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The efficacy of laser frenectomy in spontaneous closure of maxillary midline diastema in mixed and permanent dentitions

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ABSTRACT

This study aimed to assess the effect of laser frenectomy on the closure of midline diastema without orthodontic treatment in mixed and permanent dentitions. The study included 14 patients (6 children in the mixed dentition and 8 adolescents and adults in the permanent dentition) with midline diastema > 1mm. Frenectomy was conducted by a diode laser (810 nm, 3 W, CW). The amount of midline diastema was measured on the study models before, and 1, 3, and 6 months after frenectomy using a digital caliper. The degree of perceived pain was recorded using a Visual Analogue Scale (VAS) on the first and second nights after operation. There was no significant difference in the amount of midline diastema between different time periods (p=0.06), the two age groups (p=0.35), and the two genders (p=0.27). Furthermore, no significant difference was found regarding the pain level between the two groups either on the first (p=0.65) or second (p=0.65) nights. Laser frenectomy leads to slight and insignificant reduction of midline diastema in mixed and permanent dentitions therefore the application of other adjuncts such as orthodontic intervention is required for diastema closure. The use of diode laser is advocated as an appropriate tool with little pain and discomfort after application in patients needing frenectomy.

1. INTRODUCTION

The Maxillary midline diastema has been defined as a space greater than 0.5 mm in width between the proximal surfaces of upper central incisors [1]. Midline diastema is considered as a normal developmental stage in childhood, as it presents in approximately 98 per cent of the 6-year-old children. The so-called "ugly duckling stage" refers to a developmental phase in early mixed dentition in which transient spacing occurs

between the upper anterior teeth due to the pressure from canines on the roots of upper incisors [2, 3]. Although the prevalence of midline diastema shows a sharp decline after eruption of lateral incisors and permanent canines, but it still causes an esthetic problem in approximately 7% of teenage population [2]. It has been indicated that the chance of spontaneous closure of midline diastema during normal development is lower in cases showing more than 2 mm space between upper central incisors [4].

Besides the natural and physiological spacing that occurs during growth and development, there are multiple factors that may lead to maxillary midline diastema such as the racial and genetic background, an intermaxillary cleft, a tooth size-arch length discrepancy, missing anterior teeth, supernumerary teeth (mesiodens), the presence of midline pathology including odontogenic tumors (like odontoma) or midline cysts (like nasopalatine duct cyst), and habits such as thumb sucking or tongue thrusting [1], [2], [5]. The upper labial frenum is a small musculo-mucosal tissue that connects the upper lip to the alveolar process and the palatine papilla [3], [6]. It has been demonstrated that an abnormally attached fibrous labial frenum might be an etiologic factor in creating maxillary midline diastema and complicating its correction. In addition to causing midline spacing, an abnormal labial frenum can contribute to other complications including secondary periodontitis due to food retention and impaired oral hygiene, and gingival recession of incisors as a result of lip movement and continuous frenal stretching [3]. The diagnosis of an abnormally high frenum is usually made through the "blanching test". In this test, the upper lip is pulled upward and forward until the frenum is strongly stretched. The observation of a blanching or change of contour in the interdental area or palatine papilla confirms that the frenum is abnormal. In these cases, frenectomy combined with orthodontic or restorative treatment has been suggested to remove the frenum attachment and thus closing the midline diastema and improving the periodontal status of anterior teeth [7].

Frenectomy (total removal of the frenum) or frenotomy (partial removal of the frenum) is generally indicated in cases of highly attached frena with the purpose of preventing relapse of orthodontic correction or improving esthetics, speech, periodontal health, and social status [8]. These surgical procedures can be conducted by the surgical blade, electro surgery or different types of lasers. Among all techniques, laser surgery should be considered the best option due to its remarkable advantages including easy application and short surgical period, minimal bleeding, less discomfort during and after the operation, no need for sutures, minimal swelling and the lack of scar formation at the surgical site [5], [9- 11]. There have been reports of using CO_2, Diode, Er:YAG, and Er,Cr:YSGG lasers for labial frenectomy in children, adolescents, and adults [9], [12-17]. The diode laser is a small and relatively cheap device that can be used for various purposes in dentistry such as bleaching, depigmentation, treatment of oral ulcers, and performing surgical procedures such as frenectomy and gingivectomy [12], [13], [18- 20].

