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ORIGINAL ARTICLE

A randomized controlled clinical and histopathological trial comparing excisional biopsies of oral fibrous hyperplasias using CO_2 and Er:YAG laser

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Abstract This study was conducted in order to compare clinical and histopathological outcomes for excisional biopsies when using pulsed CO_2 laser versus Er:YAG laser. Patients ($n = 32$) with a fibrous hyperplasia in the buccal mucosa were randomly allocated to the CO_2 (140 Hz, 400 µs, 33 mJ) or the Er:YAG laser (35 Hz, 297 µs, 200 mJ) group. The duration of excision, intraoperative bleeding and methods to stop the bleeding, postoperative pain (VAS; ranging 0–100), the use of analgesics, and the width of the thermal damage zone (µm) were recorded and compared between the two groups. The median duration of the intervention was 209 s, and there was no significant difference between the two methods. Intraoperative bleeding occurred in 100% of the excisions with Er:YAG and 56% with CO_2 laser ($p = 0.007$). The median thermal damage zone was 74.9 µm for CO_2 and 34.0 µm for Er:YAG laser ($p < 0.0001$). The median VAS score on the evening after surgery was 5 for the CO_2 laser and 3 for the Er:YAG group. To excise oral soft tissue lesions, CO_2 and Er:YAG lasers are both valuable tools with a short time of intervention and postoperative low pain. More bleeding occurs with the Er:YAG than CO_2 laser, but the lower thermal effect of Er:YAG laser seems advantageous for histopathological evaluation.

Keywords Laser · Oral mucosa · Fibrous hyperplasia · Bleeding · Thermal damage zone · Pain

Introduction

The CO_2 laser ($\lambda = 10{,}600$ nm) has been established for the treatment of benign and premalignant intraoral lesions [1–4] since the late 1970s and is widely accepted today [5–8]. Furthermore, the surgical excision of oral malignancies in early stages has also been reported in the literature [9–11]. Due to the effect of thermocoagulation, intraoperative bleeding is reduced, providing a better view for the surgeons during treatment. On the other hand, there is a need for a safety border of 1 mm when performing incisional and excisional biopsies to allow histopathological analysis of the entire specimen, especially when suspecting premalignant lesions or established malignancy [12].

The Er:YAG laser ($\lambda = 2940$ nm) has wider applications in dentistry, including removal of carious lesions [13] or calculus from root surfaces [14], and for endodontic treatments [15]. The Er:YAG laser is also in use for oral soft tissue surgery [16, 17]. The Er:YAG laser has a higher water absorption coefficient than the CO_2 laser, and its energy is converted into local thermal energy with high-temperature peaks. This creates a massive expansion in the target chromophore of water resulting in microexplosions and tissue ablation, a process also known as photomechanical effect [18]. The thermocoagulation effect is minimal [19–21]. This has the advantage of preserving the integrity of most of the specimen for histopathological analysis [20]. On the other hand, bleeding is frequent when soft tissue surgery is performed with the Er:YAG laser [16, 19].

Patients' satisfaction following surgical interventions is mainly based on low complication rates and low pain

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sensation [22]. In clinical trials evaluating the excision of oral leukoplakias, postoperative pain has been reported to be reduced after CO_2 laser compared to scalpel excision [23] and also after Er:YAG laser compared to scalpel excision [17]. After CO_2 laser surgeries, pain seems reduced in the first few days, probably due to a thin layer of denatured collagen acting as a biological wound dressing on the surface and sealing the end of sensory nerves [8, 24, 25]. A reduced inflammatory response after Er:YAG laser surgeries may be the reason for the reported lower pain after this treatment [19].

The aim of the present study was to analyse clinical and histopathological particularities for excisional biopsies of the mucosa performed with CO_2 and Er:YAG laser in vivo. The primary outcome parameter was to evaluate the thermal damage zone on the excised specimens. Furthermore, secondary outcome variables included the time of surgery, intraoperative bleeding, the need for additional electrocoagulation or sutures, and patient's postsurgical perception of pain and use of analgesics.

Materials and methods

Patient selection and study design

Patients referred to and examined at the Department of Oral Surgery and Stomatology of the University of Bern between June 2013 and December 2015 and with an intraoral lump susceptible to be a fibrous hyperplasia and exclusively localized on the buccal mucosa were initially eligible for the study. To be included in the study, the patient had to agree to undergo an excisional biopsy and had been informed about the surgical methods (CO_2 versus Er:YAG laser), their advantages and disadvantages, and the study group allocation by randomization. They were also informed about the possibility to only monitor and not excise the lesion.

