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Research Article

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Comparative evaluative study of Erbium, chromium YSGG and wavelength-dual Diode lasers in oral soft tissue incision morphology: a histological ex vivo study

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Abstract: Laser is an advantageous system that can be used in different medical applications, and one of them is soft tissue handling in periodontal and surgical dentistry. The recent research aimed to histologically compare the erbium, chromium YSGG laser, and wavelength-dual diode laser in oral surgical incisions according to cutting morphology.
Method: This was an ex vivo study using the pieces of tongue from the sheep as samples. 810(50%) + 980 (50%) nm diode laser was operated continuously (CW) with two average powers: 1.5 and 2.5 W. 2780 nm erbium, chromium YSGG laser was used in pulse mode with two average powers: 2.5 and 3.5 W. Incisions were made on the tongue parts, and after histopathological processing, the regularity and morphology of the incision and the cutting depth of each incision were measured under a light microscope.
Results: The regularity and morphology of erbium, chromium YSGG laser incisions were significantly higher in quality (especially those of the low output power of 2.5 W) than those of the diode laser (P value < 0.05). The cutting depth was significantly higher when the power increased, no matter the type of laser system (P value < 0.05).
Conclusions: Most regular incisions have been achieved with 2.5 W power of Erbium, Chromium YSGG laser.

Keywords: Laser; soft tissue; histology; incision; morphology.

1. Introduction

Soft tissue lesions within the oral cavity are very common and can have various clinical signs, including mucosal ulceration and nodular and colored lesions. These lesions may be painful or not, and they may be uncomfortable for the patient during food mastication, speech, or appearance. Clinicians must be able to distinguish between normal findings, anatomical variation, and abnormal tissue proliferation (pathological conditions) [1], [2]. Drugs, hot or spicy food, mechanical or chemical trauma, and immunological and systemic disease are different causes leading to these lesions, or they may be idiopathic. Some of the oral soft tissue lesions required surgical removal for histopathological diagnosis [3]. The laser is one of the most advanced surgical modalities and has an effective role in oral soft tissue treatment [4].

The semiconductor GA As powers the diode laser (DL) by producing wavelengths 400 to near IR spectrum. The majority of diode lasers use a flexible optical fiber to send laser beams in either a continuous or gated pulsed mode to the working field [5]. DLs operating with spectral ranges of 810 and 980 nm have been considered as a potential tool for oral soft tissue surgery [6]. Diode lasers are effective in cosmetic surgery such as gingivectomy and excision of oral lesions such as pyogenic granuloma and epulis fissuratum. Diode laser treatment offers advantages such as no bleeding, a clearer field, a shorter operation time, a disinfected site, faster healing, minimal postoperative pain, and a lower cost [7], [8].

Erbium, Chromium YSGG laser at 2780nm wavelength, free running pulsed laser, has proved to be useful for treating many hard tissue procedures and soft tissue operations since both water and hydroxyapatite crystals absorb a significant amount of this laser [9]. Er, Cr: YSGG laser was effective in oral soft tissue surgery such as gingivectomy and implants as it preserved the morphology of fibroblasts with no evidence of carbonization and less thermal damage extent in the tissue [10], [11].

The novelty of the research was using a dual-wavelength diode (810 nm most coagulated diode laser and a 980 nm laser, which is used more in fibrous tissue) in soft tissue incision and also using the pulsed laser (Er, Cr:YSGG), which is less used in soft tissue surgery.

Histologically, few studies compare both diode and Er, Cr: YSGG laser systems and no one talks about the most regular and deepest incision by the clinicians in both lasers. Current research aimed to histologically compare the morphology of cutting by both diode and Er, Cr: YSGG lasers to get the smoothest and the most regular incision in oral surgery.

2. Methods

2.1. Study design and samples collection

It was an experimental comparative study in animal specimens to evaluate both lasers with two different powers in every system for a more specific result between two wavelength laser systems. The variables were laser wavelength and average power.