According to [21], in case of the need for frenectomy/frenotomy, this should be done after closure of the space with orthodontic intervention. Otherwise, the resultant scar after the operation would prevent from closure of the midline diastema. However, a few studies demonstrated that frenectomy without an orthodontic intervention could lead to the spontaneous closure of midline diastema due to the traction of gingival fibers during mixed or permanent dentitions [1], [3], [22], [23]. As laser frenectomy produces no scar tissue, the possibility of creating an obstacle that may prevent tooth movement during further orthodontic treatment would be negligible.

There are few studies regarding the efficacy of laser frenectomy in correction of maxillary midline diastema in different age groups. Furthermore, there is little information to estimate any possible changes in midline diastema in cases that undergo surgical removal of frenum for other purposes such as improving speech, esthetics or gingival and periodontal health. This clinical study was conducted to investigate the effect of

frenectomy with a diode laser on the spontaneous closure of maxillary midline diastema in mixed and permanent dentition cases.

2. Subjects and methods

The sample of this clinical study consisted of subjects referred to the Department of Orthodontics, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran during the period from September 2016 to May 2017 with the chief complaint of spacing between upper front teeth. The subjects were evaluated by the first investigator and those who were in need of frenectomy were selected and assigned to either mixed or permanent dentition groups. The mixed dentition group included 8 children in the age range of 8 to 10 years, whereas the permanent dentition group consisted of 9 adolescents and adults aged between 14 to 22 years. The inclusion criteria were the presence of spacing > 1 mm between upper central incisors and the diagnosis of a high frenal attachment with the frenum adhering to attached gingiva or interdental papilla, as confirmed by the blanch test. The exclusion criteria were the existence of periodontal problems, dental caries or implants in anterior teeth and any systemic disorder that may influence tooth movement. Furthermore, the patients who could not wait for a follow-up period before other treatment interventions and desired immediate management of the space problem or could not refer at follow-up periods were excluded from the sample. The study protocol was reviewed and approved by the ethics committee of Mashhad University of Medical Sciences. The treatment procedure was explained clearly to the patients or their parents (legal guardians) and written informed consent was taken before the study commencement.

2.1 The surgical intervention

At the start of treatment, all patients were referred to take OPG radiographs to determine the presence or absence of permanent teeth in the maxilla. Before the operation, an alginate impression was taken from the upper arch of each patient and poured with orthodontic plaster to prepare the study model. The local anesthesia was achieved by injection of 2% lidocaine with 1:100,000 epinephrine at both sides of the frenum. The surgical procedure was conducted using a gallium aluminum arsenide (GaAlAs) diode laser (ARC Laser GmbH, Nürnberg, Germany), emitting a wavelength of 810 nm. The laser was run at the power of 3 W and continuous-wave mode and the light was delivered through an optical fiber tip measuring 300 μm in diameter. The fiber tip was held in light contact with the soft tissue through the procedure.

After cutting the frenum attachment, the remainder of the frenal tissue was removed completely at both sides of the vestibule until a triangular excision was observed buccally (figure 1). Any soft tissue between the central incisors was also excised. There was negligible if any bleeding during the operation. No suture was required at the surgical site and just wet gauze was packed between the lip and the front teeth. The patient was asked to hold the gauze for 10 minutes and take 320 mg paracetamol if he/she perceived pain.

2.2 Follow-up periods

The patients were recalled at 1, 3 and 6 months after frenectomy. The alginate impression was taken from the upper arch of the patients at each follow-up period and study models were prepared to determine and compare any changes in midline diastema over time.

2.3 Diastema measurement

The dimension of the midline diastema was determined on the plaster models using a digital caliper (GUANGLU Caliper, China) with an accuracy of 0.01 mm. The measurements were made before frenectomy and at 1, 3, and 6 months later in both dentition groups. For this purpose, the distance between the distoincisial point of one central incisor to the distoincisial point of the other central incisor was measured and defined as "A" value (Fig 2). Then, the mesiodistal diameter of each central incisor was measured and summed to

represent the "B" value (Fig 2). Finally, the "B value" was subtracted from the "A" value to indicate the magnitude of the midline diastema. The midline diastema was measured by two observers and the measurements were repeated one week later to detect intra-rater and inter-rater reliability.