Only fibrous hyperplasias with a minimal dimension (length and/or height) of 5 mm and not exceeding 20 mm were included (Figs. 1a and 2a). Criteria for exclusion were age younger than 18 years, pregnancy, untreated diabetes mellitus, known infectious diseases (i.e. HIV, hepatitis), medication with antiplatelets (i.e. acetylsalicylic acid, clopidogrel) or oral anticoagulants (i.e. vitamin K antagonist, direct oral anticoagulants) and immunosuppressants. All patients provided written informed consent before treatment. The random allocation was performed with a computer model (www.randomization.com) using a block randomization model. Group 1 was treated by CO_2 laser and group 2 by Er:YAG laser. The study protocol had been approved by the standing ethics committee of the State of Bern (Ref Nr. KEK-BE: 203/12). Examination and data collection were done according to the guidelines of the World Medical Association Declaration of Helsinki [26].

Laser surgeries

All excisional laser biopsies were performed under local anaesthesia with articaine (4%) including adrenalin (1:200,000) (Ultracain D-S 4%, Aventis Pharma AG, Zürich, Switzerland) by one single experienced oral surgeon (V.S.). For all excisional biopsies, a wet wooden tongue blade was placed behind the target to minimize possible tissue damage by aberrant laser beams. Surgeries for group 1 were performed with an air-cooled CO_2 laser with a wavelength of 10.6 μm (Spectra DENTA Surgical Carbon Dioxide Laser, MAX Engineering Ltd., Gyeonggi-Do, South Korea) (Fig. 1a–d). A char-free mode with a frequency of 140 Hz, a pulse duration of 400 μs and a pulse energy of 33 mJ, resulting in a power of 4.62 W was used. The laser beam had a spot size of 0.2 mm and was applied to the oral soft tissue in a non-contact mode (1–2 mm distance to the mucosa) using a straight handpiece and an articulated mirror arm. Surgeries for group 2 were performed with an Er:YAG laser with a wavelength of 2940 nm (LiteTouch™, Synergon Dental Lasers, Light Instruments Ltd., Yokneam Elite, Israel) (Fig. 2a–d). The soft tissue biopsy mode with air-water cooling (22.5 ml/min), a frequency of 35 Hz, a pulse duration of 297 μs and a pulse energy of 200 mJ, resulting in a power of 7 W was used. The sapphire tip was cylindrical and 400 μm in diameter. The laser application was without contact to the tissue.

All incidental intraoperative bleeding was recorded (Fig. 2b). The need for electrocauterization (Martin ME 82, KLS Martin Group, Tuttlingen, Germany) and/or for suturing (Seralon 5-0, Serag Wiessner GmbH & Co., Naila, Germany) to stop the bleeding was recorded separately. Except for cases which needed sutures to stop the bleeding, wounds were left to open granulation and secondary epithelialization. An adhesive wound paste (Solcoseryl Dental Adhesive Paste, MEDA Pharmaceuticals Switzerland GmbH, Wangen-Brüttisellen, Switzerland) was then applied postoperatively, and patients were instructed to apply it twice daily (Fig. 1c). The duration of the excision was registered with a stopwatch. It started when the laser beam was first applied and ended when the wound paste had been applied. All surgical specimens were fixed in buffered formalin (4%) and sent for histopathological evaluation to confirm the diagnosis of a fibrous hyperplasia and evaluation of the thermal damage zone (Fig. 3a, b).

Postoperative analysis

To record the perception of postoperative pain, patients were instructed to fill in a visual analogue scale (VAS; ranging from 0 to 100). The first VAS value was filled in before surgery, the second value in the evening after surgery and then on each of the following days (up to 2 weeks). Patients were also handed out a postoperative analgesic (paracetamol 1 g, Dafalgan, Bristol-Myers Squibb SA, Baar, Switzerland) and instructed

