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Laser and Cyanoacrylate for the Treatment of Dentine Hypersensitivity: Survival Analysis and Predictive Factors

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Abstract

Objective: The aim of the present study was to determine how long the effects of laser and cyanoacrylate last when used as treatments for dentine hypersensitivity (DH). In addition, the predictive factors of DH recurrence and the prevalence of DH according to type of tooth were investigated.

Materials and methods: Sixty-two patients contributed with 434 sensitive teeth. Two hundred sixteen teeth were randomized to receive laser treatment (wavelength of 795 nm) and 218 received cyanoacrylate treatment. Both treatments were applied three times at intervals of 48 hours. Dentine hypersensitivity was assessed by air stimulus at baseline and 1, 30, 90 and 180 days after treatment by a blinded researcher. Additionally, possible etiologic factors were assessed. The data were analyzed by Kaplan-Meier survival curves and by logistic regression.

Results: Both groups had significant reductions in DH. Treatment failure occurred in 276 (63.6%) treated teeth and 158 (36.4%) teeth maintained the result of the treatment until the end of the study (censored teeth). The survival rate at 6 months was 36% for laser treatment, and 36% for cyanoacrylate. There was no significant difference between the survival curves ($p = 0.703$). Gingival recession and abfraction increased the risk of treatment failure by 2.04 ($p = 0.002$) and 2.76 ($p < 0.001$) times, respectively.

Conclusion: Overall, these two approaches to DH treatment had a survival rate of 36% at 6 months. The most prevalent hypersensitive tooth is the first premolar. Gingival recession and abfraction predict the recurrence of DH irrespective of patient age and sex.

Key words: Cyanoacrylate, dentine hypersensitivity, laser, survival analysis, dentine desensitizing agents

Introduction

Dentine hypersensitivity (DH) is characterized by the occurrence of short episodes of acute pain, stimulated by external agents, which cannot be attributed to any other dental pathology (West *et al.,* 2014). It can be considered a painful tooth response to different stimuli, such as brushing, acidic foods and thermal changes (Que *et al.*, 2010; Sicilia *et al.*, 2009).

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The most accepted mechanism of DH is the hydrodynamic theory (Brännström, 1992). This suggests that external stimuli can cause a movement of fluid in dentinal tubules, producing stretching or compression of odontoblasts at the pulp periphery, and the nerve endings connected to them, resulting in pain.

Dentinal tubule exposure in the cervical zone of the teeth is multifactorial, and may occur due to pathological factors such as a small amount of attached gingiva, abfraction, erosion, attrition, gingival recession and periodontal attachment loss (Addy, 2002; Rees and Addy, 2004; Que *et al.*, 2010). Several home or office treatments such as resin, varnishes, desensitizing toothpaste and potassium nitrate have been proposed for treating DH, showing variable results (Frechoso *et al.*, 2003; Pillon *et al.*, 2004;

Yates *et al.*, 2004; Sicilia *et al.*, 2009; Addy and West, 2013). Recently, cyanoacrylate proved to be a treatment capable of reducing DH (Flecha *et al.*, 2013). The basic principles of DH treatment are altering the fluid flow in the dentinal tubules by means of tubule occlusion or modifying or chemically blocking the pulpal nerve (West *et al.*, 2014).

DH prevalence varies widely (Cunha-Cruz *et al.*, 2011), affects patients who tend to brush their teeth more often, are between 30 and 40 years old (Rees *et al.*, 2003), and is more common in women (Que *et al.*, 2009). It can occur in all teeth, and the premolars and the maxillary first molar teeth are the most affected (Rees and Addy, 2004; Que *et al.*, 2009).

Failure in management of DH may result in its recurrence (Addy, 2002). One of the most difficult aspects of this condition that is commonly observed in clinical practice (Dababneh *et al.*, 1999; Walters, 2005; Sales-Peres *et al.*, 2011). To our knowledge, to date, no study describing the duration time of laser and cyanoacrylate treatment in cases of DH has been published. The aim of the present study was to determine how long the effects of laser and cyanoacrylate last when used as treatments for DH. In addition, the predictive factors of DH recurrence and the prevalence of DH according to type of tooth were investigated.

Materials and methods

The study was conducted at the Periodontics Clinic of the Department of Dentistry of the Federal University of Jequitinhonha and Mucuri Valleys (UFVJM), Diamantina, Minas Gerais, Brazil. The study protocol was approved by the Research Ethics Committee of the UFVJM (#061/06) and by the Research Ethics Committee of the Federal University of São Paulo (UNIFESP #0530/08). Trial Identifier in ClinicalTrials.gov is NCT01111474. The present study was also conducted in accordance with the Helsinki Declaration of 1975, as revised in 2008.