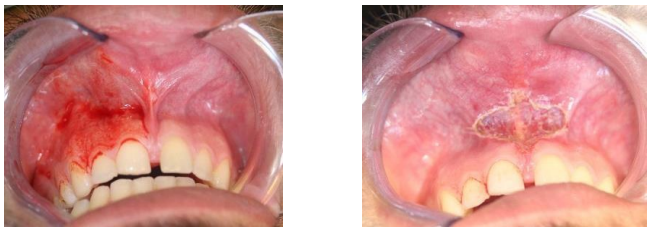

Fig 1. A. The pretreatment view of a high frenal attachment in the permanent dentition group, B. Immediately after frenectomy with an 810 nm diode laser

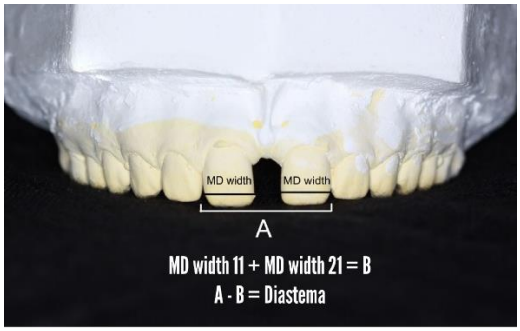

Fig 2. By subtracting the "B value" from the "A" value, the magnitude of the midline diastema was obtained.

2.4 Pain assessment

The patients were asked to define the severity of pain perceived at bedtime on days 1 and 2 after the surgical procedure using a Visual Analogues Scale (VAS). The VAS consisted of a 10-cm horizontal line graded from 0 to 10 at both sides. The left side of the scale (0) represented no pain and the right side (10) indicated the worst ever imagined pain. The patients were asked to mark the degree of pain on this scale.

2.5 Statistical analyses

The inter-rater and intra-rater reliability were analyzed using intra-class correlation coefficients (ICCs). Due to the normality of the data in Shapiro-Wilk test, the repeated measures analysis was run to compare the amount of midline diastema between different assessment intervals, and other variables including dentition stage, tooth absence, and gender were entered in the model to detect their effects. Mann-Whitney U and *Wilcoxon signed rank* tests were employed to compare the degree of pain on the first and second nights. The statistical analysis was performed using SPSS software (SPSS Inc; Chicago, Il), and the P-value<0.05 was considered statistically significant.

3. Results

From the 17 patients treated, three did not refer at the follow-up appointments. Therefore, the data from the remaining 14 patients were used in the statistical analysis. Of the 14 patients evaluated, 5 (35.7%) were male and 9 (64.3%) female. Six patients (42.9%) belonged to the age group of 8-10 years (mixed dentition group) and 8 patients (57.1%) were in the age range of 14-22 years (permanent dentition group). Four cases showed a missing lateral incisor; from which one belonged to the mixed dentition group and three were in the permanent dentition group. Maxillary canines were not visible in any of the patients in the mixed dentition stage.

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The ICC value for all variables was > 0.9 indicating excellent intra-rater and inter-rater reliability.

3.1 Comparison of the degree of midline diastema between different assessment intervals

Table 1 indicates the measurements of midline diastema before frenectomy and at the follow-up visits of 1, 3 and 6 months later. The statistical analysis exhibited that there was no significant difference in the amount of midline diastema between different time periods (P=0.06; Table 1). The degree of diastema was not significantly different between the mixed and permanent dentition groups (P=0.35; Table 1). Furthermore, there was no significant difference in midline space between patients with missing tooth in the upper arch and those without tooth agenesis (P=0.83; Table 1). In addition, the gender of the patients did not influence the values of midline diastema during the study period (P=0.27; Table 1).

Table 1. The mean, standard deviation (SD) and the results of statistical analysis to compare the amount of midline diastema between the groups over the study period

	8-10 years old		14-22 years old		The effect of time period*	The effect of age group*	The effect of tooth absence*	The effect of gender*
	Mean (mm)	SD	Mean (mm)	SD				
Before frenectomy	1.60	0.75	2.55	1.84	F= 2.82 p = 0.06	F= 0.98 p = 0.35	F= 0.05 p = 0.83	F= 1.33 p= 0.27
1 month later	1.40	0.79	2.36	1.89				
3 months later	1.39	0.72	2.38	1.97				
6 months later	1.50	0.80	2.45	1.96				

*The statistical analysis is significant at p<0.05

3.2 Assessment of pain level after frenectomy

All patients were advised to take an analgesic in case of pain after laser treatment and only 4 patients reported a maximum number of 2 acetaminophen tablets intake. The results of Mann-Whitney U test revealed that there was no significant difference regarding the degree of pain on the first (p=0.65) or second (p=0.65) nights after operation between the two age groups (Table 2). The Wilcoxon signed rank test revealed that the patient's pain was significantly greater on the first night compared to the second night in both age groups (p=0.001).