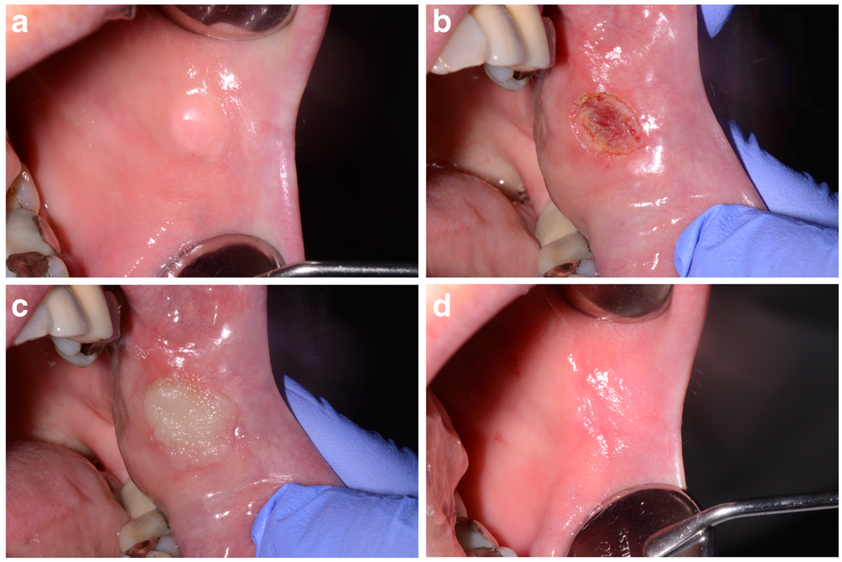

Fig. 1 Fibrous hyperplasia in the left buccal mucosa of a 70-year-old female patient (**a**). The excision was performed with the CO_2 laser in char-free mode (140 Hz, 400 µs, 33 mJ) without any visible bleeding (**b**). An adhesive wound paste (Solcoseryl Dental Adhesive Paste) was applied (**c**). Three weeks after the intervention, a full re-epithelialization had occurred (**d**)

to use it only when needed (intake every 6 to 8 h). Patients were instructed how to record the day and dose interval of their intake on their study form. Patients were also instructed to write down, in a further specific section of the study form, any postoperative bleeding that occurred.

Histopathological analysis

Biopsy specimens were fixed in a 4% neutral-buffered formalin solution, embedded in paraffin, sectioned in slices of 5 µm and stained with hematoxylin-eosin for histopathological evaluation. All measurements of the thermal damage zone were done by the same experienced pathologist (H.J.A.) not involved in the primary diagnosis of the specimens and blinded to the type of laser used. Measurements were done on a representative section on both lateral edges of the fibrous hyperplasia (Fig. 3a, b). In a zone adjacent to the epithelium of each specimen, the maximal and the minimal thermal damage were measured in micrometres.

Statistical analysis

For the descriptive analysis, the mean, median, 0.25-quantile and 0.75-quantile and maximum and minimum values were calculated for age and gender of included patients and duration of surgeries. To analyse the histopathological thermal damage zones, the median, 0.25-quantile and 0.75-quantile and maximum and minimum values of the minimal and maximal damage zones of both edges were calculated. For the analysis of pain scores, the median VAS scores (plus 0.25-quantile and 0.75-quantile) during several time periods of interest were calculated. In addition to descriptive statistics,

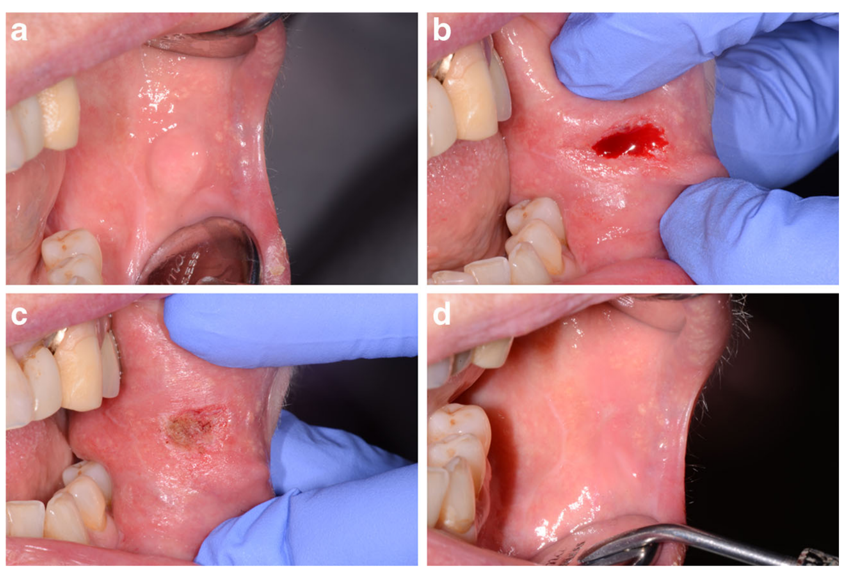

Fig. 2 Fibrous hyperplasia in the left buccal mucosa of an 85-year-old female patient (**a**). The excision was performed with the Er:YAG laser (35 Hz, 297 µs, 200 mJ) with water spray. Bleeding occurred during excision and persisted (**b**). The bleeding was stopped by electrocauterization (**c**). Three weeks after the excisional biopsy, a full re-epithelialization had occurred (**d**)

