Research Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2019;9:3:42-50.

Low-Level Laser Therapy for Treatment of Pain Associated with Orthodontic Elastomeric Separator Placement: A Clinical Study

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ABSTRACT

Background: Many patients tend to avoid orthodontic treatment just because of the fear of pain from orthodontic treatment. It has been shown that LLLT produces analgesic and anti-inflammatory effects and accelerates tissue repair. The purpose of this study was to evaluate whether the low level laser therapy (LLLT) can control the pain caused by the placement of the elastomeric separator

Materials and Methodology: Elastomeric separators were placed inter proximally across the upper permanent first molar (both mesially and distally) in both the quadrant. The experimental side was exposed to biostimulation using 810 nm gallium-aluminum-arsenide (GaAlAs) diode laser on continuous mode with power set at 200mw. The laser was applied buccally on 3 points mesial, distal and middle approximately at the center of the root of the permanent first molar on experimental side. In the placebo side the laser was held the same way and for the same duration without turning it on. The energy dose was 4J/cm^2 at each point and 12J/cm^2 on the whole. Pain was evaluated by a questionnaire using numeric rating scale after placement of elastomeric separator.

Result: In laser group the pain level gradually decreased and in placebo group the pain level gradually increased from 2 hours to 48 hour at rest (spontaneous) and while chewing. The laser group showed lower levels of pain compared to placebo group at rest and while chewing.

Conclusion: A single application of LLLT with a gallium aluminum-arsenic diode laser with 810nm wavelength reduced orthodontic pain associated with the placement of separators. Both spontaneous pain and the pain on chewing were significantly reduced with one dose of LLLT.

Keywords: Low level laser therapy, elastomeric separator, pain reduction.

INTRODUCTION

Laser, the acronym for "Light Amplification by Stimulated Emission of Radiation" dates back to approximately 50 years. In 1960, the first functioning laser was built by the Amercian physicist Maiman at the Hughes Research Laboratories by using a synthetic ruby crystal made of aluminum oxide and chromium oxide. In general, lasers are composed of the three principle parts: an energy source, an active medium and a set of two or more mirrors that form a resonator. Properties such as wavelength are determined primarily by the active medium which can be a gas, crystal or solid-state conductor.

Received: Jan. 19, 2019**: Accepted**: Mar. 20, 2019
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pISSN 2278-0076
eISSN 2321-9270

For dental laser systems, the light is typically delivered to the target tissue through an optical fiber cable, a hollow waveguide or an articulated arm. Diode lasers used in dentistry vary between approximately 800 nm and 980 nm. Although light in this range is highly absorbed by pigmented tissues and has a great penetration depth in soft-tissues, it is poorly absorbed by dental hard tissues and water. It is not as effective as the argon laser for hemostasis. Since light emitted from diode lasers is poorly absorbed by dental hard tissues, these lasers can be safely used for soft-tissue surgery applications including gingival recontouring, crown lengthening, removal of hypertrophic tissue and frenectomies close to the enamel, dentine and cementum.

Patients often feel pain or discomfort when exposed to orthodontic forces[1].It is well-known that following the placement of orthodontic appliances, the patient feels pain or discomfort for 2-4 days. Low-level laser therapy (LLLT) in which the energy output is sufficiently low to prevent a temperature rise above 36.5*C (normal body temperature) in the target tissue can be used as a convenient analgesic therapy for orthodontic patients. This type of therapy also has non-thermal and biostimulatory effects.
Although the precise mechanism underlying the analgesic effect of LLLT is not completely known, laser irradiation has neuropharmacological effects on the synthesis, release and metabolism of serotonin and acetylcholine in the central level as well as histamine and prostaglandin in the peripheral level. Many researchers have reported that Nd: YAG, He-Ne and GaAIAs diode lasers have analgesic effects for reducing orthodontic pain. Moreover, local CO2 laser therapy has been found effective in reducing the pain associated with orthodontic force applications.

