

Comparison of Clinical Outcomes of Gingival Depigmentation using Diode Laser versus Scalpel Surgery: A Prospective Interventional Study

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ABSTRACT

Introduction: Pigmentation of the gingiva, when it is not related to the skin complexion, is a dampening factor in an otherwise acceptable smile window. Gingival depigmentation is a periodontal plastic surgical procedure to remove melanin hyperpigmentation. Various techniques for depigmentation have been tried in the past to treat gingival pigmentation and the extent and rate of recurrence following the procedure varies according to the treatment modalities used and duration of follow-up. Currently there is no universally accepted gold standard technique for optimal outcomes in terms of pain, repigmentation, and patient satisfaction.

Aim: To evaluate the effectiveness of the 810 nm diode laser versus the conventional scalpel method for gingival depigmentation in terms of repigmentation, pain and patient perception.

Materials and Methods: The present prospective interventional study was conducted in Department of Periodontics at Government Dental College, Kottayam, Kerala, India for a total duration of 18 months, from April 2013 to September 2014. Individuals of age 18-40 years with thick gingival biotype having brown or black diffuse gingival pigmentation were included in the study. They were randomised into two groups of ten each, scalpel group and laser group. Pigmentation changes were assessed using Dummett and Gupta Oral Pigmentation Index (DOPI) and from standardised photographs using Image analysis software (ImageJ 1.46r) at baseline, one month, three months, and six months. Pain was recorded using a Visual Analog Scale (VAS),

and patient feedback was obtained via questionnaire at one week post-treatment. Independent samples t-test and Chi-square test were used for statistical analysis. The p-value of less than 0.05 was considered statistically significant and Statistical Package for Social Sciences (SPSS) software version 23 was used.

Results: At the six-month follow-up, both the laser and scalpel groups showed comparable levels of repigmentation, with no statistically significant differences across any parameter. The DOPI score increased slightly in both groups, with the laser group showing a mean of 1.6 ± 0.34 and the scalpel group 1.4 ± 0.44 ($p=0.36$). The area of pigmentation measured $75.8 \pm 37.33 \text{ mm}^2$ in the laser group and $89.9 \pm 43.51 \text{ mm}^2$ in the scalpel group ($p=0.52$). Similarly, the intensity of pigmentation at six months was 140.1 ± 13.79 for the laser group and 142.1 ± 13.11 for the scalpel group ($p=0.70$). Patient-perception outcomes remained positive and identical in both groups, with 100% reporting that the treatment met their expectations and resulted in an improved smile. Intraoperative and postoperative pain scores were comparable between the scalpel (3.40 ± 1.65 ; 3.40 ± 2.01) and laser groups (2.80 ± 1.75 ; 2.50 ± 1.90), with no statistically significant differences ($p=0.50$; $p=0.30$).

Conclusion: The results revealed that both scalpel as well as laser were equally efficient for depigmentation of the gingiva. Choice of technique to be used mainly depends on the availability, clinician's choice, experience, gingival biotype and the degree of pigmentation. Long term follow-up with larger multicentric trials are required to assess which technique offers sustained and stable results.

Keywords: Facial aesthetics, Gingiva, Hyperpigmentation, Melanins, Wound healing

INTRODUCTION

The colour of the gingiva is an important determinant of facial aesthetics and significantly influences the overall appearance of an ideal smile [1]. The colour of the oral mucosa is influenced by multiple factors, including the melanogenic activity of melanocytes, the thickness of the keratinised epithelium, and the extent of vascularisation [2]. Although physiological hyperpigmentation is not classified as a medical disorder, many patients perceive pigmented gingiva as unaesthetic, particularly those with a gummy smile. Laypersons are often highly sensitive to gingival colour changes caused by pigmentation and commonly regard them as unattractive [3].

Gingival depigmentation is an important periodontal plastic surgery procedure aimed at eliminating melanin-induced pigmentation on the gingiva, thereby improving the aesthetic quality of a patient's smile. Various techniques have been utilised for this purpose, including mechanical and surgical methods, electrosurgery, chemical agents

such as 90% phenol and 95% alcohol, cryosurgery, abrasion with diamond burs, free gingival grafts, and laser therapy. Among these, scalpel surgery is a well-established and time-tested approach that continues to be regarded as the gold standard [4]. It involves removal of the gingival epithelium along with a thin layer of connective tissue, after which healing occurs by secondary intention, resulting in a newly formed epithelium free of melanin pigmentation [5]. Although this technique promotes relatively faster healing, it is associated with postoperative pain [6,7]. Among various techniques, scalpel depigmentation stands out for its simplicity, cost-effectiveness, and minimal procedural complexity [8].