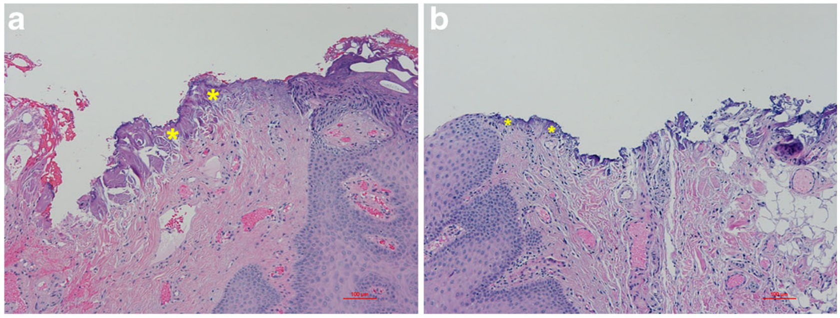

Fig. 3 Representative histopathological view of the thermal damage zone (*asterisks*) adjacent to the epithelium after an excisional biopsy performed with the CO_2 laser (140 Hz, 400 μs, 33 mJ) (**a**) and an Er:YAG laser (35 Hz, 297 μs, 200 mJ) (**b**); H & E stain

between-group comparisons were performed using the Fisher's exact test for dichotomous categorical variables and the Wilcoxon-Mann-Whitney test for continuous variables, as well as the Wilcoxon's signed rank test for paired groups of a continuous variable. The association between the dimensions of the thermal damage zone and postoperative VAS scores of the patients was analysed with an asymptotic t test for the null hypothesis of no Spearman correlation.

For all tests, two-sided p values were reported at a significance level of $\alpha = 0.05$. The analysis was performed using the software package R 3.2.2 (R Project for Statistical Computing, Vienna, Austria).

Results

Distribution of patients and lesions

Of the 32 patients, 17 were female and 15 male resulting in a female to male ratio of 1.13:1. The median age of the patients was 61 years with a range from 21 to 85 years (Table 1). Of the 32 fibrous hyperplasias excised, 17 were located on the left and 15 on the right buccal plane.

Duration of surgery and intraoperative bleeding

The median duration of all surgical excisions was 209 s (Table 2). There was no significant difference ($p = 0.1188$) between the time of surgery for the CO_2 versus Er:YAG laser excisions. The longest time of intervention was 10 min and 57 s in a case treated by Er:YAG laser which needed electrocauterization and primary wound closure by sutures to control the bleeding. Intraoperative bleeding occurred in all cases (100%) treated by Er:YAG laser. Significantly fewer cases ($n = 9$, 56%, $p = 0.0068$) had intraoperative bleeding when treated by CO_2 laser. The need to use the electrocauter was significantly higher in the Er:YAG ($n = 15$, 94%, $p = 0.0155$) than in the CO_2 laser group ($n = 8$, 50%).

Histopathological evaluation

One specimen was not included in the histopathological evaluation because the thermal damage zone could not be identified

Table 1 Patient demographics (age and gender) and localization of the excised fibrous hyperplasias using the CO_2 (char-free mode, pulse frequency 140 Hz, pulse energy 33 mJ, pulse duration 400 μs, power 4.62 W) or the Er:YAG laser (pulse frequency 35 Hz, pulse duration 297 μs, pulse energy 200 mJ, power 7 W)

	Overall	Group 1 CO_2 laser	Group 2 Er:YAG
Patients (n)	32	16	16
Age (years)			
Mean	56.3	56.8	56.0
Median (p25, p75)	61 (46.8, 67.0)	61.5 (45.0, 67.0)	59.5 (48.5, 65.5)
Minimum	21	33	21
Maximum	85	75	85
Gender (n)			
Female, n (%)	17 (53)	9 (56)	8 (50)
Male, n (%)	15 (47)	7 (44)	8 (50)
Fibrous hyperplasias (n)	32	16	16
Location			
Right buccal mucosa, n (%)	15 (47)	7 (44)	8 (50)
Left buccal mucosa, n (%)	17 (53)	9 (56)	8 (50)

