Original Article

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AN ASSESSMENT OF EFFICIENCY OF APPLICATION OF ERBIUM - YAG LASER WITH RAPID PALATAL EXPANSION IN DECREASING PAIN RESULTED FROM ACTIVE TREATMENT: AN IN VIVO STUDY

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ABSTRACT:

Introduction: Maxillary Transverse Deficiency (MTD) is one of the most pervasive and common skeletal problems in the craniofacial complex. This study aimed to evaluate the effect of associating the application of Erbium-YAG laser with rapid palatal expansion in decreasing pain resulted from appliance activation in young adult patients with permanent dentition compared with traditional treatment with RPE appliances.

Methods: Forty eight subjects aged between 15.5 - 19 years were randomly assigned to either laser group (n=24) and control group (n=24).

Patients of laser group were undergone 8 mucosal-bony perforations along the midpalatal suture, using erbium-yag laser, and two bands hyrax expander were cemented for all patients of groups.

International visual pain scale (vps) was used to compare pain resulted from screw activation along one month in both groups.

Results: findings showed significant decrease in pain degree at the last 10 days of study time (one month)

Conclusion: LARME (laser Assisted Rapid Maxillary Expansion) can be a valuable approach with young adult treated by using of rapid palatal expanders in reducing pain sensation throughout activation phase because of its possible role in facilitating midpalatal suture separation.

Keywords: Maxillary transverse deficiency, Rapid Maxillary Expansion, Erbium-YAG Laser, Visual pain scale.

INTRODUCTION:

Maxillary transverse deficiency (MTD) is one of the most pervasive and common skeletal problems in the craniofacial complex, often combined with a simultaneous vertical or antero-posterior skeletal discrepancy. [1]

The most frequently reported clinical manifestations are uni- or bilateral posterior crossbites, palatal inclination of teeth, dental crowding, high palatal arch, narrow, tapering arch form and problems associated with nasal breathing. [2] The prevalence of MTD is reported to be 8.5 to 22 per cent. [3,4] The maxillary constriction can be purely skeletal, purely dental or a combination of both. [5]

Rapid palatal expansion (RPE) is a common orthodontic procedure used to correct maxillary arch constriction by opening the mid-palatal suture. This procedure is commonly used to correct

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posterior crossbites in the primary, mixed, or permanent dentition. [6]

Several types of fixed appliances are commonly used to correct posterior crossbites by widening the mid-palatal suture. These include the Haas expander, Minne expander, Hyrax®, quad helix, as well as removable expanders. The Hyrax® appliance is one of the more common types of RPE appliances currently used to correct posterior crossbites. It is a hygienic, fixed metal appliance with a nonspring-loaded jackscrew, which is attached to either 2 or 4 teeth. [7-9] The abutments may be the primary canines, primary molars, permanent premolars, or molars depending on the age of the individual. The expansion screw is turned with a key either once or twice daily (1/4 mm expansion/turn) for the entire expansion phase of treatment which usually lasts from 2-4 weeks. RPE utilizes large forces to produce maximal orthopedic repositioning with a minimum of orthodontic movement. A single activation of the expansion screw produces approximately 3-10 pounds of force. Since RPE is a common orthodontic intervention when the maxillary dental arch requires orthopedic expansion, many aspects of this procedure have been investgated in depth and are described in the dental literature. [10-14]

Clinicians using RPE procedures are aware that patients frequently report pain during the expansion phase of treatment. However, there are rare literature studies available documenting this occurrence. [6]

Laser applications in dentistry have shown significant therapeutic advantages over conventional forms of treatments. [12] Since 1988 Erbium lasers are the mainly used laser systems in dentistry for cavity preparation. Two Erbium laser systems are preferred: first, the Erbium: YAG laser, which emits light at 2.94 µm, and second, the Erbium, chromium: YSGG laser, which emits light at 2.79 µm. however, Erbium lasers can be operated up to a pulse repetition rate of 40 Hz and average powers of 20 W at pulse energies of 1 J. [15]

In the modern clinical practice, the laser can be used routinely for the ablation of bone and for the removal of root tips, osseous recontouring, apical surgery exposure of bony impacted teeth, and other procedures. Continued research into the role of the erbium family laser for treatment around implants and the ideal settings for bone to minimize iatrogenic damage is indicated for the future. [16]

To date, no research has attempted to study the effect of using Erbium-YAG laser as an alternate of traditional surgical procedures to create perforations along the midpalatal suture in order to reduce pain resulted from rapid maxillary expansion in young adult patient with permanent dentition.