The population consisted of 62 patients of both genders with DH who were referred to the Periodontics clinic of UFVJM for DH treatment. Participants were informed about the research and signed the free and informed consent term before the trial began. Included in the study were participants who had good general and oral health; complained of pain in teeth located in different hemi-arches of the mouth; manifested pain or discomfort with the stimulus caused by a jet of air from a triple syringe, and who initially responded to tooth stimulus with a score ≥ 5 on a numerical scale. Those excluded were patients who had undergone professional desensitizing treatment, or had used desensitizing over-the-counter products; patients under chronic use of anti-inflammatory, analgesic and psychotropic drugs; pregnant and breast feeding women; patients presenting with allergies and idiosyncratic responses to product ingredients, eating disorders, and systemic conditions that were etiologic or predisposing to DH; excessive dietary or environmental exposure to acids; and periodontal surgery or orthodontic treatment in the preceding three months. Also excluded were teeth or periodontium with pathology, or defects likely to cause pain; teeth restored in the preceding three months, including abutment for fixed or removable prostheses, crowns, extensive restorations, and those with restorations extending into the test area (cervical). During the study period, patients were instructed not to use desensitizing products. The study population was composed of 15 (24.2%) men and 47 (75.8%) women, with a mean age of 31.4 ± 10.7 years (ranging from 12 to 60 years).

In a previous study (Gerschman *et al.*, 1994), a 67% reduction in the mean value of thermal sensitivity (air jet) was found when treatment with a low intensity laser was compared with a placebo. Based on both statistical reasoning and clinical judgment, as recommended by Le Henanff *et al.* (2006), 15% was considered an adequate non-inferiority margin (Piaggio *et al.*, 2006) to calculate the sample size. The following data were used for size estimation: level of significance = 5%, power of the test = 90%, two-tailed test. As safety margin because of losses, 20% was added to the sample size. The final sample size estimated was 218 teeth in each group.

Before the treatment began, clinical examination and a careful history taking were performed by the same investigator (ODF). The following DH etiologic factors were investigated (Bahsi *et al.*, 2012; Mantzourani and Sharma, 2013; Kontaxopoulou and Alam, 2015): gingival recession (gingival margin displacement apical to the cemento-enamel junction); abfraction (structural fractures along the cervical margins); erosion (loss of hard tooth structure by chemical means, notably acids, resulting in sharply defined, wedge-shaped depressions); attrition (wear of teeth following contact with opposing teeth); attached gingiva (wide attached gingiva height); bruxism (tooth-grinding or clenching in combination with abnormal tooth wear); cemento-enamel junction; correct tooth position; and abrasion (loss of hard structure caused by friction against the tooth with an extrinsic agent resulting in cavities along the cervical margins of the teeth).

A split mouth design was used, and the selection of quadrant was randomized. Randomization was conducted by an independent researcher (PFG), who did not known patients and interventions, by using opaque and sealed envelopes. Each patient received both interventions allocated, which were removed from the envelope at the time of the treatment. The professionals who applied the treatments (CGSA, FRM, NMVB) only knew the treatment to be applied in time to perform it. Blinding was achieved by replacing the laser goggles of each patient with sleeping masks, and simulating the application of the other treatment (noise and touch). Interventions were always performed by the same researchers (CGSA, FRM, NMVB) who did not participate in evaluations.

The teeth of different quadrants received different treatments (laser or cyanoacrylate) and adjacent teeth received the same treatment. The laser device used was a GaAIAs infrared diode laser (Clean Line Easy Laser®, Taubaté/SP, Brazil). Laser application was performed in accordance with the manufacturer's standard advice, in three sessions at intervals of 48 hours. The irradiation parameters were: nominal wavelength of 795 nm, infrared, nominal power of 120 mW, spot size of 0.031 cm^2. The deposited energy density per spot area was 30.96 J/cm² applied for eight seconds at three points around the cervical region of the tooth, and the total density energy applied on each tooth surface was 92.88 J/cm². The teeth assigned to the cyanoacrylate group were treated with three applications of cyanoacrylate glue (SuperBonder®, Itapeví/SP, Brazil) with a micro-disposable applicator at intervals of 48 hours.