The source of the samples was the tongue of the recently slaughtered Iraqi sheep (five tongues) aged 8– 17 months and irradiated within five hours after slaughter. The incision was made on the lateral surface of each tongue after cutting into small pieces; the dimensions of each piece were 1.5 cm length*2 cm width*1 cm thickness (Figure 1). For each laser type, there were two groups with two different average powers, each with seven pieces, so the whole number was 14 for each laser system.

2.2. Laser systems

The dual-wavelength diode laser (QUICKLASE 12W dual 4 (810+980), England, UK) was used with an optical fiber delivery system in continuous emission mode (CW), and a power meter (PINTUDY, Guangzhou, CN) was used for power adjustment. The second system was the Erbium, Chromium YSGG laser (WATERLASE I PLUS, California, USA) with a gold handpiece and MZ6 tip in pulse emission mode (PW). (The complete illustration of the laser group's parameters is shown in Table 1).

The laser radiation was made perpendicularly on the piece of tongue in contact mode, so the incision was made with a 1.5 cm length adjusted in 20 sec, and the horizontal speed of the operator was 0.75 mm/sec.

2.3. Histology

After finishing the laser surgery, each piece was placed in 10% formalin and sent for histological processing in the histopathological lab. The blocks were sectioned at five micrometers in microtone; the first section was neglected, and from each block, three sections were selected for Hematoxylin and Eosin (H&E) staining. The number of slides for each laser single group was 21, and 84 was the total number of slides. The microscope that was used for reading the results was the light microscope (GOWE Lab Instrument

Laboratory Binocular Head Biological Microscope, Japan) with an additional camera (5 MP USB CMOS Camera Microscope Digital Electronic Eyepiece with 0.5X C Mount Lens, mainland China) and software computer program (S-EYE 2.0, China).
The histological assessment criteria:
- Morphology and regularity of the incision: it has been scored from zero to four, where zero is the least incisional quality and four is the highest incisional quality (very ideal incision, which is similar to a cold blade incision, scored 4; the very rough and worst quality scored 0, with ≥2 smooth, linear borders mostly of the incisional margins and < 2 rough and uneven edges in most incisions).
- The depth of each incision: it has been measured in micrometers.

2.4. Statistical analysis

Data statistical analysis has been performed by SPSS. For data comparison between two systems and the four groups, the unpaired t-test, Mann-Whitney test, post hoc-tukey test, anova one-way test, and Kruskal-Wallis test were employed. The level of significance was 0.05.

3. Result and discussion

3.1. Result

A. Morphology and regularity of the incision

The Mann-Whitney test compared the medians of all samples of both laser systems and showed that the morphology and regularity of the incision quality of the erbium, chromiumYSGG laser was significantly higher than that of the diode laser, with a P value of 0.048 (<0.05), as shown in **Table 2** (**Figure 2 (a)**). When the Kruskal Wallis test compared the medians between the four groups of both laser systems, no significant difference was seen; the P value was 0.075 (>0.05), as shown in **Table 3**. Mann Whitney test compared the medians of each two groups of lasers: P value = 0.284 between first Group (G1) and G2, P value = 0.169 between G1 and G3, *P*= 0.875 between G1 and G4, *P*= 0.005 between G2 and G3, *P*= 0.201 between G2 and G4, *P* = 0.233 between G3 and G4. This means that the only significant difference can be found between G2 (2.5 W diode laser), where less quality of incision was seen, and G3 (2.5 W erbium, chromium YSGG laser), where higher quality of incision was seen (*P<0.05*), as shown in **Table 4**.

B. Cutting depth of the laser

The unpaired t-test compared the means and standard deviations (mean ± SD) of all samples of both laser systems. It showed that in the depth of the incision, between the Er, Cr: YSGG laser and diode laser, it was not significant difference, *P*= 0.212 (>0.05), as shown in Table 2. An ANOVA one-way test compared the means and standard deviations between four groups of both laser systems; they were significantly different, P value = <0.001 (Figure 2 (b), as shown in Table 3. A post hoc Tukey test compared the means and SDs of each of the two groups: P value = 0.424 between G1 and G3, P value =0.826 between G2 and G4, and P value = <0.001 between all other two groups. This means that there was a high significant difference between every double groups except between 1.5 W of DL (G1) and 2.5 W erbium, chromium YSGG laser (G3), and between 2.5 W of DL (G2) and 3.5 W erbium, chromium YSGG laser (G4), where nearly similar depths of the incisions were produced in these groups, as shown in Table 4, Figure3 illustrated some sections with regularity scores and depth measurement of the incision.