Table 2 Analysis and comparison of time of surgery, frequency of intraoperative bleeding, need of electrocauterization and need of sutures between the CO_2 and the Er:YAG laser group

	Overall	Group 1 CO_2 laser	Group 2 Er:YAG laser	*p* value
Patients, *n*	32	16	16	
Time (s)				
Mean	208.7	179.8	237.6	0.1188
Median (p25, p75)	190.0 (143.5, 258.8)	158.5 (103.5, 243.8)	201.0 (165.8, 259.5)	
Minimum	82.0	82.0	147.0	
Maximum	657.0	365.0	657.0	
Intrasurgical bleeding, *n* (%)				
Bleeding occurred	25 (78)	9 (56)	16 (100)	*0.0068*
Need of electrocauterization	23 (72)	8 (50)	15 (94)	*0.0155*
Need of sutures	1 (3)	0 (0)	1 (6)	1.0000

CO_2 laser: char-free mode, frequency 140 Hz, pulse duration 400 µs, pulse energy 33 mJ, power of 4.62 W. Er:YAG laser: frequency 35 Hz, pulse duration 297 µs, pulse energy 200 mJ, power 7 W. Italics settings indicate statistically significant findings

p25 25th percentile, *p75* 75th percentile

adequately. The excluded case was from the CO_2 laser group. The remaining 31 specimens (15 from the CO_2 and 16 from the Er:YAG laser group) were available for evaluation. The minimal thermal damage zone was 4.5 µm in the Er:YAG and 27 µm in the CO_2 laser group (Table 3). The median of all minima was significantly different for the Er:YAG versus the CO_2 laser group ($p<0.0001$). The maximal thermal damage zone (172 µm) was found in the CO_2 laser group, and the median of all maxima was significantly higher for this group ($p<0.0001$). The pooled median value (maxima and minima) of the thermal damage zone of all specimens was 54.5 µm and was significantly different when comparing both laser groups ($p<0.0001$).

Postoperative pain (VAS scale), analgesic intake and healing patterns

All standardized study forms were filled in correctly by the patients and were available for analysis. VAS pain scores for both groups during the first week following surgery are shown in Fig. 4. The differences for the mean VAS scores between men and women for days 1–3 were not statistically significant ($p=0.1904$). For days 1–7 ($p=0.0031$) and 1–15 ($p=0.0035$), the differences between genders were significant, with female patients reporting higher pain values. The median VAS score on the evening after surgery (day 1) was 5 for the CO_2 laser group and 3 for the Er:YAG group (Table 4). From the 10th day on, median pain values were 0 for both methods. When comparing the combined mean VAS scores of both groups for days 1–3, 1–7 and 1–15, there were no statistically significant differences. No statistically significant correlation could be found between the pooled dimensions of the thermal damage zone and postoperative VAS scores of the patients during the first 3 days ($p=0.97$) or the first week ($p=0.95$).

Less than 10% of all patients used systemic analgesia (Table 4). One patient from the Er:YAG and one patient from the CO_2 laser group took the analgesic only on the evening of

Table 3 Histopathological evaluation and comparison of the thermal damage zones between the CO_2 and the Er:YAG laser group

	Overall	Group 1 CO_2 laser	Group 2 Er:YAG laser	*p* value
Patients, *n*	31	15	16	
Histopathologic thermal damage zone (µm)				
Minimum	4.5	27.2	4.5	
Median of all minima (p25, p75)	29.5 (18.2, 49.9)	49.9 (40.9, 57.9)	18.2 (12.5, 22.7)	*<0.0001*
Maximum	172.5	172.5	131.7	
Median of all maxima (p25, p75)	81.7 (55.6, 122.6)	122.6 (102.1, 141.9)	56.8 (48.8, 72.6)	*<0.0001*
Median of all values (p25, p75)	54.5 (27.2, 81.7)	74.9 (49.9, 122.6)	34.0 (18.2, 59.0)	*<0.0001*