Since the 1970s, lasers have been widely utilised in both medical and dental fields for a variety of surgical procedures [9]. The diode laser, a high-power semiconductor device, operates at a wavelength between 800 and 1000 nm, enabling precise soft-tissue incision while simultaneously reducing the bacterial load within periodontal pockets [10]. Lasers are widely employed for depigmentation procedures and

are recently preferred over conventional technique. The commonly used lasers for gingival depigmentation are the diode laser (810 nm), CO₂ lasers (10,600 nm), neodymium-doped Yttrium Aluminum Garnet (YAG) lasers (1,064 nm) [11].

For gingival depigmentation with lasers, melanocytes must be located within the penetration depth of the laser and contain melanin capable of absorbing light energy, which is then converted into heat through photo thermolysis [11]. It has been argued that lasers are reliable, safe, practical and results in reduced postoperative pain and bleeding. Furthermore, it can sculpt, cut, and remove gingival tissues [12]. Gingival repigmentation is the reappearance of melanin which begins with melanocyte migration from adjacent tissues, and its recurrence varies with treatment type and follow-up duration. Currently, there is no universally accepted gold standard technique for optimal outcomes in terms of pain, repigmentation, and patient satisfaction. The clinical evidence directly comparing these two modalities remains limited, especially pertaining to standardised assessment of pigmentation, pain, and patient feedback [13,14]. Moreover, the existing research relies on subjective clinical indices with minimal photographic assessment and often has short follow-up period. Additionally, use of an image analysing software to objectively analyse the pigmentation changes in this study is a novel approach. Considering the clinical relevance and biological rationale, it was deemed important to conduct a comparative evaluation of outcomes following gingival depigmentation performed using laser and scalpel techniques. Accordingly, the present study focused on evaluating the effectiveness of the 810 nm diode laser versus the conventional scalpel method for gingival depigmentation. The secondary objective was to assess intraoperative and immediate postoperative patient discomfort in both methods.

MATERIALS AND METHODS

The present prospective interventional study was conducted in Department of Periodontics at Government Dental College, Kottayam, Kerala, India for 18 months from April 2013 to September 2014. The study was conducted in accordance with the ethical standards of the World Medical Association Declaration of Helsinki and was approved by the Institutional Ethical Committee of Government Dental College, Kottayam (Certificate No: IEC/M/04/2012/DCK). All participants were selected from the outpatient Department of Periodontics at Government Dental College, Kottayam, Kerala, India. Written informed consent was secured from each patient before participation.

Inclusion and Exclusion criteria: Individuals with 18-40 years of age with thick gingival biotype who self-reported of having brown or black diffuse gingival pigmentation were included in the study. Smokers, patients with debilitating systemic disease/condition, pregnant women and lactating mothers, pathologic gingival hyperpigmentation and previous gingival depigmentation procedures were excluded from the study.

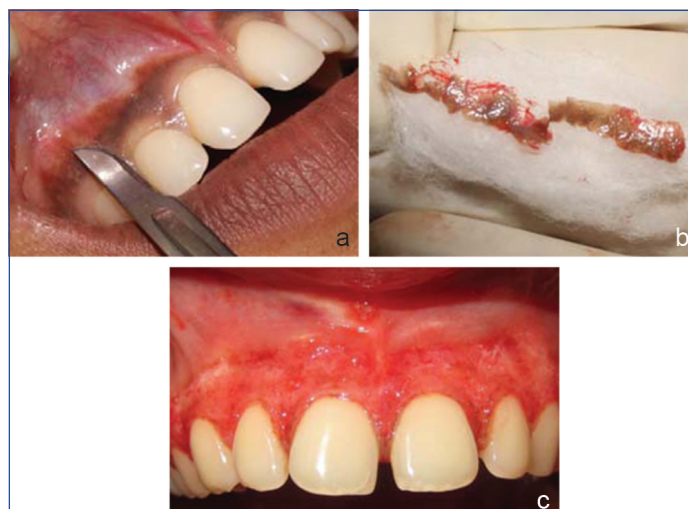
Sample size calculation: Sample size was calculated according to the Pocock's method [15] with α error at 5% and power 90% which was found to be 20 patients, 10 in each group.