MATERIALS AND METHODS:

Sample selection

Patients who need RPE were asked to participate in the study. All patients demonstrated either bilateral dental crossbites as a result of maxillary constriction in permanent dentition phase. The 2 points Hyrax® was the appliance of choice for expansion by the author. Mental disability, current use of pain medication, chronic illnesses, presence of other oral pathology, inability to speak (either parent or patient), or failure to give informed consent were criteria for exclusion. The Ethical Committee of the dental school, at Hama University approved the protocol (Resolution No: 245, dated 18/8/2013). All patients gave informed consent assent for participation in the study.

The study was conducted on 48 patients which were divided into two groups, first group (Study group) (mean age, 17.2 years; 12 females, 12 males), treated with a rapid palatal expansion appliance assisted with the application of Erbium-YAG Laser interventions. The second group (Study group) (mean age, 17.6 years, 12 females, 12 males) treated with rapid palatal expansion appliance alone as control group.(Table 1)

Treatment Procedures:

Consents forms were handed over and signed by all patients. A set of records (PA cephalograms, dental casts, and intraoral and extraoral photograph) was obtained for each patient as diagnostic records.

RME appliances were cemented instantly after finishing of laboratory procedures for control group patients, and after the laser intervention for study group patients (Fig1).

Laser intervention procedures

Patients of study group (laser assisted expansion group) underwent a laser intervention by the orthodontist and a surgeon according to the following protocol:

After the operation room was prepared to the procedure, each patient was asked to use oral rinse in order to have clean work field, then the Erbium-YAG laser machine (KaVo KEY Laser 3 1243) was prepared and set accurately for the programs chosen for every step, as the following:

The handpiece type (2062) with laser program (Frectomy 2062 50 10) after modifying the sitting of the program to be (Energy 400mj. Frequency 15 Hz) was used to make 8 perforations along the palatal mucosa above the midpalatal suture area directly in order to create a hole for the second handpiece. (Fig 2) (Fig 3).

The handpiece type (2060) with laser program (27.apictomy 2060) which is modified to (Energy 400mj, frequency 15Hz) was used to make bony perforations in the sites of the previous mucosal holes for about 5 seconds until bleeding were shown in the radiated points. Similar approach was reported in previous studies. [13] (Fig 4) (Fig 5)

Appliance Activation:

Patients were asked to activate the appliance by themselves by turning the screw twice a day. Activation started immediately after the appliance was cemented. And it ended when overcorrection was achieved with the palatal cusps of the upper molars riding up on the buccal cusps of the lowers. Patients kept on expansion until crossbite was solved with some overcorrection (mean treatment time was 1.38±0.62 months).

Pain Investigating:

Along with the introductory letter explaining the study and protocol, verbal instructions were given to the patient on how to utilize Visual Pain Scale (VPS) (Fig 6)

The first expansion was performed in the orthodontic department and the patient was asked to rate his/her perceived pain using the pain scales after the expansion was performed. And he was asked to repeat the expansion procedure and pain measurements at home for the remaining turns. The patient's pain response, immediately after he/she completed turning the screw, was recorded on a data collection sheet for the entire phase of expansion.

pain investigating period was divided into three times (T1 for first 10 days, T2 for second 10 days and T3 for third 10 days), and mean pain degree for every time was recorded from the author.

Patients was informed to avoid taking any drugs especially pain relievers during activation phase of treatment in order to have reliable results about the real feel of pain.

Statistical analysis

A pilot study was carried out for on four patients (two for each group), and the number of sample patients was determined consequently by using of G-Power program (G-Power v 3.1.9.2, by entering the concludes statistical values respectively to the program in order to have a 95% power sample, the program suggested that a sample consisted of 48 patients (24 patients for each group) was sufficient to achieve 95% sample Power.

The patient's date of birth and date that the expansion started were recorded on the data collection sheet. Each child's pain response was recorded.

Missed turns and the reason for missing the turn were also recorded. Forms were collected at the end of the expansion phase of the treatment and the data were entered into STATA® Version 6 (Stata Corp., College Station, TX).

RESULT:

Descriptive Statistics

The main characteristics of the samples were summarized in Table 1. The study group (n = 24) consisted of 6 girls and 12 boys with a mean age of 17.2 years ± 1.4 at T1.