The teeth were tested before and after interventions through thermal testing with an air jet from a triple syringe. The air jet was applied to each tooth involved at a distance of 3 - 4 mm from its surface for four seconds, and the sensitive tooth was isolated from the adjacent teeth with utility wax. The stimulus was immediate removed when the patient did not tolerate the pain. The subject self-scored the pain level using a numerical rating scale, ranging from 0 (no pain) to 10 (maximum pain) (Flecha *et al.*, 2013). Data from the initial evaluation were considered as baseline. All other subsequent assessments (1, 30, 90 and 180 days) were made by the same investigator (ODF) to whom the treatments were unknown until the end of the interventions.

Statistical analysis was performed by statistical software (SPSS, version 23, Armonk/NY, US) with a 5% level of significance. The Kolmogorov-Smirnov test showed a non-normal distribution of data. Mann-Whitney and Wilcoxon tests were used for inter- and intra-group comparisons. The categorical variables were associated with DH by the Chi-squared test. In this study, it was decided to analyze "per protocol": in other words, included in the analysis were those participants who agreed to undergo the designated intervention and completed the follow-ups until the end, without any deviation from the main protocol.

The method used to calculate the survival time for DH treatment was the Kaplan-Meier method. In this method, it was assumed that the event was independent, i.e., there was information about the possible failure for each treated tooth. By the Kaplan-Meier method, the survival time of DH treatment was calculated until occurrence of the event of interest; in this case it was the recurrence of DH (treatment failure), taking into account that there were cases with no treatment failure at the end of the study (censored cases; Prinja *et al.,* 2010). Survival times were measured from the date of treatment, and for all teeth endpoints were taken as failure or censored. For survival analysis, the treated teeth were considered as failures (DH recurrence) when a score ≥ 5 in the numeric scale was obtained in the post-treatment assessment. The survival curves for the laser and cyanoacrylate treatment were compared by the log-rank test.

Logistic regression was performed in order to verify the odds ratio of independent variables that predicted DH recurrence, i.e., that predicted treatment failure. In the non-adjusted regression, the independent variables that obtained a *p*-value less than 0.10 in the Chi-squared test were added. For the adjusted model, variables that had a *p*-value less than 0.05 in the simple regression and the confounding variables (age and sex) were selected. The model selection was based on an ascending stepwise procedure including variables to achieve the maximum Hosmer-Lemeshow goodness of fit.

Results

Sixty-two patients enrolled in this trial contributed 434 sensitive teeth: 216 (49.8%) teeth were randomized in the laser group and 218 (50.2%) in the cyanoacrylate group. There was a mean number of 7.0 ± 4.1 hypersensitive teeth per volunteer. One single tooth (treated with laser) that presented acute sensitivity and spontaneous pain had to be covered with glass ionomer cement and was excluded from statistical analysis. All other teeth remained vital after treatment and presented no adverse reactions or complications in the exams during 6 months follow-up.

There was a statistically significant difference between the two treatments one day after treatment. There were statistically significant differences when the scores obtained at baseline were compared with those obtained at all assessment times for both treatments (*Table 1*).The prevalence of teeth with DH is shown in *Table 2*.

In the laser group, there were 138 (63.9%) cases of DH recurrence and 78 (36.1%) censored treated teeth. For the cyanoacrylate treatment, there were 138 (63.3%) episodes of DH recurrence and 80 (36.7%) censored teeth. Overall, DH recurred in 276 (63.6%) treated teeth, and 158 (36.4%) teeth maintained the result of the treatment until the end of the study (censored teeth; *Table 3*). There was no statistically significant difference between the treatment survival curves ($p = 0.703$; *Figure 1*).

Recurrence of DH was statistically associated with gingival recession ($p < 0.001$), abfraction ($p < 0.001$), attrition ($p < 0.001$), attached gingiva ($p < 0.001$), bruxism ($p < 0.001$) and exposed cemento-enamel junction ($p < 0.001$; *Table 4*).

Non-adjusted logistic regression was performed with the independent variable tooth position. However, the statistical test did not run because of the low sample number in this group. The multiple logistic regression was adjusted by gingival recession, abfraction, attrition, attached gingiva, bruxism, cemento-enamel junction, sex and age variables. The Hosmer-Lemeshow goodness of fit for the final adjusted model was 0.997. Gingival recession and abfraction were significantly associated with DH recurrence (treatment failure), respectively, in both univariate [OR 3.10 (2.06-4.66); $p < 0.001$]; and OR 3.90 (2.43-6.25); $p < 0.001$] and multivariate [OR 2.04 (1.29-3.21); $p = 0.002$; and OR 2.76 (1.63-4.65); $p < 0.001$] analyses (*Table 5*).

