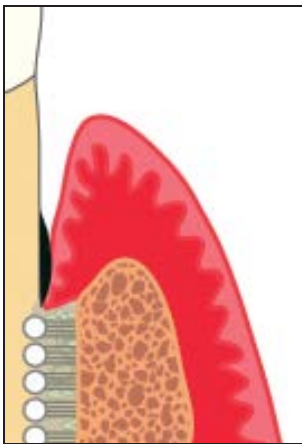

Fig 3 *Clinical sequence of SRP + laser application.*

Cr:YSGG device (Waterlase MD Turbo, Biolase) with a wavelength of 2.78 μm was used in the present study. The laser system used had a pulse duration of 140 to 200 μs with a repetition rate of 20 Hz. The average power output could be varied from 0 to 6 W (300 mJ/pulse). The delivery system consisted of a fiber-optic tube terminating in a handpiece with a tip bathed in an adjustable air-water spray (Fig 1). The power output of the Er, Cr:YSGG laser was set to 1.0 W (50 mJ/pulse), a repetition rate of 20 pulse/second and an air-water spray ratio of 10% air and 15% water. A Z6 series tip of 600 μm in diameter and 9 mm in length was used. The laser was applied for 60 seconds on each tooth surface from the coronal to the apical aspects of the pocket (Fig 2a). The fiber-optic tip was led in parallel paths with an inclination of 5 to 15 degrees toward the root surface (Fig 2b). The clinical sequence of laser application is depicted in Fig 3.

To avoid operator bias, all patients were treated under local anesthesia by the same experienced clinician.

Data analysis

The statistical analysis was intention to treat, and the site was considered as the statistical unit. Each outcome variable was reported at every visit as mean ± SD. The primary outcome variables were PPD and CAL gain. Only sites with PPD ≥ 4 mm at baseline were considered eligible and included in the analysis. The secondary outcome variables were the changes in GR and BoP. Plaque scores were considered as confounding variables.

Table 1	Measurements at baseline, calculated on 30 patients (752 teeth, 4,512 sites, 3,654 sites with PPD ≥ 4 mm)	
	SRP (control group)	**SRP + laser (test group)**
Sites ≥ 4 mm (n)	**1,759**	**1,895**
PPD (mm)	5.6 ± 1.3	5.5 ± 1.1
• vestibular sites (cv)	5.4 ± 1.1	5.3 ± 1.3
• lingual sites (cl)	5.5 ± 1.0	5.2 ± 1.2
• interproximal sites (mv, dv, ml, dl)	5.9 ± 1.3	5.9 ± 1.3
CAL (mm)	6.5 ± 1.2	6.5 ± 1.4
• vestibular sites (cv)	6.6 ± 1.1	6.4 ± 1.3
• lingual sites (cl)	6.4 ± 1.3	6.3 ± 1.0
• interproximal sites (mv, dv, ml, dl)	6.6 ± 1.3	6.8 ± 1.2
GR (mm)	1.2 ± 1.2	1.1 ± 1.0
• vestibular sites (cv)	1.2 ± 0.9	1.0 ± 1.2
• lingual sites (cl)	0.9 ± 0.7	1.0 ± 1.0
• interproximal sites (mv, dv, ml, dl)	0.7 ± 1.1	0.9 ± 1.0
BoP (%)	71	69
PI (%)	42	37

PPD = pocket probing depth; CAL = clinical attachment level; GR = gingival recession; BoP = bleeding on probing; PI = Plaque Index; cv = central-vestibular; mv = mesiovestibular; dv = distovestibular; cl = central-lingual; ml = mesiolingual; dl = distolingual.

After checking normality using the Kolmogorov-Smirnov test, continuous variables were compared between groups by analysis of variance, using the treatment group as the factor. All comparisons were analyzed using two tails and a significance level of < .05. For an adequate interpretation of the data, since multiple comparisons were carried out, the level of significance for changes between visits and for visits was adjusted (Bonferroni correction).

The sample size calculation was based on detecting a difference between groups of 0.5 mm in the main outcome variable (CAL gain) with an assumption of a common standard deviation (SD) of 0.6 mm, an α error of .05, and a β error of 0.20. This analysis resulted in 30 patients, who were included and randomized, assuming that no patients would drop out.

A software package (Statgraphics, Statpoint Technologies) was used for the statistical analysis.