Whereas control group (n = 24) consisted of 12 females and 12 males with the mean age of 17.6 years ± 1.1 at T1.

Analytics Statistics

Pain was measured by using of VPS, the presence and source of pain was recorded during three different times for every patient.

Studying of pain presence:

Study of pain presence according to expansion protocol and time period:

Table (2) showed a gradually decrease in pain presence ratio from T1 to T3, and in order to study it more specifically, many other statically tests were carried out.

Impact of expansion protocol in pain presence frequencies according to time period:

Chi Square Test was carried out in order to study significance of differences in pain presence frequencies between both groups according to time period:

Table (3) showed no significant differences in pain presence frequencies at T2 and T3 whatever the group. Chi square test wasn't carried out at T1 because all the patient of two groups felt some pain whatever the followed expansion protocol, and that refers that there was no significant differences in pain presence frequencies at T1 in both groups.

The impact of time period in the pain presence according to the treatment group:

McNemar statistical test was undergone to study the significance of paired differences in the presence of the pain between three times (expansion day, After one week, after one month) according to group as following:

When comparing the frequency of pain presence between T1 and T3 Table (4) showed a significant difference in pain presence in the study group, whereas there wasn't any significant difference in pain presence frequency between any other two times in both groups. (also see chart 1)

Studying of pain Source:

Results of investigating pain source according to group and time period:

Table (5) showed the source of pain in both groups according to treatment time, it was clear that pain resulted from laser intervention was noted in laser group only in the first time.

The Impact of expansion protocol in pain source frequencies according to time period:

Chi square statistical test was carried out to study the significance of differences in pain source frequencies between study groups according to time period as following:

Table (6) showed significant differences in pain source frequencies between both groups at T1. Laser interventions alone or laser interventions in addition to appliance activations were the dominant pain sources in the study group only.

Chi square test wasn't calculated in both (T2, and T3) time period because all patients of both groups felt a pain resulted from activation process whatever the expansion protocol followed.

Studying of pain degree:

The impact of treatment protocol in pain degree, pain degree changes and pain changes percentage according to the treatment group:

Independent T test was used to study the significance in differences in means of pain degree, pain degree changes and pain changes percentage between groups according to treatment period as following:

Table (7) showed a significant difference in pain degrees mean at T3 between treatment groups, and according to the statistical result, it was concluded that the pain degrees after one month was in the study group less than degrees in the control group at the same time.

The impact of time period on the pain degrees according to treatment protocol:

Nondependent T test was used to study the significance of paired differences of pain degree means, between three treatment times (T1, T2, T3) according to treatment protocol as following:

Table(8) showed significant paired differences in the mean values between the times (T1, T2, T3) in both groups except pain values between (T2 and T3) in control group.

By analyzing statistical results, it was noticed that pain degrees at T2 and T3 was less than it at T1 in both groups, and the pain values at T3 was less than it at T2 in laser group. (also see chart 2)

DISCUSSION:

Since Haas [17] began popularizing the fixed, palatal expander in the United States in an article published in 1961, the use of expanders to significantly widen the maxillary arch in mature patients has generally considered unsuccessful. [5,18,19]

The pessimistic view of rapid maxillary expansion (RME) in adults is based in part on anatomic studies of the nature face, which show the midpalatal suture and adjacent circum-maxillary articulations becoming more rigid nag beginning to fuse by the midtwenties. [20]

Hence, most previous studies showed that RME treatment is able to induce significantly more favorable skeletal changes in the transverse plane when it is initiated before the pubertal peak in skeletal growth. This clinical finding agrees with histological data previously noted by Melsen21 which demonstrated a higher level of response to mechanical stimuli in the midpalatal suture in preadolescent patients due to a lesser degree of interdigitation between the 2 halves of the maxilla.

On the other hand, literature mentions several problems accompanied by RME on mature patients. Bell and Starnbach

[22,23] report that activation of an appliance against mature sutures can lead to the sensation of pain and necrosis of oral mucosa under the appliance. These forces can also result in periodontal defects as the teeth are pushed though the buccal cortical plate, which lead to bony defects and gingival recession. These complications can be avoided by surgically releasing the osseous structures that resist the expansive forces.