Table 2. Comparison of pain degree on the first and second nights after laser frenectomy in different age groups

Parameter	8-10 years old		14-22 years old		Mann Whitney U test**
	Median (IQR)*	Mean±SD	Median (IQR)	Mean±SD	p-value
First night	1 (1)	1.00 ± 0.63	1 (4)	1.38 ± 1.18	0.65
Second night	0 (0)	0.17 ± 0.41	0 (1)	0.50 ± 1.07	0.39
Wilcoxon Signed Rank test**	p=0.009		p=0.001		

*IQR= Interquartile range

**The statistical analysis is significant at p<0.05

4. Discussion

This study evaluated the effect of laser frenectomy on spontaneous closure of midline diastema during mixed and permanent dentitions. The mixed dentition patients were in the age range of 8 to 10 years when the canines were not erupted to the oral cavity. The removal of frenum adhesion was conducted using an 810 nm diode laser (3 W, CW) and a 300 µm fiber tip, and the measurements of midline diastema were made before frenectomy, and at 1 ,3, and 6 months later. The ICC values for all variables were > 0.9. It is assumed that

ICC values of <0.5, 0.5–0.75, 0.75–0.9, and >0.9 represent poor, moderate, good and excellent reliability, respectively [24]. The outcomes of this study showed that there was no significant difference regarding the amount of midline diastema during different time periods and between mixed and permanent dentition cases. Furthermore, neither tooth absence nor sexuality affected the amount of midline diastema closure in the sample.

In this study, the initial midline diastema was 1.60 ± 0.75 mm in the mixed dentition group before frenectomy. This reduced to 1.40 ± 0.79 mm and 1.39 ± 0.72 mm at the 1- and 3-month follow-ups, respectively; and then increased to 1.50 ± 0.80 mm at the 6-month follow-up period. The midline diastema was not thoroughly closed in any of the patients of the mixed dentition group over the 6-month after the surgical operation. In comparison, the initial midline diastema in permanent age group was 2.55 ± 1.84 mm before frenectomy and it declined to 2.36 ± 1.89 mm at the 1-month follow up. However, during 3 and 6 months after frenectomy, the amount of midline diastema increased to 2.38 ± 1.97 mm and 2.45 ± 1.96 mm, respectively. Similar to the mixed dentition group, none of the patients in this group had a completely closed diastema over the 6-month follow-up. Overall, the alteration in the amount of diastema was statistically and clinically insignificant in both dentition groups and consisted of a small decline followed by a negligible reversal in midline space over the study period.

There are different schools of thoughts regarding the timing of frenectomy in relation to orthodontic treatment. Most investigators support a viewpoint that in patients with midline diastema, frenectomy should be postponed until complete closure of the diastema by orthodontic intervention [6], [21], [25], [26]. In this way, the scar tissue formed after the operation helps maintaining the teeth in close approximation and improves the stability of the final result. On the other hand, some orthodontists recommend that frenectomy should precede orthodontic treatment especially when a too wide diastema prevents eruption of other anterior teeth or when the presence of a hypertrophic frenal attachment precludes complete space closure as a response to orthodontic forces [21]. In these cases, tooth movement to bring the teeth together should be started immediately after the surgical procedure. Otherwise, the created scar and granulation tissue formed between the teeth during healing may act as an obstacle and impede closure of the midline diastema [21]. A few authors recommended removal of "abnormal" frenum attachment at an early age to allow spontaneous closure of midline space without orthodontic intervention, thus intercepting an early developing malocclusion [1]. They believe that during dental development, natural eruptive forces apply mesial pressure towards the midline and thus allowing partial or total closure of the midline diastema [1]. The outcomes of the present study revealed that the spontaneous closure of midline space does not occur after frenectomy in mixed and permanent dentitions. Although frenectomy with diode laser is not associated with the formation of scar tissue to preclude tooth movement [16], [27], the closure of midline diastema was very small over the 6-month follow-up period. This means that in most cases, frenectomy should not be accomplished as a sole approach for closure of midline space and complementary procedures such as orthodontic or restorative treatments are required for thorough diastema closure.