Results

Patient characteristics at baseline

A total of 30 patients, including 752 teeth or 4,512 sites, were examined. The mean age of the patients was 48.5 ± 9.4 years, and 20 out of 30 were women. Only four patients were smokers (< 10 cigarettes/day). The clinical measurements recorded in the sites with PPD ≥ 4 mm at baseline are reported in Table 1. All patients included in the study completed the treatment and the 6-week and 6-month follow-up evaluations. None of the teeth included in the study were lost during the follow-up period.

At baseline, no differences could be found between test and control groups regarding PPD, CAL, or GR (Table 1).

Six weeks after treatment

Table 2 shows the measurements for PPD, BoP, PI, GR, and CAL recorded 6 weeks after therapy. Changes in CAL, PPD, and GR have been considered as CAL gain, PPD reduction and GR reduction. Although a significant mean PPD reduction could be observed for both test and control groups between baseline and 6 weeks follow-up (0.7 ± 1.4 mm and 0.9 ± 1.2 mm, respectively), no statistically significant difference was noticed between the two treatment modalities. When PPD changes were analyzed separately for buccal/labial, lingual, and interproximal sites, again, no additional efficacy could be detected for laser application in the test group. For both treatment modalities, the PPD reduction was more pronounced at interproximal sites than at buccal/labial and lingual surfaces.

At 6 weeks follow-up, the mean CAL in the test group yielded a gain of 0.1 ± 1.1 mm, which was statistically significantly less than in the

control group with 0.5 ± 0.4 mm, respectively (*P* < .05). Regarding site-specific evaluations, the results for CAL gain (for both treatment modalities) were similar to PPD reduction with statistically significantly better outcomes at interproximal than at labial/buccal or lingual sites.

The differences in GR between the two treatment groups at 6 weeks follow-up did not reach statistical significance. In contrast to PPD and CAL, the GR changes did not differ between interproximal and buccal/labial or lingual sites.

Compared with SRP (control group), the adjunctive laser application (test group) did not improve the results for PPD reduction. On the contrary, with regard to CAL gain, the outcome in the test group was slightly inferior compared with the control group.

Table 2	Clinical outcomes at 6 weeks and 6 months, calculated on 30 patients (3,654 sites with PPD ≥ 4 mm)			
	SRP (control group)		SRP + laser (test group)	
	1,759		1,895	
Sites ≥ 4 mm (n)	6 wk	6 mo	6 wk	6 mo
PPD (mm)	4.7 ± 1.1	4.5 ± 1.3	4.8 ± 1.3	4.7 ± 1.1
• vestibular sites (cv)	4.9 ± 0.9	4.6 ± 1.2	4.8 ± 1.6	4.6 ± 1.8
• lingual sites (cl)	4.9 ± 1.0	4.8 ± 1.0	4.7 ± 1.6	4.7 ± 1.4
• interproximal sites (mv, dv, ml, dl)	4.2 ± 0.9	4.0 ± 1.1	4.8 ± 1.2	4.7 ± 1.2
CAL (mm)	6.0 ± 1.4	5.9 ± 1.2	6.4 ± 1.3	6.4 ± 1.0
• vestibular sites (cv)	6.3 ± 0.8	6.1 ± 1.0	6.2 ± 1.2	6.1 ± 1.1
• lingual sites (cl)	6.0 ± 1.1	5.9 ± 1.0	6.3 ± 0.9	6.4 ± 0.6
• interproximal sites (mv, dv, ml, dl)	5.7 ± 1.4	5.7 ± 0.8	6.7 ± 1.1	6.8 ± 1.2
GR (mm)	1.3 ± 1.1	1.4 ± 1.4	1.6 ± 0.9	1.8 ± 0.9
• vestibular sites (cv)	1.4 ± 0.8	1.5 ± 0.9	1.4 ± 1.0	1.5 ± 1.4
• lingual sites (cl)	1.1 ± 1.0	1.1 ± 1.4	1.6 ± 1.1	1.7 ± 1.6
• interproximal sites (mv, dv, ml, dl)	1.5 ± 1.0	1.7 ± 1.1	1.9 ± 1.1	2.1 ± 1.2
BoP (%)	36	34	39	36
PI (%)	39	37	36	34

PPD = pocket probing depth; CAL = clinical attachment level; GR = gingival recession; BoP = bleeding on probing; PI = Plaque Index; cv = central-vestibular; mv = mesiovestibular; dv = distovestibular; cl = central-lingual; ml = mesiolingual; dl = distolingual.

Six months after treatment

Descriptive statistics at 6 months after therapy is reported in Table 2. PI showed a continuous decrease in both treatment procedures.