3.2 Discussion

The discussion of the first criterion, that every laser system works with a different delivery system since a small flexible fiber optic with bare glass fiber of diode is less controlled than that of the MZ6 of erbium, chromium YSGG laser, which was rigid and not resisted by the tissue of the tongue according to the operator observation, second cause the higher power on any laser system can lead to less regularity due increase the power density which leads to more area being exposed to the photothermal effect; this leads to more histological artifacts through the tissue, then more irregular cutting, the significant difference between the highest power of diode and lowest power output of erbium, chromium YSGG laser is a clear example of this discussion, as in previous research, the diode laser of 980 nm and higher power 4W gives the poor quality of laser incision [12].

Additionally, depending on the laser category, other variables impact the results including the emission mode and the radiation frequency. As in the previous research, greater quality of incision was shown in the specimens with a high frequency and low power output of radiation [13]. Also, the specimens with lower tissue damage extent show better incisional quality, as in previous research the higher regularity score (mean) had been shown at Er family, especially with 20 Hz frequency and long pulse, and lower incisional quality had been seen at the diode laser [14]. Current result is controversial to the earlier study that said the creation of the micro-explosions of Er family laser on the tissue was the reason for the irregular shape (rough edge) of the incision [15]. The presence and absence of water or air spray also affect the regularity of this incision [14], [16]. This study shows that the wavelength and radiation per unit area affected the regular shape of the incision.

Regarding the second criterion, the choice of laser wavelength, laser parameters, and the implementation of control systems have an important part in determining the cutting depth of soft tissue incisions by laser [17]. In this current study, the laser parameters were chosen according to the surgeon's usage of these two laser systems in the oral soft tissue incision. According to the results, the low power of the diode laser had nearby cutting depth to the low power of the erbium, chromium YSGG laser, and the high output of the DL also had a comparable cutting depth to the high output of the erbium, chromium YSGG laser. This means the cutting efficiency of each of the two low or high parameters was comparable for the two laser systems, but the cutting depth was different in the power increase of each system. This means that the cutting depth did not show wavelength-dependent but nearly a linear response as laser power increases, and this agrees with previous studies [18], [19]. This was a controversy over a previous study that showed that when the wavelength increased from 810 to 1064 nm, the cutting depth decreased, and the cutting depth was not power dependent [5]. Fornaini et al. showed that the diode laser's incision depth ranges from 2 to 6 mm [18].

In oral tissues exposed to laser radiation, photon energy is converted to thermic energy through absorption. This results in a variety of thermal changes, which can include brief heating (between 42° and 50°), Denaturation of proteins and coagulation at 60°C, vaporization and ablation at 100° C, or even carbonization (over 200°C). This photothermal effect causes histological changes in the incisional and peri-incisional areas [21].

In the diode laser, the laser-tissue interaction mechanism depends on the radiation's absorption within the correlated chromophores. In the 800–1000 nm range of wavelengths, hemoglobin (μ A) = 4.1-1.1 cm-1 and melanin (μ A) = 134-61.7 cm-1 are the principal absorbers [5]. Thus, there is very little absorption in water (μ A) = 0.02-0.36 cm-1) [5]. This shows that the diode laser is not ideal for soft tissue cutting because the laser energy in the continuous mode spreads through a vast region of tissue, and there is a higher chance of larger thermal damage leading to less regular incision; nevertheless, excellent coagulation and hemostasis are produced by this energy's strong blood absorption [12].

In the erbium, chromium YSGG laser, the water is the main targeted chromophore, so it is an ideal system for soft tissue surgery with little heating in the surrounding tissue, thermal damage extent, and histological artifacts [22], [23].

Erbium lasers are a great option for surgical soft tissue operations since they feature water as their principal chromophore and also because they are pulsed lasers, which allows for thermal relaxation time, less thermal damage, and a more regular shape of the incision [11].