Simple randomisation was performed using the coin-flip method to assign participants to the treatment groups. In each patient, the selected sites in the maxilla extended from the distal aspect of the right canine to the midline and from the distal aspect of the left canine to the midline.

Study Procedure

Treatment protocol and interventions: The surgical procedure was performed according to the patient's smile line, because a very high smile line can make the pigmentation more apparent. Based on the smile line, sites with dense bands of gingival pigmentation extending from mesial aspect of right first molar to mesial of left first molar were selected. But clinical parameters were assessed only from distal aspect of right canine to mesial aspect of left canine.

Scalpel group: After aseptic precautions and proper isolation of the surgical field, topical anaesthetic, followed by infiltrative anaesthesia using 2% lignocaine hydrochloride with adrenaline (1:100000) was given. Blade no.15, with bard parker handle was used. The entire pigmented epithelium along with a thin layer of lamina propria (split thickness flap) was removed. Complete removal of pigmented layer was ensured. [Table/Fig-1] shows scalpel depigmentation being done with No.15 blade.



[Table/Fig-1]: a) Shows scalpel depigmentation procedure being done with No.15 blade; b) Shows the removed pigmented epithelium; and c) Shows the immediate postoperative view.

Laser group: The procedure was done in an isolated room allocated for the laser unit. Occupational Safety and Health Administration (OSHA) guidelines for laser safety precautions were strictly followed [16]. Topical anaesthetic, followed by infiltrative anaesthesia using 2% lignocaine hydrochloride with adrenaline (1:100000) was given. Semiconductor diode surgical laser unit (Picasso, wavelength 810 nm at power 0-7 W) laser at 1 Watt (W) power and continuous mode in a contact method using a flexible fibre optic hand piece (tip diameter 400 μ m) was used. [Table/Fig-2] shows depigmentation procedure performed with diode laser. The depigmentation procedure involved applying brief, delicate horizontal strokes resembling a paintbrush technique to effectively remove the epithelial lining.

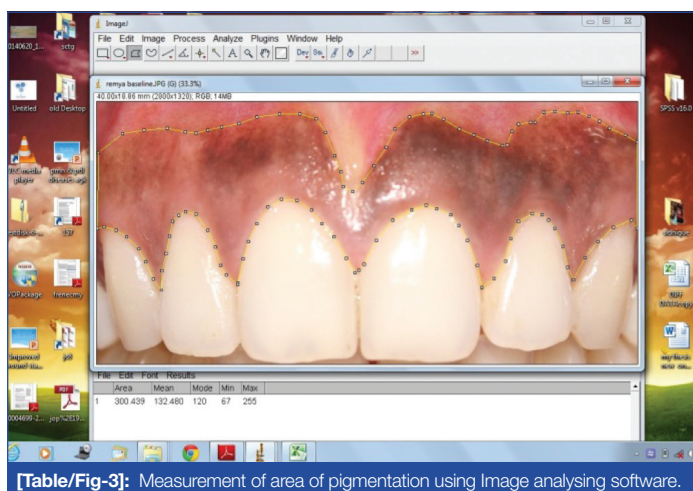


[Table/Fig-2]: Laser depigmentation in progress.

Both groups were given non eugenol coe pack, oral hygiene maintenance instructions and analgesics (Paracetamol 650 mg) 8th hourly for two days. After one week periodontal pack was removed in both groups and the postsurgical site was assessed for healing and routine brushing techniques were restarted after one week. Following treatment, patients were recalled for follow-up visits at one week, one month, three months, and six months postoperatively.

Outcome assessment: Colour change was assessed by Dummett Oral Pigmentation Index (DOPI) and by image-analysing software at baseline, one month, three months and six months [17].