There are few studies concerning the effect of frenectomy on spontaneous closure of midline diastema and so comparison of the results of this study with other investigations is limited. In the study of [22], 40 schoolchildren (8 to 9 years of age) with diastema more than 1 mm were randomly allocated into two groups including a group of frenectomy with surgical blade and a group without any treatment (control). At the 6-month, 2- and 5-year follow-ups, the diastema closure was significantly greater in the frenectomy group compared to the group without treatment. However, the difference between the groups gradually declined and after 10 years, there was no longer any significant difference. [3] assigned 59 patients in need of frenectomy to each of the two groups: 1) frenectomy by CO2 laser with orthodontic intervention (including 31 patients)

and 2) frenectomy by CO2 laser without orthodontic intervention (including 27 patients). They observed that over the first follow-up (2 to 12 weeks after intervention), the diastema was closed in 4 patients of the first group and none of the patients of the second group, although the difference between groups was not statistically significant. At the second follow-up period (4 to 19 months after intervention), the frequency of diastema closure was significantly different; as 20 patients in the first group (frenectomy and concomitant orthodontic treatment) and only 3 patients in the second group (frenectomy alone) showed closed diastema [3]. The outcomes of the present study are similar to the results of [3], implying that frenectomy is not sufficient for diastema closure and complementary approaches such as active orthodontics forces are required to help closing the midline space. [1] reported that frenectomy in a 9-year-old girl with a high frenal attachment lead to spontaneous closure of midline spacing within 2 months after the surgical procedure. They attributed this finding to the mesial movement of the teeth which is maximal during active eruption. Georgieva [23] performed labial frenectomy combined with nonsurgical periodontal therapy in a 34-year old male with severe periodontitis. She observed complete diastema closure 9 months after therapy, implying the efficacy of frenectomy as a self-sufficient approach for correcting midline diastema. The different outcomes obtained in this study compared to previous investigations may be related to the variations in methodology, age range of the subjects or follow-up periods.

The diode laser was applied for frenectomy in the present study to prevent the complications of the conventional technique with a surgical blade such as pain and bleeding. Frenectomy with diode laser provides a relatively painless treatment and a clean and dry environment with markedly less post-surgical complications. The energy emitted by the diode laser is mainly absorbed by soft tissue pigments. As the absorption of diode laser by tooth and bone is poor, the risk of inadvertent damage to the hard tissue is reduced when using diode laser for frenum removal [15], [28].

According to VAS scores, the level of pain in the mixed and permanent dentition groups was 1.00 ± 0.63, and 1.38 ± 1.18 on the first night, and reduced to 0.17 ± 0.41, and 0.50 ± 1.07 on the second night after operation, respectively. The pain reported by the patients was very mild and the difference between the two groups was not significant, neither on the first nor on the second nights. The intensity of pain after laser frenectomy decreased over time, so that pain level on the second night was significantly lower than that of the first night in both age groups. Most of the previous studies reported less pain and discomfort following laser frenectomy compared to frenum removal by the conventional technique [17], [29- 33]. [34] demonstrated that the use of diode laser for labial frenectomy caused patient satisfaction due to avoidance of needle-infiltrated anesthesia and optimum healing post-surgically.

One of the limitations of this study was the small sample size. Furthermore, the study did not include a control group without intervention to assess the natural changes that occur in the degree of midline diastema over the study period. Future clinical studies should include larger sample sizes over longer follow-up periods, possibly by adding an untreated control group to better analyze the alterations in the midline spacing after laser frenectomy with/without concomitant orthodontic treatment.

5. Conclusion

Within the limitations of the present study, the following results could be drawn:

1- The amount of midline diastema in the mixed dentition patients showed a slight decline at 1 and 3 months after laser frenectomy, but increased negligibly at the 6-month follow-up.

2- The midline diastema in the permanent dentition group decreased over 1 month after laser frenectomy, but it showed a little rise at 3- and 6-month follow-ups.

3- The diastema was not completely closed in any of the patients in the mixed and permanent dentition

groups at the end of the 6-month study period. Therefore, other modalities such as orthodontic or restorative interventions are required for complete space closure.

4- There was a mild degree of pain and discomfort on the first night after laser frenectomy, which reduced to a negligible value on the second night, suggesting that this modality is an appropriate approach for patients with high frenal attachment.

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