LLLT effectively controls pain caused by the application of the first archwire but it does not affect the start of pain after the first archwire is placed and does not alter the most painful day. Induction of laser analgesia is a new treatment modality that has the advantages of being non-invasive, easy to apply and having no known adverse tissue reactions. The correction of malocclusion during orthodontic treatment, especially in the early stages results in the patient's experiencing some degree of pain.[1]

The pain mechanism in orthodontic treatment is a result of compression forces consequently leading to ischemia, inflammation and edema in the periodontal tissues. In patients who experience a higher degree of pain, the orthodontist may recommend the use of pharmacological agents or nonpharmacological methods for pain relief considering their pain sensitivity threshold or emotional condition.
As a nonpharmacological method, low- level laser therapy (LLLT) has analgesic properties and anti-inflammatory effects through increasing the local blood flow by reduction of prostaglandin E2 levels and inhibition of cycloxygenase. Some studies have already investigated the action of LLLT in pain reduction during orthodontic tooth movement. Some researchers have pointed out that the use of LLLT reduced the risk of incidence of pain by 24% compared with control or placebo groups.

Standardization of the type and use of LLLT needs to be established. The clinical results and efficacy of LLLT in reducing orthodontic pain are directly related to the type of laser, wavelength, energy density (J/cm2), time of application per point and frequency. The risk of bias of studies included in the systematic reviews indicate that the use of LLLT for the reduction of pain or discomfort at any stage of orthodontic treatment presents limited clinical evidence.

The aim and purpose of this study was to evaluate the effect of LLLT on pain experienced by patients undergoing elastic separation of the first molars during the early stage of orthodontic treatment.

MATERIALS AND METHOD

The study was a split mouth design. The experimental side was exposed to biostimulation using 810 nm gallium-aluminum-arsenide (GaAlAs) diode laser. The emitted light was not allowed to affect the placebo side and the laser was held the same way and for the same duration without turning it on. Pain was evaluated by a questionnaire formulated using the numeric rating scale after placement of elastomeric separator. All the patients were instructed to complete a survey at home over the next 3 days and advised not to take any

analgesics. The survey was mainly to quantify pain levels experienced by the patients. The patients were motivated to answer the questionnaire.

Inclusion criteria:-

- Patients above 12 years of age.
- Presence of fully erupted first and second molar.
- Presence of fully erupted upper second premolar.

Exclusion criteria:

- Patients using antibiotics or analgesics
- Pregnant or breastfeeding patients
- Patients with systemic disease.
- Patients allergic to NSAIDS
- Patients who have undergone any type of surgical procedure during the preceding 2 weeks.
- Presence of treated or untreated apical bone lesion.

Sample size consisted of 30 subjects. In each subject the right and left quadrants were randomly divided into two groups.

Group A (control side): Quadrant which did not receive low intensity laser therapy

Group B (experimental side): Quadrant which received laser therapy.

Elastomeric separators were placed inter proximally across the upper permanent first molar (both mesially and distally) in both the quadrant. The experimental side was exposed to biostimulation using 810 nm gallium-aluminum-arsenide (GaAlAs) diode laser on continuous mode with power set at 200mw. The laser was applied buccally on 3 points that is mesial, distal and middle of the root of the permanent first molar on experimental side. The emitted light was not allowed to affect the placebo side and the laser was held the same way and for the same duration without turning it on. The vertical level of application was approximately at the center of the root with fiber tip of the laser placed nearly perpendicular in close contact with the gingival tissue. The energy dose (200×20) was 4J /square centimeter at each point and 12J per square centimeter on the whole. Pain was evaluated by a questionnaire formulated using the numeric rating scale after placement of elastomeric separator. All the patients were instructed to complete a survey at home over the next 3 days and advised not to take any analgesics. The survey was mainly to quantify pain levels experienced by the patients. The patients were motivated to answer the questionnaire.

Statistical Analysis

The descriptive statistics were computed. The inferential statistics included paired t test, oneway ANOVA and post hoc Tukey test.

RESULT

Table 1: Intragroup comparison of VAS at different time interval in laser and placebo group using oneway ANOVA test during pain evaluation at rest.