Calculating area and Intensity of pigmentation: The total surface area of pigmentation was measured with the help of four standardised photographs of each patient at baseline, one month, three months and six months. The images were copied on to an Image analysing software, (Image J 1.46r, National Institutes of Health (NIH), Bethesda, Maryland, USA) where the pigmented area was demarcated by an examiner other than the investigator. Photographs were cropped from canine to canine and were calibrated to real life size as 40 mm-2800 pixels. Pigmented area from canine to canine was calculated. Intensity of pigmentation was assessed from upper canine to canine on all the photographs. The gingival pigmentation was assessed by a single examiner (AGK) who was blinded to the treatment group to which the patient was assigned. [Table/Fig-3] shows measurement of area of pigmentation using image analysing software.



Postoperative outcomes measured were pain, patient perception towards the treatment and expectations from the treatment. Intraoperative pain was assessed on the same day of procedure and postoperative pain at one week using the Huskisson VAS, a single-item instrument consisting of a 100 mm horizontal line anchored at both ends, with 0 indicating “no pain” and 10 indicating “pain as severe as possible” [18]. Patient perception towards the treatment was assessed with a pre validated questionnaire that was collected from the patient at one week. The original questionnaire by Tal H et al., consisted of 10 items, which were culturally adapted and reduced to seven items following expert review [19]. Content validation demonstrated strong agreement, with a Content Validation Index-Scale (CVI-S) of 0.91 and a Content Validation Index-Universal Agreement (CVI-UA) of 0.77. The kappa value of 0.78 indicated substantial agreement beyond chance. The response was recorded as Yes/No. Outcomes measured included whether the treatment had met the patient expectations, effect of the procedure on oral hygiene practices and whether there was a positive change in the smile.

STATISTICAL ANALYSIS

Data were recorded in Microsoft Excel and subsequently analysed using SPSS software version 23. Categorical variables were summarised using descriptive statistics. An independent samples t-test was employed to compare the means between the two groups for the DOPI, pigmented area, and intensity. Patient perception between the groups was assessed using the chi-square test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

[Table/Fig-4] presents the clinical outcomes of gingival depigmentation using scalpel and laser techniques, evaluated at baseline, one month,

three months, and six months. In terms of the DOPI, both laser and scalpel groups showed significant reductions over time ($p < 0.001$). The scalpel group had a sharper initial decline, especially at one month, where they performed significantly better than the test group ($p = 0.03$). However, there were no significant differences between the groups at baseline, three months, or six months. For the area of pigmentation, both groups again demonstrated significant reductions over time ($p < 0.001$ within groups), indicating clinical improvement. However, no significant inter-group differences were found at any follow-up point ($p > 0.05$), suggesting comparable effectiveness. Regarding the intensity of pigmentation, both groups showed gradual improvement. The scalpel group exhibited significant changes ($p < 0.001$), while the laser group showed marginal significance ($p = 0.05$). There were no significant differences between the groups in intensity at any time point.

Parameters	Baseline (Mean±SD)	1 month (Mean±SD)	3 months (Mean±SD)	6 months (Mean±SD)	p-value
DOPI [17]					
Laser group	3.1±0.67	0.1±0.19	0.7±0.32	1.6±0.34	<0.001
Scalpel group	2.8±0.32	0.4±0.28	0.8±0.37	1.4±0.44	<0.001
p-value	0.19	0.03	0.69	0.36	
Area of pigmentation					
Laser group	253.7±44.89	14.4±8.67	49.7±36.24	75.8±37.33	<0.001
Scalpel group	274.1±42.49	17.5±12.78	60.2±35.92	89.9±43.51	<0.001
p-value	0.22	0.65	0.54	0.52	
Intensity of pigmentation					
Laser group	113.4±9.48	155.4±22.36	149.4±15.01	140.1±13.79	<0.001
Scalpel group	113.1±16.07	153.4±12.90	147.0±20.30	142.1±13.11	0.05
p-value	0.88	0.76	0.82	0.70	

[Table/Fig-4]: Changes in the DOPI, pigmentation area and pigmentation intensity at 1, 3, and 6 months for both the scalpel and laser groups.

[Table/Fig-5] summarises patient perceptions of the depigmentation procedures through questionnaire-based assessments carried out at one week postoperatively. Pain during the treatment was reported more frequently by participants in the scalpel group (40%) compared to the laser group (20%), though the difference was not statistically significant ($p = 0.32$). A higher proportion of patients in the laser group reported a burning sensation during the procedure, which also was not statistically significant ($p = 0.16$). Other aspects, such as post-treatment pain during the first week, difficulty with food intake, and impact on oral hygiene practices, showed no significant differences between the groups ($p > 0.05$). A 100% of participants in both groups felt that the treatment met their expectations and noticed a positive change in their smile, indicating high overall satisfaction regardless of the method used.