Table 1. Evolution of mean and median of the pain scores at baseline and post-treatment assessment.

	Time	Mean (SD)	Median (25%, 75%)	*p*-value** (Intragroup)		*p*-value†† (Intergroup)	
Laser				Baseline x 1 day	< 0.001		
				Baseline x 30 days	< 0.001		
				Baseline x 90 days	< 0.001		
	Baseline	7.49 (1.7)	7.0 (6.0 - 9.0)	Baseline x 180 days	< 0.001		
	1 day	4.67 (2.9)	5.0 (2.0 - 7.0)	1 day x 30 days	< 0.001		
	30 days	3.58 (2.7)	3.0 (1.0 - 6.0)	1 day x 90 days	< 0.001		
	90 days	2.97 (2.8)	2.0 (0.0 - 5.0)	1 day x 180 days	< 0.001		
	180 days	2.36 (2.7)	1.0 (0.0 - 4.0)	30 days x 90 days	< 0.001		
				30 days x 180 days	< 0.001	Baseline	0.090
				90 days x 180 days	< 0.001	1 day	0.002
Cyanoacrylate						30 days	0.476
				Baseline x 1 day	< 0.001	90 days	0.472
				Baseline x 30 days	< 0.001	180 days	0.508
				Baseline x 90 days	< 0.001		
	Baseline	7.77 (1.7)	8.0 (7.0 - 9.0)	Baseline x 180 days	< 0.001		
	1 day	3.77 (3.0)	3.0 (1.0 - 6.0)	1 day x 30 days	0.816		
	30 days	3.84 (3.0)	3.0 (1.0 - 6.0)	1 day x 90 days	0.013		
	90 days	3.23 (3.0)	3.0 (0.0 - 6.0)	1 day x 180 days	< 0.001		
	180 days	2.57 (2.9)	2.0 (0.0 - 4.0)	30 days x 90 days	< 0.001		
				30 days x 180 days	< 0.001		
				90 days x 180 days	< 0.001		

**Wilcoxon test. ††Mann-Whitney test. (For more details, see Flecha *et al.,* 2013).

Table 2. Prevalence of teeth with dentine hypersensitivity.

	N	%
Tooth		
First premolar	104	23.96
Second molar	94	21.66
Canine	63	14.52
Central incisive	59	13.59
Lateral incisive	46	10.60
First molar	46	10.69
Second molar	22	5.07

Table 3. Survival time for laser and cyanoacrylate treatments.

Treatment	Time	Cumulative survival time	SE	Cumulative failures
Laser	1 day	0.48	0.03	112
	30 days	0.42	0.03	124
	90 days	0.38	0.03	132
	180 days	0.36	0.03	138
Cyanoacrylate	1 day	0.56	0.03	94
	30 days	0.43	0.03	124
	90 days	0.39	0.03	132
	180 days	0.36	0.03	138

Discussion

Dentine hypersensitivity is a common clinical condition, and there are several treatment options (Dababneh *et al.*, 1999; Walters, 2005). However, in the literature there is a lack of information about the survival time of the existing treatments. In daily practice, the common recurrence of DH can be noted, even in cases of combination of therapies (Walters, 2005; Cummins, 2009). In the present study, the duration of a new approach was compared with the duration of laser treatment for DH treatment. Both of these were effective in reducing the DH and had low duration of time.

Both cyanoacrylate and laser treatment were effective in the reduction of DH at all evaluation times. The cyanoacrylate acts by obliterating the dentinal tubule entrances; consequently, there is no more fluid movement and the pain level reduces (Flecha *et al.*, 2013). Laser therapy is capable of reducing DH by stimulating tertiary dentine production, which causes an occlusion of dentinal tubules (Ladalardo *et al.*, 2004).

According to Rees *et al.* (2003), the types of teeth affected by DH tend to vary between studies and populations, and different distribution patterns have been described. Studies have suggested that in patients without periodontal disease, the region between canines and premolars seems to be predisposed to the occurrence of DH (Jalali and Lindh, 2010; Bahsi *et al.*, 2012). This prevalence can be justified by vigorous brushing, common in this area, which can cause gingival recession and/or abrasion of the root dentine surface, causing DH. Addy *et al.* (1987) reported that gingival recession and hypersensitivity were significantly more extensive on the left side. According to the authors, this distribution has been noticed in normal population groups and reflects the increased strength of brushing on the left side by right-handed individuals. The present study confirmed the findings of years ago (Addy *et al.*, 1987): that the teeth most frequently found with DH were the premolars and canines, and this may suggest that the population tends to maintain the standards of brushing over the course of time.