		MEAN	STANDARD DEVIATION	F	SIG.
LASER	T1	4.5000	0.93772	46.223	0.000*** (H.S)
	T2	2.8000	1.49482		
	T3	1.5000	1.13715		
PLACEBO	T1	5.8000	0.99655	3.523	0.034* (S)
	T2	6.4000	1.45270		
	T3	6.9000	2.15519		

***p < 0.001 **p<0.01 *p<0.05

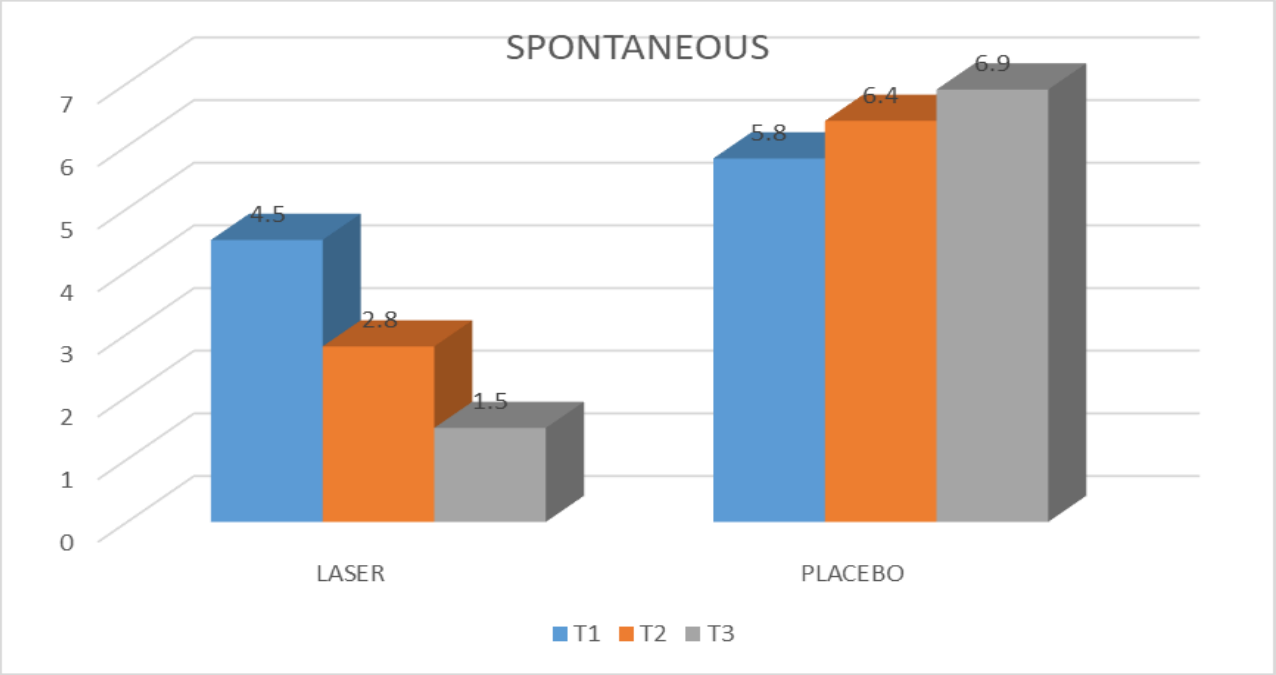


Fig 1. Intragroup comparison of VAS at different time interval in laser and placebo group during pain during pain evaluation at rest.

Table 2: Multiple comparison within the group using post hoc Tukey test during pain evaluation at rest.

			MEAN DIFFERENCE	STANDARD ERROR	SIG.	95% CONFIDENCE INTERVAL	
						LOWER BOUND	UPPERBOUND
LASER	T1	T2	1.70000*	0.31294	0.000 *** (H.S)	0.954	2.446
		T3	3.00000*	0.31294	0.000*** (H.S)	2.254	3.746
	T2	T3	1.30000*	0.31294	0.000*** (H.S)	0.554	2.046
PLACEBO	T1	T2	-0.60000	0.41495	0.322 (N.S)	-1.589	0.389
		T3	-1.10000*	0.41495	0.026* (S)	-2.089	-0.111
	T2	T3	-0.50000	0.41495	0.453 (NS)	-1.489	0.489

***p < 0.001 **p<0.01 *p<0.0

Table 3: Comparison of laser and placebo group at different time intervals using independent T test during pain evaluation at rest.