Regarding CAL gain 6 months after therapy, the SRP group showed a greater gain (0.6 ± 1.2 mm) than the SRP + laser group (0.1 ± 1.9 mm). A similar but less pronounced effect could be noted for PPD reduction (1.1 ± 1.4 mm and 0.8 ± 1.6 mm, respectively).

Discussion

The present study aimed to investigate the efficacy of adjunctive Er, Cr:YSGG laser compared with conventional SRP. A total of 30 patients affected by moderate to advanced chronic periodontitis were enrolled in the study. They showed a high level of plaque accumulation and BoP and needed periodontal causal therapy. Using a split-mouth design, the study compared conventional mechanical debridement with an approach consisting of SRP followed by adjunctive laser treatment. Er, Cr:YSGG lasers have a performance similar to that of Er:YAG lasers,[8] which are proven in the current literature as the most appropriate laser devices for nonsurgical periodontal treatment.[16]

The results of the present randomized clinical trial showed that both treatment protocols were efficacious in the therapy of patients suffering from chronic periodontitis, resulting in a significant improvement of the main measurement variables (PPD and CAL changes). Comparing the outcomes of the two treatment modalities, no significant differences could be noted between the SRP and SRP + laser groups regarding PPD reduction. In other words, the application of Er, Cr:YSGG laser in addition to SRP had not reduced PPD at the end of the 6-month healing period. On the contrary, with respect to CAL

gain, the conventional approach with SRP alone achieved better results compared with the combined therapy with laser. The observation that laser as an add-on treatment to SRP does not improve the efficacy is in accordance with other studies.[17,18,21]

In the present study, the better results of SRP as a monotherapy regarding CAL gain at 6 months follow-up are difficult to explain. It can be speculated that a delayed periodontal wound healing after laser application in comparison to healing after conventional mechanical debridement[19] might have had an influence. In vitro studies have shown a decreased periodontal ligament cell attachment on the surface of intact roots treated by Er:YAG laser under water irrigation compared with mechanically treated root surfaces.[8] Although previous studies have demonstrated that Er:YAG laser application was not associated with major compositional or chemically deleterious changes on the root surface,[16] it might be difficult to estimate to what extent a reduction in organic components could influence the detachment of newly formed cementum.[20]

The present study did not demonstrate clinical efficacy of laser application as adjunctive therapy to SRP at 6 months follow-up. The outcome variables were clinically evaluated, and no histologic samples could be taken. Hence, one can speculate that investigating the healing on a histologic level might provide more beneficial results for laser application in the treatment of chronic periodontitis.

Two interesting investigations evaluated the treatment outcomes of laser application in periodontitis-affected patients, both histologically and clinically.[22,23] The healing response to laser-assisted new attachment procedure (LANAP) was investigated in eight patients presenting 12 teeth predetermined for surgical extraction. After 9 months of healing, 10 bloc biopsies were taken and histologically analyzed. The results for 6 out of 10 teeth showed obvious signs of regeneration with new cementum formation and inserting collagen fibers, while 4 teeth healed with a long junctional epithelium.[22] The clinical efficacy of LANAP at 9 months follow-up was proven in another study by the same authors.[23]

The beneficial results might be explained by the modified laser application according to the LANAP protocol and the different wavelength. While in the present study the laser application was directed only toward the root surfaces, the LANAP protocol requires an additional removal of the pocket epithelium corresponding to a classical curettage. Even if the protocols of the above-mentioned trials and the present study differed widely, the results indicate that differences in the healing modalities may be detected depending on the variables measured. This, in turn, means that longer healing periods might be required to make those differences clinically visible.

Conclusions

Based on a limited number of studies and the heterogeneity between them, a comparison of the results of laser application as an adjunct to SRP is difficult. The present randomized controlled trial evaluated the adjunctive benefit of Er, Cr:YSGG laser application in addition to SRP. Based on an appropriate sample size calculation and with adequate power, the present study clearly demonstrated that the adjunctive use of an Er, Cr:YSGG laser did not improve the results regarding PPD and GR changes at 6 weeks' and 6 months' reevaluation after initial therapy. Nevertheless, when not only clinical but also histologic data are evaluated, laser application might be beneficial.