Questions	Scalpel group (Data expressed as %)		Laser group (Data expressed as %)		Chi-square value	p-value
	Yes	No	Yes	No		
Q1 Was the treatment painful?	40	60	20	80	0.95	0.32
Q2 Did you experience any burning sensation during treatment?	20	80	50	50	1.97	0.16
Q3 Did you experience pain during the first week after treatment?	50	50	60	40	0.20	0.65
Q4 Did the treatment meet your expectations	100	0	100	0	-	-
Q5. Did you experience difficulty during food intake in the first week after treatment?	60	40	50	50	0.2	0.65

Q6. Did the treatment affect your oral hygiene practices during the first week?	80	20	80	20	0	1
Q7. Did you notice a positive change in your smile after treatment?	100	0	100	0	-	-

[Table/Fig-5]: Assessment of patient perception using questionnaire at one week postoperatively.

[Table/Fig-6] presents the comparison of intraoperative (VASIN) and postoperative (VASPO) pain scores between the scalpel and laser groups. For intraoperative pain (VASIN), the scalpel group reported a mean score of 3.40 ± 1.65 , while the laser group reported a slightly lower mean score of 2.80 ± 1.75 which was not statistically significant ($p=0.50$). Similarly, postoperative pain (VASPO) at one week did not differ significantly between the two groups. The scalpel group recorded a mean postoperative VAS score of 3.40 ± 2.01 , whereas the laser group showed a lower mean score of 2.50 ± 1.90 and the difference between the groups was not statistically significant ($p=0.30$). The preoperative and postoperative images of the scalpel depigmentation and laser depigmentation have been shown in [Table/Fig-7,8].

	Group	N	Mean	Std. Deviation	p-value
VASIN	Scapel group	10	3.40	1.647	0.50
	Laser group	10	2.80	1.751	
VASPO	Scapel group	10	3.40	2.011	0.30
	Laser group	10	2.50	1.900	

[Table/Fig-6]: Assessment of VAS intraoperative (VASIN) and postoperative (VASPO).



[Table/Fig-7]: (a) Shows the pre operative image and (b) shows post operative image at 1 month, (c) 3 months and (d) 6 months after scalpel depigmentation.

DISCUSSION

In the current study gingival depigmentation performed with scalpel and laser techniques were compared in terms of repigmentation, postoperative outcomes, pain and patient perception towards the treatment. Various techniques for depigmentation that have been tried in the past to treat gingival pigmentation include chemical cauterisation [20,21], gingivectomy [9], abrasion of gingiva, scalpel surgery,



[Table/Fig-8]: (a) Shows the pre operative image and (b) shows post operative image at 1 month, (c) 3 months and (d) 6 months after laser depigmentation.

cryotherapy [22-26], radiofrequency ablation, electrosurgery [27,28], free gingival autograft, and laser therapy [21,22,28-31]. Even with this wide array of techniques scalpel surgery for depigmentation which is a time-tested technique, remains the gold standard. But information on whether laser technique provides superior and sustained results when compared to scalpel technique is very limited. This study compared the efficacy of two widely used techniques for gingival depigmentation, diode laser and conventional scalpel method.

In scalpel group, depigmentation was done by removing the pigmented epithelium and a thin layer of connective tissue (split thickness flap) using a number 15 blade. Surgical excision with a blade allowed for precise, controlled removal of pigmented tissue. The authors found that this approach allowed precise and controlled removal of pigmented tissue, with the advantage of immediate assessment of the treated site, thereby reducing the likelihood of residual pigmentation. The surgical stripping technique was further noted to provide tactile feedback and avoid the risk of thermal injury to underlying structures, while also enabling the elimination of pigment-containing cells located in deeper connective tissue layers, including melanophages and melanophores [4].