CO_2 laser: char-free mode, frequency 140 Hz, pulse duration 400 µs, pulse energy 33 mJ, power of 4.62 W. Er:YAG laser: frequency 35 Hz, pulse duration 297 µs, pulse energy 200 mJ, power 7 W. Italics settings indicate statistically significant findings

p25 25th percentile, *p75* 75th percentile

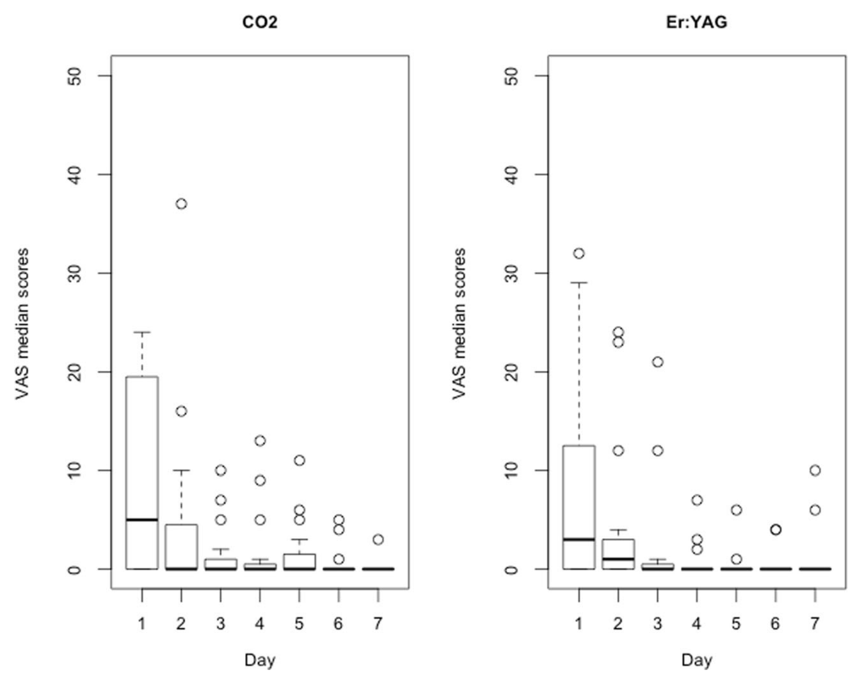

Fig. 4 Box plot illustrating the pain recorded by a visual analogue scale (VAS 1–100) during the first week (days 1 to 7) after excisions by CO_2 and Er:YAG laser. Day 1 = day of intervention

intervention (day 1). A third patient (CO_2 laser group) took paracetamol (1 g) on days 1 to 6. One patient from the CO_2 laser group (on the day of surgery) and none from the Er:YAG laser group recorded a postsurgical bleeding. One week after excision, all cases had an ongoing wound healing without complete re-epithelialization. By the third week (second scheduled follow-up), wound closure was achieved in all cases.

Discussion

This randomized controlled trial (RCT) evaluated clinical and histopathological outcomes of 32 excisional biopsies of fibrous hyperplasias on the buccal mucosa performed with CO_2 and Er:YAG laser. In the histopathological evaluation, the thermal damage zone was significantly thinner in Er:YAG laser specimens. Clinical outcomes showed no difference in duration of surgery but significantly more bleeding and need to use the electrocauter when using the Er:YAG laser. No correlation could be found between the laser method used and the sensation of postoperative pain on a VAS scale filled in by patients for 15 days. For both laser treatments, patients' sensation of pain and use of analgesics were low.

The overall mean and median duration of surgery irrespective of the method used was relatively short with not more than 4 min needed to perform the excisional biopsy and achieve hemostasis. Even if bleeding was more pronounced

Table 4 Analysis and comparison of reported postoperative complications, pain (VAS values) and analgesic intake between the CO_2 laser and the Er:YAG laser group

	Overall	Group 1 CO_2 laser	Group 2 Er:YAG laser	p value
Patients, n	32	16	16	
VAS values (1–100)				
Day 1, median (p25, p75)	4.0 (0.0, 15.2)	5.0 (0.0, 19.2)	3.0 (0.0, 11.8)	0.7773
Day 2, median (p25, p75)	0.0 (0.0, 4.0)	0.0 (0.0, 4.2)	1.0 (0.0, 2.5)	0.8336
Day 3, median (p25, p75)	0.0 (0.0,0.2)	0.0 (0.0, 0.5)	0.0 (0.0, 0.2)	0.8339
Day 4, median (p25, p75)	0.0 (0.0, 0.0)	0.0 (0.0, 0.2)	0.0 (0.0, 0.0)	0.8226
Days 1–3, median (p25, p75)	0.0 (0.0, 6.0)	0.0 (0.0, 6.2)	0.0 (0.0, 5.2)	0.2807
Days 1–7, median (p25, p75)	0.0 (0.0, 1.0)	0.0 (0.0, 2.2)	0.0 (0.0, 1.0)	0.8226
Days 1–15, median (p25, p75)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.5249
Analgesics, n (%)	3 (9)	2 (13)	1 (6)	1.0000