3.2.1 Figures, and Tables

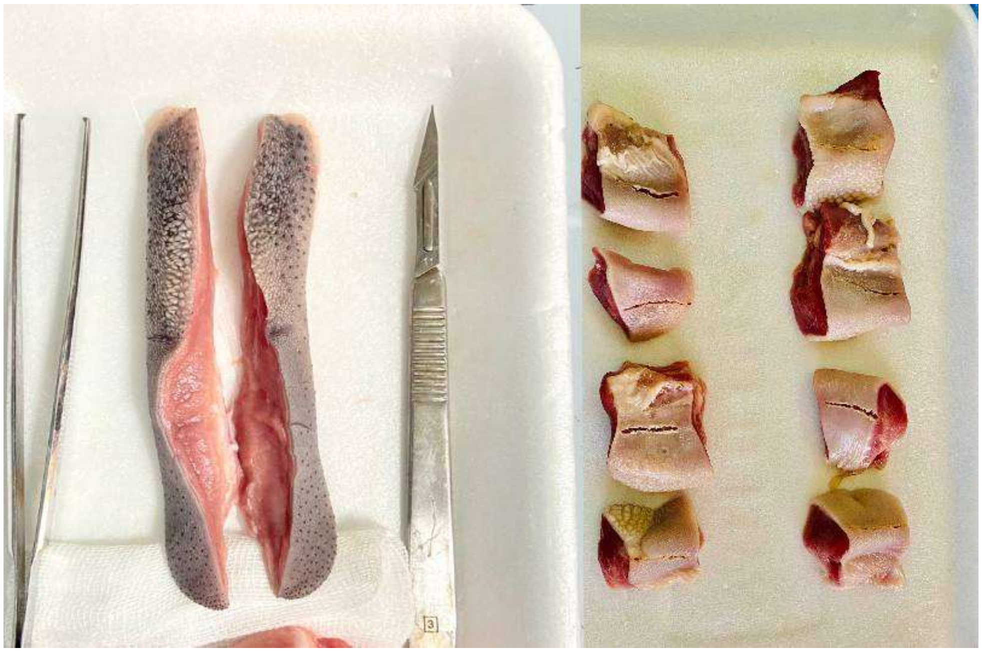
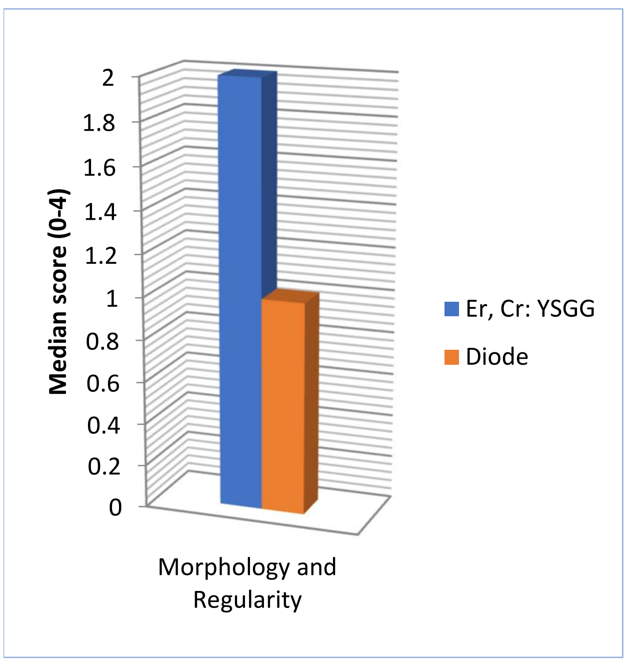
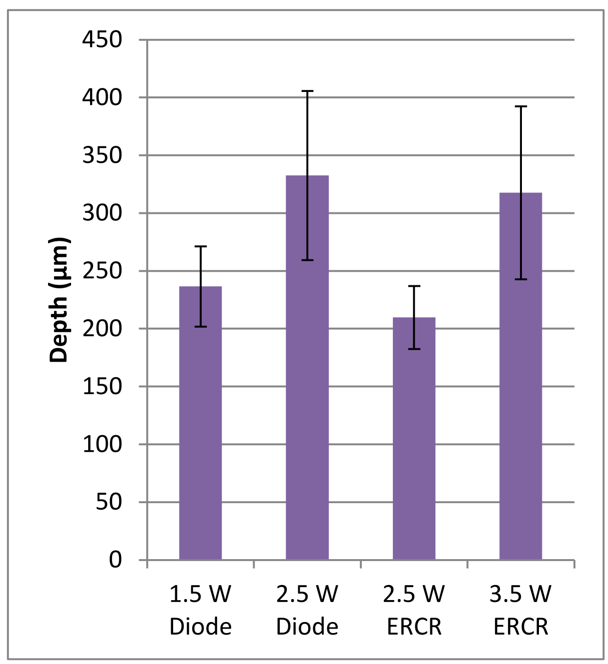