In laser group intervention with semiconductor diode laser at 1 W power in contact mode was used with depigmentation carried out using gentle, short, horizontal brush-like strokes. Laser ablation was effective, comfortable, and a reliable method for gingival depigmentation. Additionally, this technique was quicker and easier to perform compared to the traditional epithelial excision approach. It provides a relatively bloodless surgical field, has the ability to coagulate or vaporise the area, provides sterilisation of wound site, minimal mechanical trauma, swelling and scarring [4,32,33].

The scalpel technique, which has long been regarded as the gold standard for gingival depigmentation, demonstrated a significantly sharper reduction in DOPI scores at one month post-treatment compared to the diode laser group ($p=0.03$). This may be attributed to the more aggressive removal of pigmented epithelial and connective tissue layers achieved with the scalpel technique, resulting in more immediate depigmentation. However, this initial

difference did not persist at later follow-up points (3 and 6 months), where both methods demonstrated comparable outcomes in terms of DOPI, area, and intensity of pigmentation. The results of our study is consistent with the study by Inchingolo F et al., 2024 [10]. Irrespective of the technique used whether the conventional surgical scalpel or the modern diode laser, minor repigmentation was consistently observed following treatment [34]. Remarkably, this phenomenon occurred with such uniformity that no significant differences in the intensity of repigmentation were detected during the follow-up period [35]. These findings highlight a key insight: despite differences in technique, both surgical methods demonstrate similarly effective outcomes in achieving gingival depigmentation, indicating that the initial severity of pigmentation does not significantly influence treatment success [36]. Even though the exact mechanism for clinical repigmentation is unclear, it is believed to occur due to the migration of active melanocytes from neighboring pigmented tissues into the treated sites [37]. In contrast, Ginwalla TM et al., attributed repigmentation to the presence of residual melanocytes left behind after treatment [38].

Pain perception was slightly higher in the scalpel group (40%) than the laser group (20%), although not statistically significant. This result was consistent with the study by Mikhail FF et al., 2023, Suragimath G et al., 2016, Lagdive S et al., 2009 and Urmi D et al., 2007 [9,36,39,40]. A study by Prasanth T et al., 2023 showed a slightly higher discomfort in few individuals on the laser side as compared to the scalpel groups [41]. This could be attributed to the thermal effect of the laser on the adjacent tissues. However, the overall reduction in pain was comparatively similar in all groups.

The diode laser group also reported a higher incidence of burning sensation during the procedure (50%), suggesting that laser induced thermal effects may lead to intraoperative discomfort despite being less invasive overall. No significant differences were found in terms of postoperative complications, including pain during the first week, difficulty with food intake, or oral hygiene disruption. Compared with other surgical techniques, healing is quite faster in this method. The advantages of laser technique are less pain, ease of handling, faster haemostasis, short treatment time, dry surgical field, decreased swelling, oedema, scarring and minimal mechanical trauma [42]. The disadvantage of laser treatment is delayed wound healing, thermal damage, deep penetration, relatively high cost, harmful to eyes and skin and also requires special trainings.

Limitation(s)

The main limitation of the present study was its small sample size (n=20), which, although statistically justified, limits the generalisability of the findings. Additionally, the follow-up period of six months may not be sufficient to fully assess the long-term stability of depigmentation outcomes or the recurrence rate of pigmentation. A longer follow-up would be necessary to evaluate the potential for relapse. Moreover, potential confounding factors such as individual variations in melanocyte activity, oral hygiene practices, and genetic predispositions which can influence both the rate and extent of repigmentation were not accounted for in the current study. Future studies should consider these variables to better understand their impact on depigmentation outcomes and to improve the reliability of comparisons between treatment modalities.

CONCLUSION(S)

Both diode laser and scalpel techniques are effective for gingival depigmentation, showing significant reduction in pigmentation over a 6-month follow-up period. While the scalpel technique demonstrated a more rapid initial reduction in pigmentation, particularly evident in the DOPI at one month, long-term outcomes between the two methods were comparable in terms of area and intensity of pigmentation. Patient satisfaction was high in both groups, with all participants reporting positive aesthetic outcomes and an enhanced

perception of their smile. Nevertheless, individuals in the scalpel group reported pain more often. Based on these findings, both techniques can be considered viable for gingival depigmentation, with the choice depending on clinical setting, patient preference, and operator expertise. However, further studies with larger sample size and longer follow-up durations are recommended to validate these findings and assess the long-term risk of repigmentation.

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