Acknowledgments

References

1. Genco RJ. Host responses in periodontal diseases: Current concepts. J Periodontol 1992;63:338–355.
2. Slots J. Subgingival microflora and periodontal disease. J Clin Periodontol 1979;6:351–382.
3. Cobb CM. Non-surgical pocket therapy: Mechanical. Ann Periodontol 1996;1:443–490.
4. Tunkel J, Heinecke A, Flemmig TF. A systematic review of efficacy of machine-driven and manual subgingival debridement in the treatment of chronic periodontitis. J Clin Periodontol 2002;29 (suppl):s72–s81.

5. Bower RC. Furcation morphology relative to periodontal treatment. Furcation root surface anatomy. J Periodontol 1979;50:366–374.

6. Fleischer HC, Mellonig JT, Brayer WK, Gray JL, Barnett JD. Scaling and root planing efficacy in multirooted teeth. J Periodontol 1989;60:402–409.

7. Adriaens PA, Edwards CA, De Boever JA, Loesche WJ. Ultrastructural observations on bacterial invasion in cementum and radicular dentin of periodontally diseased human teeth. J Periodontol 1988;59:493–503.

8. Aoki A, Sasaki KM, Watanabe H, Ishikawa I. Lasers in nonsurgical periodontal therapy. Periodontol 2000 2004;36:59–97.

9. Ishikawa I, Aoki A, Takasaki AA, Mizutani K, Sasaki KM, Izumi Y. Application of lasers in periodontics: True innovation or myth? Periodontol 2000 2009;50:90–126.

10. Schwarz F, Aoki A, Sculean A, Becker J. The impact of laser application on periodontal and peri-implant wound healing. Periodontol 2000 2009;51:79–108.

11. Fujii T, Baehni PC, Kawai O, Kawakami T, Matsuda K, Kowashi Y. Scanning electron microscopic study of the effects of Er:YAG laser on root cementum. J Periodontol 1998;69:1283–1290.

12. Tewfik HM, Garnick JJ, Schuster GS, Sharawy MM. Structural and functional changes of cementum surface following exposure to a modified Nd:YAG laser. J Periodontol 1994;65:297–302.

13. Schwarz F, Sculean A, Georg T, Reich E. Periodontal treatment with an Er:YAG laser compared to scaling and root planing. A controlled clinical study. J Periodontol 2001;72:361–367.

14. Schwarz F, Sculean A, Berakdar M, Georg T, Reich E, Becker J. Periodontal treatment with an Er:YAG laser or scaling and root planing. A 2-year follow-up split-mouth study. J Periodontol 2003;74:590–596.

15. O'Leary TJ, Drake RB, Naylor JE. The plaque control record. J Periodontol 1972;43:38.

16. Schwarz F, Aoki A, Becker J, Sculean A. Laser application in non-surgical periodontal therapy: A systematic review. J Clin Periodontol 2008;35(suppl):s29–s44.

17. Karlsson MR, Diogo Löfgren CI, Jansson HM. The effect of laser therapy as an adjunct to non-surgical periodontal treatment in subjects with chronic periodontitis: A systematic review. J Periodontol 2008;79:2021–2028.

18. Rotundo R, Nieri M, Cairo F, et al. Lack of adjunctive benefit of Er:YAG laser in non-surgical periodontal treatment: A randomized split-mouth clinical trial. J Clin Periodontol 2010;37:526–533.

19. Lopes BM, Marcantonio RA, Thompson GM, Neves LH, Theodoro LH. Short-term clinical and immunologic effects of scaling and root planing with Er:YAG laser in chronic periodontitis. J Periodontol 2008;79:1158–1167.

20. Sasaki KM, Aoki A, Masuno H, Ichinose S, Yamada S, Ishikawa I. Compositional analysis of root cementum and dentin after Er:YAG laser irradiation compared with CO_2 lased and intact roots using Fourier transformed infrared spectroscopy. J Periodontal Res 2002;37:50–59.

21. Sgolastra F, Petrucci A, Gatto R, Monaco A. Efficacy of Er:YAG laser in the treatment of chronic periodontitis: Systematic review and meta-analysis. Lasers Med Sci 2012;27:661–673.

22. Nevins ML, Camelo M, Schupbach P, Kim SW, Kim DM, Nevins M. Human clinical and histologic evaluation of laser-assisted new attachment procedure. Int J Periodontics Restorative Dent 2012;32:497–507.

23. Nevins M, Kim SW, Camelo M, Martin IS, Kim D, Nevins M. A prospective 9-month human clinical evaluation of Laser-Assisted New Attachment Procedure (LANAP) therapy. Int J Periodontics Restorative Dent 2014;34:21–27.