Fig. 1: Sample preparation and irradiation with Er, Cr: YSGG laser.





(a) (b)

Fig.2: **(a)** Morphology and regularity of incision, the result between the samples of two laser systems **(b)** Cutting depth in the samples of the four groups of two lasers.

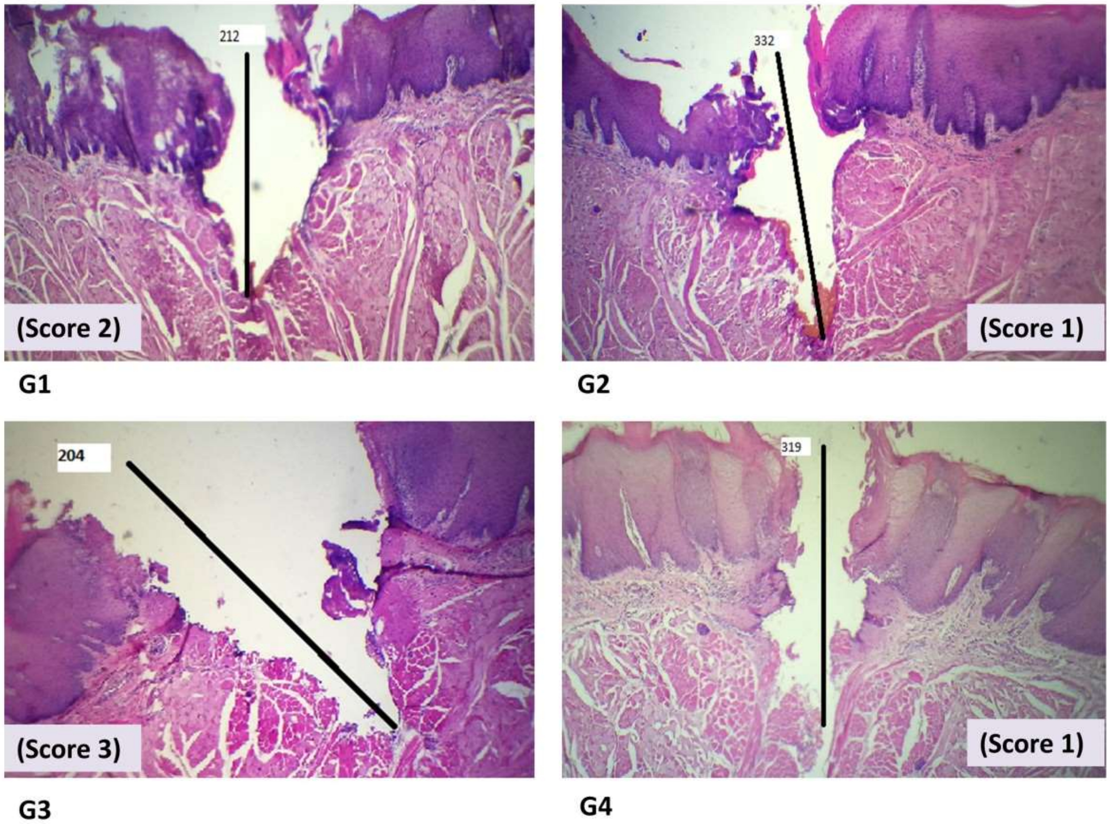


Fig. 3: Histological changes including regularity scores and incision depth in slides from four study group (4X magnification).