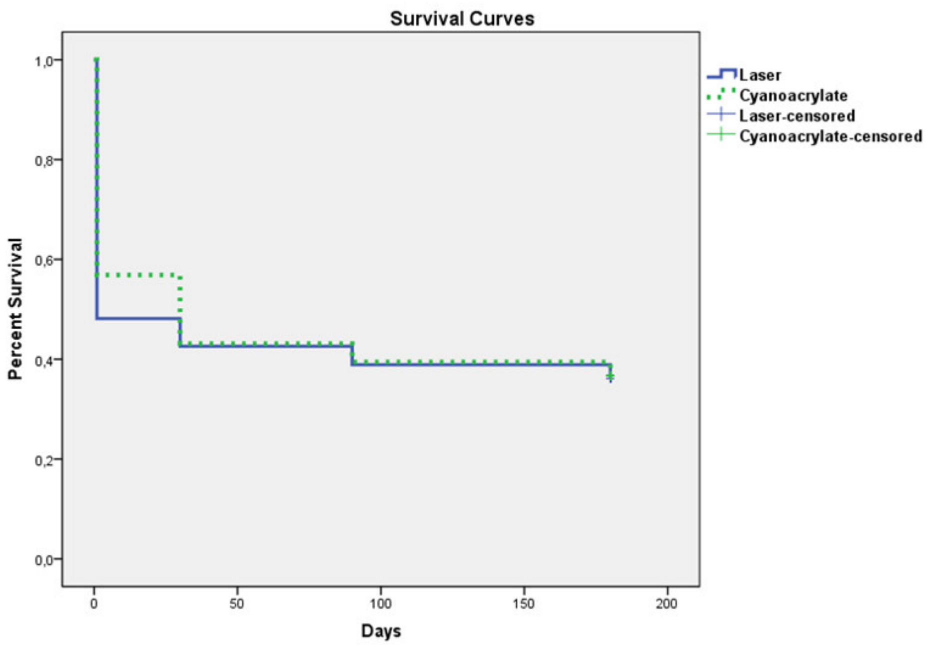

Figure 1. Kaplan-Meier survival curves according to the dentine hypersensitivity treatment.

Table 4. Association between recurrence of dentine sensitivity and variables.

Variable	Recurrence of dentine hypersensitivity		*p*-value
	Yes, n (%)	No, n (%)	
Gingival recession			
Yes	192 (74.1)	67 (25.9)	< 0.001
No	84 (48.0)	91 (52.0)	
Abfraction			
Yes	126 (81.8)	28 (18.2)	< 0.001
No	150 (53.6)	130 (46.4)	
Erosion			
Yes	44 (63.8)	25 (36.2)	0.974
No	232 (63.6)	133 (36.4)	
Attrition			
Yes	58 (82.9)	12 (17.1)	< 0.001
No	218 (59.9)	146 (40.1)	
Attached gingiva			
Present	180 (60.0)	120 (40.0)	0.020
Lacking	96 (71.6)	38 (28.4)	
Bruxism			
Yes	130 (75.1)	43 (24.9)	< 0.001
No	146 (55.9)	115 (44.1)	
Cemento-enamel junction			
Present	75 (46.3)	87 (53.7)	< 0.001
Lacking	201 (73.9)	71 (26.1)	
Frenulum			
Yes	4(100.0)	0 (0.0)	0.128
No	272 (63.3)	158 (36.7)	
Tooth position			
Adequate	271 (63.2)	158 (36.8)	0.089
Inadequate	0 (0.0)	5(100.0)	
Abrasion			
Yes	5 (71.4)	2 (28.6)	0.664
No	271 (63.5)	156 (36.5)	

In the present study, 75.8% of participants were female. This prevalence could be justified by the fact that women have greater awareness of their general health and feature better oral hygiene or excessive oral hygiene habits, such as aggressive tooth brushing (Rees, 2000; Addy, 2002; Porto *et al.*, 2009).

Of the 434 teeth included in this study, 59.6% had gingival recession, considered an important predisposing factor for DH (Taani and Awartani, 2002; Kehua *et al.*, 2009; Amarasena *et al.*, 2011). Gingival recession and subsequent root surface exposure allow more rapid and extensive exposure of dentinal tubules, subsequently causing DH (Dababneh *et al.*, 1999; Que *et al.*, 2010). Of the treated teeth, 35.4% had abfraction, a lesion representing microstructural loss of tooth tissue, created under action of occlusal forces related to biomechanical factors in the area of the highest stress concentration, that is, in the cervical region (Litonjua *et al.*, 2003).