CO_2 laser: char-free mode, frequency 140 Hz, pulse duration 400 µs, pulse energy 33 mJ, power of 4.62 W. Er:YAG laser: frequency 35 Hz, pulse duration 297 µs, pulse energy 200 mJ, power 7 W

VAS visual analogue scale (range 0 to 100), *p25* 25th percentile, *p75* 75th percentile in the Er:YAG laser group and the electrocauter was applied in 94% of the cases (versus 50% in the CO_2 laser group), this did not have a significant impact on the duration of intervention. Excisional biopsies were all performed by the same oral surgeon (V.S.) in the same clinical setting to minimize operator's influence. Furthermore, only one type of lesion (fibrous hyperplasia) in the same anatomical localization (buccal mucosa) was chosen for this study.

The diminished bleeding and better view during surgeries is a well-known advantage of the CO_2 laser and is due to the sealing of small blood vessels [12, 27, 28]. Previous studies by our group reported bleeding frequencies during CO_2 laser intervention with the need to use the electrocauter in 5.5% [28], in 15% [12] and in 17% [8] of cases. No intraoperative bleeding complication was recorded by Tuncer et al. [29] after the use of CO_2 laser to remove 43 different lesions and by Pié-Sánchez et al. [30] when performing upper lip frenectomies. Tambuwala et al. [31] had a split mouth design and removed leukoplakia with CO_2 laser and the scalpel in the buccal plane of 30 patients. Scalpel excision resulted in a shorter surgical time but significantly more bleeding than with CO_2 laser. In 15% of the excisions with the CO_2 laser, sutures were needed. In our study, there was no need for suturing in any CO_2 laser case but in one Er:YAG laser case. In the present study, the electrocauter was used to stop the bleeding, and suturing of the laser wound was only applied when hemostasis was still not achieved.

Time of surgery and bleeding were compared in another clinical study using Er:YAG and CO_2 laser [32]. In contrast to our study, they used the Er:YAG laser without water cooling, applied both lasers in a defocused mode and ablated pigmented lesions on the gingiva for cosmetic reasons in a split mouth model in 20 patients. Duration of surgery was longer ($p < 0.001$) and more bleeding happened ($p < 0.001$) during Er:YAG than during CO_2 laser ablation. Further studies are needed to evaluate if by excising other types of oral lesions in other regions of the mouth, the time of surgery could become different between methods, especially if the tissue is more vascularized.

To the best of our knowledge, this is, after Zaffe et al. [19], only the second study comparing the histopathological characteristics of human oral biopsies taken by CO_2 and Er:YAG laser. Zaffe et al. [19] detected epithelial blisters, epithelial lamina clefts, erosions and cells with perinuclear halo (intracellular edema) or devoid of nucleus at the edges of CO_2 laser biopsies, while the central part and the specimens taken by Er:YAG laser did not show relevant morphological changes. In contrast to our study, no measurement of the dimension of the thermal damage zone was performed. Immunohistochemistry of the specimens excised by CO_2 laser by Zaffe et al. [19] detected a reduction of the expression of markers of intracellular proteins and nuclear cell-cycle proliferation suggesting a stress effect on cell synthesis not found after Er:YAG application.

In another study, epithelial changes, connective tissue modifications including thermal necrosis, presence/absence of vascular modifications and the overall width of tissue modifications were evaluated on cadaver calf tongue samples after excision with different lasers and parameters, including CO_2 laser (continuous wave and superpulse mode) and Er:YAG laser with air/water spray [21]. The width of visible epithelial (110 μm) and stromal changes (<100 μm) was the smallest after Er:YAG application, and no vascular changes were detected in this laser group. No statistical evaluation comparing the widths of changes between the different laser types was performed. Due to different methods of evaluation, it is not possible to compare the width measurements of the thermal damage zone of our study with the described widths of changes in this animal study. Nevertheless, our results similarly showed significant less thermal damage after Er:YAG than after CO_2 laser surgery.

Merigo et al. [21] described a more precise cut with the CO_2 laser than with the Er:YAG laser, which exhibited an irregular aspect. However, the Er:YAG laser still showed a better performance in terms of histological anatomy in the area of exposure. In the present study, similar microscopic findings were seen in the evaluation of the fibrous hyperplasias after intraoral excisional biopsies. While the CO_2 laser results in a more precise linear cut, the Er:YAG laser exhibits a cratered surface due to microexplosions resulting from its thermomechanical effect. However, in the histopathological examination, the CO_2 laser specimens often showed groups of blisters in the thermally damaged tissue in contrast to the more compact and unaltered aspect in the neighbouring areas of the cut in Er:YAG laser specimens. These findings were similar to the microscopic description of epithelial blisters and lamina clefts described for CO_2 laser in an earlier study [19].