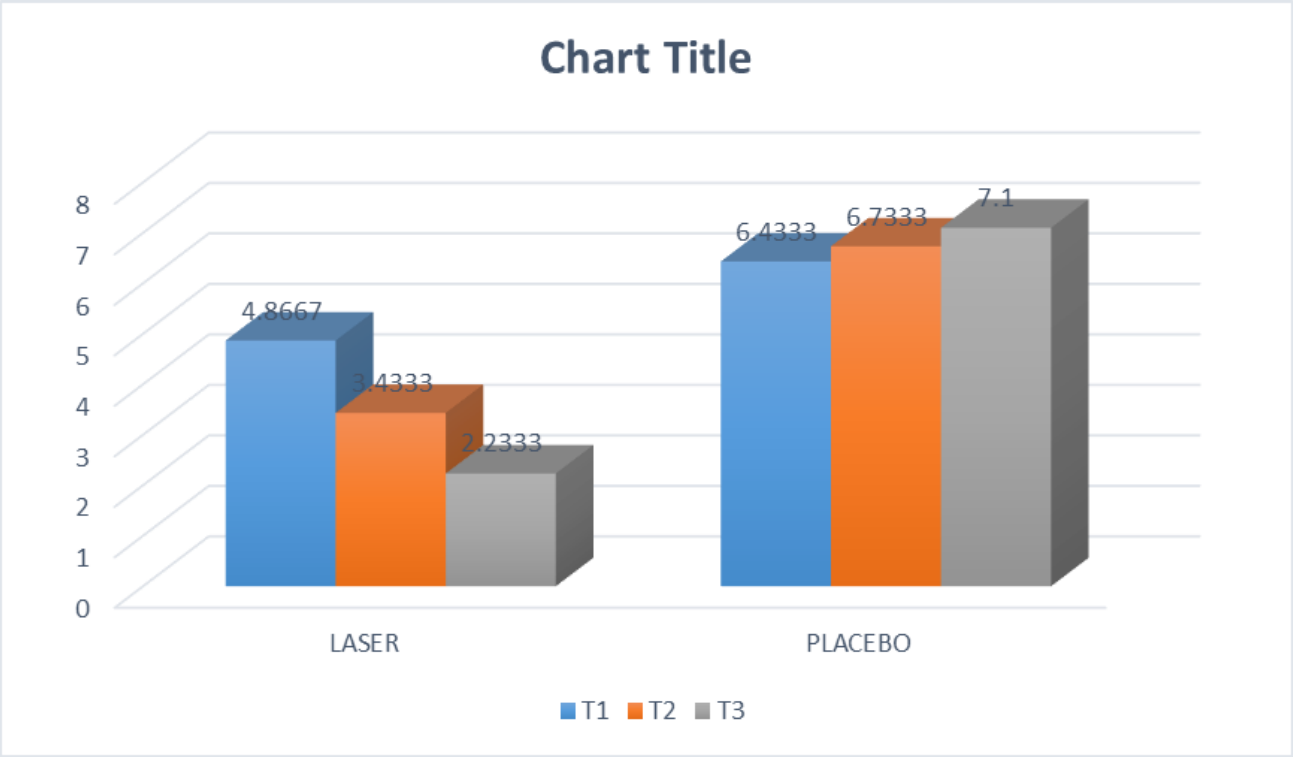
		MEAN	STANDARD DEVIATION	T	SIG.
T1	LASER	4.5000	0.93772	-5.204	**0.000*** (H.S)**
	PLACEBO	5.8000	0.99655		
T2	LASER	2.8000	1.49482	-9.460	**0.000*** (H.S)**
	PLACEBO	6.4000	1.45270		
T3	LASER	1.5000	1.13715	-12.138	**0.004*** (H.S)**
	PLACEBO	6.9000	2.15519		

***p < 0.001 **p<0.01 *p<0.05

Table 4: Intragroup comparison of VAS at different time interval in laser and placebo group using oneway ANOVA test during pain evaluation while eating.

		MEAN	STANDARD DEVIATION	F	SIG.
LASER	T1	4.8667	1.33218	26.971	**0.000*** (H.S)**
	T2	3.4333	1.45468		
	T3	2.2333	1.38174		
PLACEBO	T1	6.4333	0.85836	3.309	**0.041* (S)**
	T2	6.7333	0.98027		
	T3	7.1000	1.15520		

***p < 0.001 **p<0.01 *p<0.05



Intragroup comparison of VAS at different time interval in laser and placebo group during pain evaluation while eating.