In clinical practice, skeletal correction of the transverse discrepancy via orthodontics (orthopedics) is successful until the age of approximately 14-15 years depending on the gender of the patient. After this age, orthodontic widening becomes virtually impossible and very painful. [18,21,24] In general, it is assumed that closure of the midpalatal suture prevents this type of expansion. [18,21]

Although numerous articles have reported the pain associated with various types of orthodontic procedures such as separator placement, initial, and routine arch wire placement, none have reported on the pain associated with RPE. [7] The purpose of this study was to investigate the effect of making several perforations along the midpalatal suture by using of Erbium-YAG laser on the intensity of pain that young adults experience during RPE procedures.

Measurements of pain in young adults through self-reports must be interpreted cautiously. Pain can be difficult to measure due to developmental factors, different attitudes towards pain, and prior pain experiences. However, with proper utilization of a valid pain scale, the factors associated with painful medical or dental treatments performed on young adults can be identified.

This study was intended to quantify the rule of Erbium-YAG laser interventions in improving patient comfort and decrease pain degree.

VAS-scale was used in this study, which is useful in evaluating facial pain. [25]

This study suggests that most patients undergoing this very common orthodontic procedure experience some pain, usually during the early phases of expansion. According to Zimring et al. [12] the maximum load produced by any single activation occurs immediately at the time of the turning of the jackscrew and begins to dissipate soon thereafter. Human and animal studies have shown that when sutural tissues are expanded rapidly, highly vascular disorganized connective tissue of an inflammatory nature is created, which results in the perception of pain. [26,27] Cleall et al. [26] report that the midpalatal suture widened very soon after the application of pressure in the rhesus monkey. As expansion continued, less disruption of the midpalatal tissues occurred with each progressive turn of the screw. That observation may explain the decrease in reported pain by the children in this study. The decreasing trend in reported pain may also be explained by the fact that children may become more comfortable with the procedure, and

thus the fear and anxiety of turning the appliance may be lessened with each turn. [7]

Our conclusion about pain related with activation of raped palatal expander was similar to those resulted from previous study, but the new result was about the positive effects of perforation carried out by laser instrument, which can play an important role in facilitating suture separation and thereby reducing suture resistance and pain sensation.

A gradually decrease in pain degree was noticed after one week, and one month respectively. But a significant decrease was noted at T3 in study group, which wasnot noticed in control group, and that can refer clearly to the advantages of Erbium-YAG laser application.

On the other hand, a few pain was resulted from laser interventions in most study group patients, but this pain was so mild, and caused no complications after the session.

Finally, It is difficult to compare the results of this study using rapid orthopedic forces to those studies previously cited which evaluated pain associated with lighter orthodontic forces. In addition, too many variables exist among these investigations such as subject age, type of arch wires used, and type of malocclusions to make valid comparisons. [7]

CONCLUSION:

Based on the data and the statistical interpretation used in this study, the following conclusions were drawn:

Both approaches caused some pain in the same way.

Because of Erbium-YAG laser intervention and it is possible rule in decreasing the average of midpalatal suture interdigitating and creating better environment for expansion response, we noted more comfortable treatment with less pain in patients with MTD.

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FIGURES:

Figure 1: The design of the rapid maxillary expanders used in the study

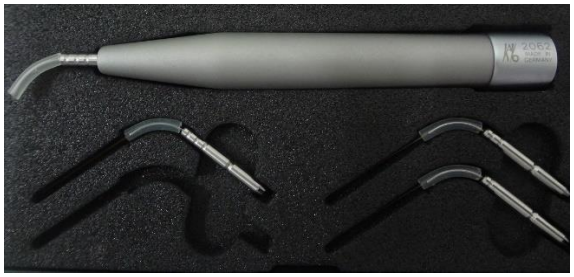


Figure 2: The handpiece 2062 used to create a pass along palatal mucosa to the bone.

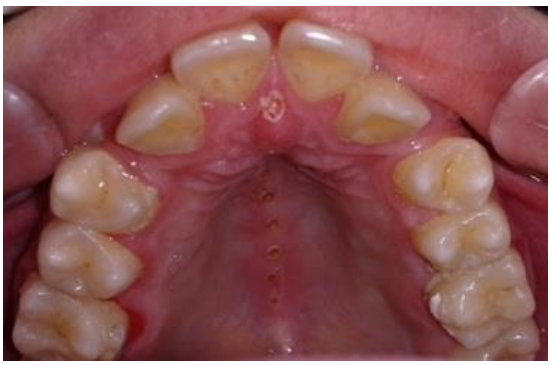


Figure 3: Mucosal perforations resulted from application of laser radiation by means of handpiece 2062.