Table1. Detailed descriptions of laser parameters

Laser system group	Average Power(W) &Energy Per Pulse	Water/Air Spray %	Frequency (Hz)	Pulse Duration (µsec)	Peak Power	Power Density W/ cm^2	Tip/ Fiber Optic Diameter (µm)
Group1: Diode dual λ(810+980nm)	1.5(CW)	___	___	___	___	1153.8	(400)
Group2: Diode dual λ (810+980nm)	2.5(CW)	___	___	___	___	1923	(400)
Group3: Er,Cr:YSGG λ 2,780 nm	2.5(PW) 50mJ/pulse	10/10	50	700	71.43	892.8	(600)
Group4: Er,Cr:YSGG λ 2,780 nm	3.5(PW) 70mJ/pulse	10/10	50	700	100	1250	(600)

Table 2. Data analysis between two laser systems samples.

Criteria	Test type	Diode laser N=42	Er, Cr: YSGG laser N=42	P value
Morphology regularity of the incision score (0-3)	Mann-Whitney test median (range)	1 (0-3)	2 (0-3)	**0.048**
Cutting depth of the incision (µm)	Unpaired t-test Mean± SD	284.6±74.46	263.67±77.87	**0.212**

Table 3. Data analysis between four groups of different powers and lasers.

criteria	Test Type	Group 1 N=21	Group 2 N=21	Group 3 N=21	Group 4 N=21	P value
Morphology and regularity of the incision	Kruskal Wallis test	1 (0-3)	1 (0-2)	2 (0-3)	1 (0-3)	0.075
Depth (µm)	ANOVA one-way test	236.62±34.6	332.57±73.05	209.81±27.24	317.52±74.82	<0.001

Table 4. Data analysis between every two groups of the different powers or lasers.

Criteria	Test type	1st group	2nd group	P value
Morphology and regularity of the incision	Mann Whitney test	1.5 W Diode	2.5 W Diode	0.284
			2.5 W ERCR	0.169
			3.5 W ERCR	0.875
		2.5 W Diode	2.5 W ERCR	0.005
			3.5 W ERCR	0.201
		2.5 W ERCR	3.5 W ERCR	0.233
Cutting depth of the incision (µm)	post hoc Tukey test	1.5 W Diode	2.5 W Diode	<0.001
			2.5 W ERCR	0.424
			3.5 W ERCR	<0.001
		2.5 W Diode	2.5 W ERCR	<0.001
			3.5 W ERCR	0.826
		2.5 W ERCR	3.5 W ERCR	<0.001

4. Conclusion

The microscopic investigations performed in this work have led to the finding that erbium, chromium YSGG laser samples, specifically the low-power (2.5 W) samples, produced the highest degree of incision regularity. The deepest incisions have been shown with the higher power outputs of the erbium, chromium YSGG and diode lasers (G2 and G4), while the shallowest cutting depths have been shown with the lower powers of the two systems (G1 and G3).

References:

[1] S. B. C. Tarquinio, M. A. Peres, L. J. C. De Oliveira, and K. D. Da Silva, “Oral Lesions in Soft Tissues,” in Oral Epidemiology, M. A. Peres, J. L. F. Antunes, and R. G. Watt, Eds., in Textbooks in Contemporary Dentistry. , Cham: Springer International Publishing, 2021, pp. 251–263. doi: 10.1007/978-3-030-50123-5_15.
[2] E. Schmidt, Ed., Diseases of the Oral Mucosa: Study Guide and Review. Cham: Springer International Publishing, 2021. doi: 10.1007/978-3-030-82804-2.
[3] Prof. K. Kamburoglu, Dr. G. Sonmez, Esra EceÇakmak, Prof. E. Baris, and Prof. H. Altan, “Case presentation of oral soft tissue lesions by using ultrasound, terahertz and histopathology,” Oral Surg. Oral Med. Oral Pathol. Oral Radiol., vol. 134, no. 3, p. e78, Sep. 2022, doi: 10.1016/j.oooo.2022.04.029.
[4] S. Srivastava, V. Ebenezer, and R. Balakrishnan, “Lasers in Oral and Maxillofacial Surgery- A Review,” J. Pharm. Sci. & Res, vol. 15, no. 3, p. 1057, 2023.
[5] A. Hanke, R. Fimmers, M. Frentzen, and J. Meister, “Quantitative determination of cut efficiency during soft tissue surgery using diode lasers in the wavelength range between 400 and 1500 nm,” Lasers Med. Sci., vol. 36, no. 8, pp. 1633–1647, Oct. 2021, doi: 10.1007/s10103-020-03243-4.
[6] E. Azma and N. Safavi, “Diode laser application in soft tissue oral surgery,” J. Lasers Med. Sci., vol. 4, no. 4, pp. 206–211, 2013.
[7] Damanhour University (and PhD Student in Prosthodontic Department Alexandria University), Egypt and M. M. Sarhan, “Revolutionizing oral surgery: The benefits of diode laser for soft tissue lesion removal,” J. Clin. Images Med. Case Rep., vol. 4, no. 4, Apr. 2023, doi: 10.52768/2766-7820/2390.
[8] H. Mazin Akram, O. Husham Ali, N. Kadhum Omran, and A. Omran Ali, “Diode Laser Versus Scalpel Gingivectomy,” Biomed. Pharmacol. J., vol. 10, no. 4, pp. 1799–1804, Dec. 2017, doi: 10.13005/bpj/1295.
[9] prof. dr. Janez Diaci and prof. dr. Boris Gaspirc, “REVIEW Comparison of Er:YAG and Er,Cr:YSGG lasers used in dentistry,” LA&HA J, vol. 2012, no. 1, [Online]. Available: https://www.laserandhealthacademy.com/media/objave/academy/priponke/1_13_laha_journal_2012_1a.pdf
[10] M. N. Alqutub, “Peri-implant parameters and cytokine profile among Peri-implant disease patients treated with Er Cr YSGG laser and PDT,” Photodiagnosis Photodyn. Ther., vol. 37, p. 102641, Mar. 2022, doi: 10.1016/j.pdpdt.2021.102641.
[11] J. Orozco, D. Rico, L. Barrios, V. Hoyos, and P. Blanco, “Artefactos histológicos asociados a gingivectomía con láser y electrobisturí: serie de casos,” Biomédica, vol. 43, no. 3, pp. 315–322, Sep. 2023, doi: 10.7705/biomedica.6930.
[12] C. Fornaini et al., “Four different diode lasers comparison on soft tissues surgery: a preliminary ex vivo study,” LASER Ther., vol. 25, no. 2, pp. 105–114, 2016, doi: 10.5978/islsm.16-OR-08.
[13] P. Vescovi et al., “Nd:YAG laser versus traditional scalpel. A preliminary histological analysis of specimens from the human oral mucosa,” Lasers Med. Sci., vol. 25, no. 5, pp. 685–691, Sep. 2010, doi: 10.1007/s10103-010-0770-4.
[14] L. Monteiro et al., “A histological evaluation of the surgical margins from human oral fibrous-epithelial lesions excised with CO2 laser, Diode laser, Er:YAG laser, Nd:YAG laser, electrosurgical scalpel and cold scalpel,” Med. Oral Patol. Oral Cirugia Bucal, pp. 0–0, 2019, doi: 10.4317/medoral.22819.
[15] E. Merigo et al., “Laser-assisted surgery with different wavelengths: a preliminary ex vivo study on thermal increase and histological evaluation,” Lasers Med. Sci., vol. 28, no. 2, pp. 497–504, Feb. 2013, doi: 10.1007/s10103-012-1081-8.
[16] F. F. Sperandio, D. T. Meneguzzo, L. S. Ferreira, P. A. Da Ana, L. H. Azevedo, and S. C. O. M. De Sousa, “Different air-water spray regulations affect the healing of Er,Cr:YSGG laser incisions,” Lasers Med. Sci., vol. 26, no. 2, pp. 257–265, Mar. 2011, doi: 10.1007/s10103-010-0849-y.
[17] C. Fornaini et al., “450 nm Blue Laser and Oral Surgery: Preliminary ex vivo Study,” J. Contemp. Dent. Pract., vol. 17, no. 10, pp. 795–800, Oct. 2016, doi: 10.5005/jp-journals-10024-1933.
[18] H. Wurm et al., “Comparative ex vivo Investigations on the Cutting Quality of the CO2 Laser and the Diode Pumped Er:YAG Laser,” Front. Surg., vol. 8, p. 764450, Dec. 2021, doi: 10.3389/fsurg.2021.764450.
[19] S. Yammine, E. Jabbour, S. El Toum, and A. Cassia, “Histological Study of Induced Incisions on Rabbits' Tongues with Three Diode Lasers with Different Wavelengths in Continuous Mode,” Scientifica, vol. 2018, pp. 1–8, 2018, doi: 10.1155/2018/2691942.
[20] C. Fornaini, J. P. Rocca, M. F. Bertrand, E. Merigo, S. Nammour, and P. Vescovi, “Nd:YAG and Diode Laser in the Surgical Management of Soft Tissues Related to Orthodontic Treatment,” Photomed. Laser Surg., vol. 25, no. 5, pp. 381–392, Oct. 2007, doi: 10.1089/pho.2006.2068.
[21] SR Pohlhaus, “Lasers in dentistry: minimally invasive instruments for the modern practice,” 2012, vol. 105, p. 211886.