Table 5: Multiple comparison within the group using Post hoc Tukey test during pain evaluation while eating.

			MEAN DIFFERENCE	STANDARD ERROR	SIG.	95% CONFIDENCE INTERVAL	
						LOWER BOUND	UPPER BOUND
LASER	T1	T2	1.43333	0.35901	0.000*** (H.S)	0.5773	2.2894
		T3	2.63333	0.35901	0.000*** (H.S)	1.7773	3.4894
	T2	T3	1.20000	0.35901	0.003*** (H.S)	0.3439	2.0561
PLACEBO	T1	T2	-0.30000	0.25958	0.483 (N.S)	-0.9190	0.3190

		T3	-0.66667	0.25958	0.032* (S)	-1.2856	-0.0477
	T2	T3	-0.36667	0.25958	0.339 (N.S)	-0.9856	0.2523

***p < 0.001 **p<0.01 *p<0.05

Table 6:Comparison of laser and placebo at different time intervals using independent T test during pain evaluation while eating.

		MEAN	STANDARD DEVIATION	T	SIG.
T1	LASER	4.8667	1.33218	-5.415	**0.000*** (H.S)**
	PLACEBO	6.4333	0.85836		
T2	LASER	3.4333	1.45468	-10.304	**0.000*** (H.S)**
	PLACEBO	6.7333	0.98027		
T3	LASER	2.2333	1.38174	-14.800	**0.016** (S)**
	PLACEBO	7.1000	1.15520		

***p < 0.001 **p<0.01 *p<0.05

The result obtained from the study were,

In laser group the pain levels gradually decreased from 2 hours to 24hours and further to 48 hours and the difference were statistically significant at rest (spontaneous) **[**Table 1,2 Graph 1] and while chewing [Table 4,5 Graph 2]. In placebo group the pain level gradually increased from 2 hours to 24 hours and further to 48 hours and the difference was statistically significant at rest [Table 1,2 Graph 1] and while chewing [Table 4,5 Graph 2].In intergroup comparison the laser group showed lower levels of pain compared to placebo group which was statistically significant at rest and while chewing [Table 3,6].

DISCUSSION

Pain is a common experience in orthodontic patients. Fear of pain and discomfort during orthodontic treatment is a concern for many which arises from ischemia, inflammation and oedema in the compressed periodontal ligament. In an inflamed and ischemic periodontal ligament, mediators such as histamine, bradykinin, prostaglandins and serotonin, are released.[1]

These mediators irritate the nerve ends of the pain receptors, thus causing pain. Orthodontic pain usually begins at 2 hours after the force applied and reaches its maximum intensity at bed time or at 24 hours. The pain can last approximately for 5 to 7 days.

A low-level laser with infrared radiation was chosen for this study based on previous data in the literature. Many authors have demonstrated that LLLT penetration into deeper tissues (I e, bone) is more effective than the visible laser, which is normally used for gum and skin treatments. The transmission of laser through tissue is highly wavelength specific and is optimal in the optical window of 500 to 1200 nm. Here, we used the 810-nm wavelength, which is also in the optimal optical window.[5]

The word 'therapeutic laser' describes the purpose and intent of the treatment. The major components of an LLLT system are the laser device itself, a delivery system, and a controller. All common commercially available LLLT systems use semiconductor diode lasers. These are generally variants of either Gallium: Aluminium: Arsenide (GaAlAs) which emit in the near infrared spectrum (wavelength 700-940 nm), or Indium: Gallium: Arsenide: Phosphorus (InGaAsP) devices which emit in the red portion of the visible spectrum range (wavelength 600-680 nm).[6]

Mechanism of Action of Low Level Laser Therapy

The mechanisms of low level laser therapy are complex but essentially rely upon the absorption of particular visible red and near-infrared wave-lengths in photoreceptors within sub-cellular components, particularly the electron transport (respiratory) chain within the membranes of

mitochondria. The absorption of light by the respiratory chain components causes a short-term activation of the respiratory chain and oxidation of the NADH pool. This stimulation of oxidative phosphorylation leads to changes in the redox status of both the mitochondria and the cytoplasm of the cell. The electron transport chain is able to provide increased levels of promotive force to the cell, through increased supply of ATP as well as an increased in the electrical potential of the mitochondria membrane, alkalization of the cytoplasm and activation of nucleic acid synthesis. Because ATP is the "energy currency" for a cell, LLLT has a potent action that results in stimulation of the normal functions of the cell.[8]