Romeo et al. [20] evaluated the histologic effect of increasing energy (60 to 150 mJ) of Er:YAG laser used without a cooling system and a frequency of 30 Hz resulting in a power of 1.8 to 4.5 W on cadaver swine tongue. The thermal damage zone was <1 mm in all samples and the most favourable results were obtained with intermediate power settings (80–100 mJ). The thermal damage zone in these groups was just a few microns wide. In the group with the highest output energy (150 mJ), the thermal damage zone had a score or 2.44 (scoring system ranging from 0 to 3; 2 = 5 to 8 cellular layers damaged; 3 = more the 8 cellular layers damaged).

The settings used in the present study were chosen according to the manufacturer's recommendation for soft tissue biopsy, and the pulse output energy (200 mJ) and resulting power (7 W) were higher than in Romeo et al. [20]. The significantly smaller median thermal damage zone of the Er:YAG laser (34.0 μm median overall) compared to CO_2 laser (74.9 μm median overall) in the present study is in line with the findings of earlier studies [19–21] but has to be interpreted with caution, due to the low number of specimens included. The extent of the thermal damage zone is of clinical importance, especially when planning the excision of a potentially malignant lesion. To perform proper diagnosis and exclude or grade dysplasia, there is a need for the entire lesion to be available for histopathological evaluation. When performing excisional biopsies in daily practice, maintaining a constant working distance may be difficult, especially if lesions are large and/or difficult to access. Also, a precise and evenly shaped cut may be difficult to achieve with the Er:YAG laser. Thus, clinicians using laser for diagnosis or therapy of oral soft tissue lesions should not solely consider the expected thermal damage zone when planning the proper safety border for biopsy. Based on the findings of the present study, a safety border of 1 mm with CO_2 and Er:YAG laser can be recommended.

Hedge et al. [33] evaluated pain on a VAS scale (1–100) following gingival melanin depigmentation using Er:YAG, CO_2 laser and surgical stripping on the first day visit and after 1 week in 35 patients. On the first postoperative day, they found a median pain value of 19 (0 to 76) after Er:YAG and 20 (0 to 75) after CO_2 laser ablation. In the present study, a median pain of 3 (0 to 11.8) in the Er:YAG group and a median pain of 5 (0 to 19.2) in the CO_2 laser group were found. The lower pain scores in the initial phase found in the present study may be explained by the different types of intervention (excisional biopsy of a single fibrous hyperplasia in the cheek versus ablation of pigmented areas on the gingiva [33]), laser modes used (focused versus defocused [33]) and single site application versus multiple (in all four quadrants [33]). Similar to our study, a significant drop of the VAS values was found by Hedge et al. [33] 1 week after intervention. Another study compared the excision of white patches in different regions of the mouth using Er:YAG laser ($n = 173$) and scalpel ($n = 221$). Significantly less pain (VAS scale) was recorded on day 3 in the laser group when lesions were >0.5 cm and less analgesics were taken [17]. In a previous study analysing the excisional biopsies of 100 fibrous hyperplasia with two different CO_2 laser modes (continuous wave versus char-free mode), median VAS scores on day 1 were 10 and 9, respectively. The use of analgesics amounted to 10% in the char-free mode group, which is similar to the findings in this study. In this investigation, an overall low use of analgesics (9%) after both laser interventions was seen.

Conclusions

The CO_2 and Er:YAG lasers are both valuable tools to excise oral soft tissue lesions such as fibrous hyperplasias. Clinical parameters such as the time of intervention, pain and the use of analgesics seem low and similar with both laser methods. Due to the lower thermal effect, tissue integrity is better preserved after Er:YAG than CO_2 laser excisions with the advantage of a smaller damage zone in the histopathological evaluation. An important disadvantage using Er:YAG laser is frequent bleeding and the need to apply further hemostatic methods such as electrocauterization or suturing. Studies with larger cohorts and ideally also a control group including scalpel are necessary to confirm these findings and to better define the advantages and disadvantages of laser modalities to perform excisional biopsies in the oral mucosa.

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Compliance with ethical standards The study protocol had been approved by the standing ethics committee of the State of Bern, Switzerland (Ref Nr. KEK-BE: 203/12).

Conflict of interest The authors declare that they have no conflict of interest.

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