[22] R. Kawamura et al., “Ex Vivo Evaluation of Gingival Ablation with Various Laser Systems and Electroscalpel,” Photobiomodulation Photomed. Laser Surg., vol. 38, no. 6, pp. 364–373, Jun. 2020, doi: 10.1089/photob.2019.4713.
[23] G. Tenore et al., “The Impact of Laser Thermal Effect on Histological Evaluation of Oral Soft Tissue Biopsy: Systematic Review,” Dent. J., vol. 11, no. 2, p. 28, Jan. 2023, doi: 10.3390/dj11020028.

عنوان البحث باللغة العربية(دراسة تقييمية مقارنة لليزر الاربيوم كروميوم YSGG وليزر دايود ثنائي الصمام مزدوج الطول الموجي في شكل شق الأنسجة الرخوة الفموية: دراسة نسيجية خارج الجسم الحي)

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الخلاصة: الليزر هو نظام مفيد يمكن استخدامه في تطبيقات طبية مختلفة، وأحدها هو التعامل مع الأنسجة الرخوة في جراحة الفم وماحول الاسنان. يهدف البحث الحالي إلى المقارنة النسيجية بين ليزر الإربيوم كروميوم YSGG وليزر الصمام الثنائي ثنائي الطول الموجي في الشقوق الجراحية الفموية وفقًا لشكل القطع. **الطريقة:** كانت هذه دراسة خارج الجسم الحي باستخدام قطع لسان من الأغنام كعينات. تم تشغيل ليزر ديود(50%)980 + (50%)810 نانومتر بشكل مستمر (CW) بمعلمتي قوى: 1.5و 2.5 واط. تم استخدام ليزر الإربيوم كروميوم YSGG 2780 نانومتر في وضع النبض بمعلمتي قوى: 2.5 و 3.5 واط. تم عمل شقوق في أجزاء اللسان، وبعد المعالجة النسيجية، تم قياس انتظام وشكل الشق وعمق القطع لكل شق تحت المجهر الضوئي. **النتائج:** كان انتظام وشكل شقوق ليزر الإربيوم كروميوم YSGG أعلى بكثير في الجودة (خاصة تلك ذات طاقة الخرج المنخفضة البالغة 2.5 واط) مقارنة بتلك الموجودة في ليزر الصمام الثنائي (قيمة P <0.05). وكان عمق القطع أعلى بكثير عندما زادت الطاقة، بغض النظر عن نوع نظام الليزر (قيمة P <0.05). **الاستنتاجات:** تم إجراء معظم الشقوق المنتظمة باستخدام قوة 2.5 واط من ليزرالاربيوم كروميوم YSGG.