Abfraction and gingival recession were predisposing factors associated with DH recurrence, independently of the other variables, including age and sex. In cases of abfraction, constant loss of hard tooth tissue occurs in the cervical area (Jakupovic *et al.*, 2014), and in cases of gingival recession, there are root surface exposures (Que *et al.*, 2010). Probably, these two conditions are capable of increasing the odds of DH recurrence because there is continuous exposure of dentine surfaces; that is, new dentinal tubules (which were not previously desensitized/treated) are exposed to the oral cavity. Consequently, the treatments for DH may fail. Another explanation herein proposed would be that mechanical challenges (tooth brushing, daily meals and chewing) may eliminate the protective effect of the desensitizing agents by removing the outer surface of dentine and/or the desensitizing agents themselves. Subsequently, dentinal tubules would be exposed and the treatment for DH would tend to fail.

Table 5. Logistic regression of variables that predicted recurrence of dentine hypersensitivity.

Variable	Non-adjusted		Adjusted	
	OR (CI 95%)	*p*-value	OR (CI 95%)	*p*-value
Gingival recession				
No	1		1	
Yes	3.10 (2.06 - 4.66)	< 0.001	2.04 (1.29 - 3.21)	0.002
Abfraction				
No	1		1	
Yes	3.90 (2.43 - 6.25)	< 0.001	2.76 (1.63 - 4.65)	< 0.001
Attrition			-	
No	1			
Yes	3.23 (1.68 - 6,23)	< 0.001		
Attached gingiva			-	
Present	1			
Lacking	1.68 (1.08 - 2.61)	0.021		
Bruxism			-	
No	1			
Yes	2.38 (1.51 - 3.63)	< 0.001		
Cement-enamel junction failure			-	
Lacking	1			
Present	0.30 (0.20 - 0.45)	< 0.001		
Sex			-	
Male	1			
Female	0.93 (0.54 - 1.48)	0.690		
Age	1.03 (1.01 - 1.05)	0.002	-	

The most important findings of this study were related to the low longevity of DH treatment, and the results of regression analysis that showed the main predictors of treatment failure were gingival recession and abfraction. It is important for clinicians to advise their patients with DH that the laser and cyanoacrylate therapies are not a lasting treatment for DH, and the presence of gingival recession and/or abfraction could increase the odds of its recurrence by 3 times in a period no longer than 6 months. Therefore, these two conditions should be considered as prognostic factors in cases of DH. Furthermore, because there was no significant difference in the survival curves for the two treatments, the cyanoacrylate can be chosen for the treatment of DH rather than laser because it is cheaper, easier to have access to and easier to manipulate.

It should be clear that the survival analysis used in this manuscript has its own terminology that is unusual in dentistry; for such reason, it may be misunderstood sometimes (Douglas de Oliveira *et al.*, 2017). For example, the term "survival" used throughout the text is linked to the treatment longevity, and does not refer to survival of a person with a disease or to the survival of a tooth. The present study does not demonstrate that the laser and cyanoacrylate are ineffective, it only presents the average duration of efficacy of DH treatment.

Although the clinical trial was well conducted, it may have had some limitations. Firstly, the COX regression could not be performed, since the assumption of proportional hazard between curves was not achieved. Secondly, failure was determined by an arbitrary cut-off point on a numerical scale. Unfortunately, there is no consensus in the literature about the DH diagnostic criteria, and several methods have been used to evaluate this condition (Rees *et al.*, 2003; Que *et al.*, 2010; Douglas de Oliveira *et al.*, 2013). If a higher or lower cut-off point were used, the survival rate might increase or decrease.

Studies of survival analysis for the DH treatment are needed to reinforce the present findings, or not. Further clinical trials should be conducted focusing on different DH treatments and protocols. Moreover, epidemiological studies should be conducted to gain better understanding of the risk factors for DH and its recurrence.

Conclusions

It can be concluded that after 1 day of treatment, DH could recur in 52% cases of teeth treated by laser, and in 44% cases treated with cyanoacrylate. Overall, these two approaches to DH treatment had a survival rate of 36% in 6 months. The most prevalent hypersensitive tooth was the first premolar. Gingival recession and abfraction predicted the recurrence of DH independently of age and sex.

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