The effects of different types of light on mast cells are well recognized. There is direct evidence that 660, 820 and 940 nm light can trigger mast cell degranulation. These types of cell are distributed preferentially about the microvascular endothelium in skin, oral mucosa and dental pulp. Mast cells in these locations contain the pro-inflammatory cytokine TNFα (tumor necrosis factor) in their granules. The release of TNFα promotes leukocyte infiltration of tissues by enhancing expression of endothelial-leukocyte adhesion molecules.[9]

In addition, mast cell proteases, such as chymase facilitate entry of leukocytes into tissues. As mast cells play a fundamental role in controlling leukocyte traffic, modulation of mast cell functions by LLLT can be of considerable importance in the treatment of sites of inflammation in the oral cavity.

LLLT has also been proven to reduce synthesis of inflammatory mediators in neural tissue as well as more rapid maturation and regeneration, particularly axonal growth. It also reduces pain in patients suffering from post-herpetic neuralgia, cervical dentinal hypersensitivity and also from periodontal pain during orthodontic tooth movement.[12]

Elastomeric separators were placed interproximally across the upper permanent first molar (both mesially and distally) in both the quadrants. The experimental side was exposed to biostimulation using 810 nm gallium-aluminum-arsenide (GaAlAs) diode laser on continuous mode with power set at 200mw. The laser was applied buccally on 3 points mesial, distal and middle of the root of the permanent first molar on experimental side. The emitted light was not allowed to affect the placebo side and the laser was held the same way and for the same duration without turning it on the placebo side. The vertical level of application was approximately at the center of the root with fiber tip of the laser placed nearly perpendicular in close contact with the gingival tissue. The energy dose (200×20) was 4J /square centimeter at each point and 12J per square centimeter on the whole.

Pain was evaluated by a questionnaire formulated using the numeric rating scale after placement of elastomeric separator. The questionnaire made it possible to obtain and analyse information about pain perception for all the groups.

Differences in pain perception are not age related. The age range of the sample was 12 to 15 years. Pain perception varies considerably from patient to patient and this biases the quantification of pain. However, the significance level of $P < 0.001$ for the variables at end of the pain was a strong indicator for a statistically significant and relevant correlation between LLLT and pain reduction.

The study concluded that a single application of LLLT with a gallium aluminum- arsenic diode laser with 810-nm wavelength reduced orthodontic pain associated with the placement of separators. Both spontaneous pain and the pain on chewing were significantly reduced with one dose of LLLT.

The result obtained were similar to a studies conducted by Irfan Qamruddin et al and Mai M.E et al on the effect of a single dose of low-level laser therapy on spontaneous and chewing pain caused by elastomeric separators and the result shows that a single dose of low-level laser therapy can be an efficient modality to reduce the postoperative pain associated with the placement of elastomeric separators.[15]

The present study is in accordance with a study conducted by Mehta GD et al to evaluate the efficacy of low-intensity laser therapy in reducing pain and orthodontic treatment duration. Thus this study concluded that the low-intensity laser therapy is a good option to reduce pain and treatment duration.[14]

CONCLUSION AND SUMMARY

A single application of LLLT with a gallium aluminum- arsenic diode laser with a 810-nm wavelength can reduce orthodontic pain associated with the placement of separators. Both spontaneous pain and the pain on chewing were significantly reduced with one dose of LLLT.

In laser group the pain level gradually decreased from 2 hours to 48 hours and the difference was statistically significant at rest (spontaneous) and while chewing. In placebo group the pain level gradually increased from 2 hours to 48 hours and the difference was statistically significant at rest and while chewing .In intergroup comparison the laser group showed lower levels of pain compared to placebo group which was statistically significant at rest and while chewing.

The study concluded that

1. Pain duration reduced in the LLLT group compared with the placebo group.
2. The level of orthodontic pain was less in the LLLT group than placebo group.
3. The intensity of pain was lower in LLLT group than placebo group.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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