Figure 4: The handpiece 2060 used for bone ablation.

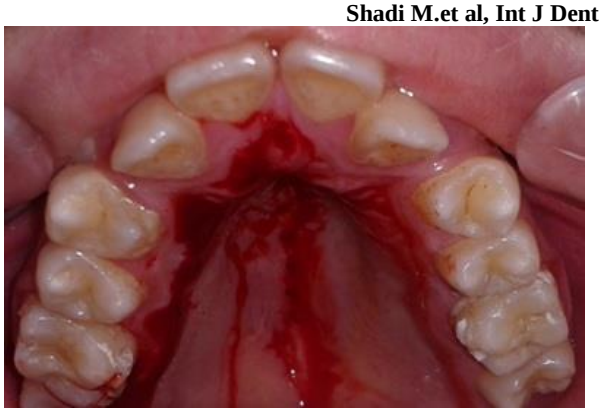


Figure 5: Bleeding resulted from application of laser radiation by means of handpiece 2060 which refers to penetrating of whole cortex bone.

Figure 6: Schematic figure of Visual Pain Scale (VPS)

CHARTS:

Chart (1) percentage of pain presence according to time period and group

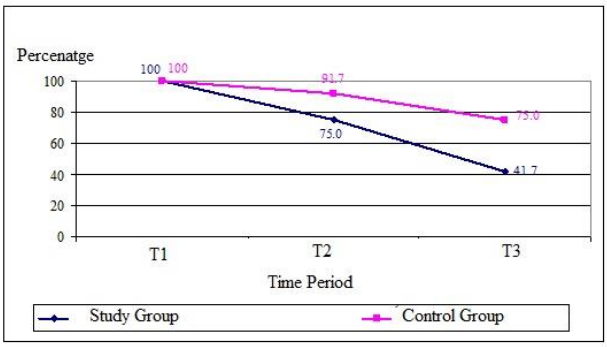
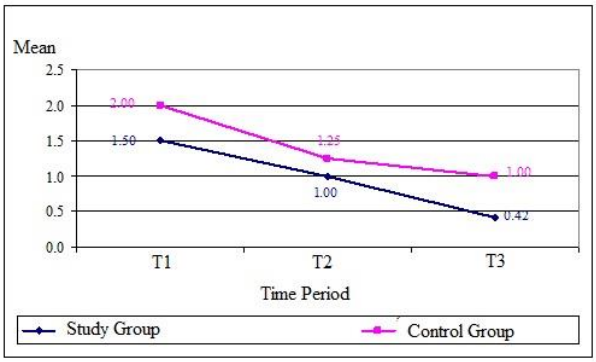


Chart 2: pain degrees average according to time and group.



TABLES:

Table 1: The characteristics of Laser (study) group and control group.

	N	Male	Female	Max Age	Min Age	Mean age	SD
Control group	24	12	12	18.7	16.5	17.6	1.1
Laser group	24	12	12	18.6	15.8	17.2	1.4

Table 2: results of pain presence observation according to group and time

Time	Group	Patients number			Percentage		
		No Pain	Mild Pain	Total	No Pain	Mild Pain	Total
T1	Study Group	0	24	24	0	100	100
	Control Group	0	24	24	0	100	100
T2	Study Group	6	18	24	25	75	100
	Control Group	2	22	24	8.3	91.7	100
T3	Study Group	14	10	24	58.3	41.7	100
	Control Group	6	18	24	25	75	100

Table 3: Chi square test results of study of differences significances in pain presence frequencies between study gtoup and control group according to time

Variables = Expansion Protocol * Pain Presence				
Time	**N**	**Chi square Value**	**df**	**P value**
T1	48	-	-	
T2	48	1.200	1	0.273ns
T3	48	2.743	1	0.098ns

Table 4: McNemar test results to study the paired differences significances in pain presence frequencies in three times according to group.

Variable= time period * presence of pain					
Group	**Time Period (A)**	**Time Period (B)**	**n**	**Significance (*P*-value)**	
Study Group	T1	T2	48	0.250	*No Sinificance*
		T3	48	0.016	***Significance***
	T2	T3	48	0.219	*No Sinificance*
Control Group	T1	T2	48	1.000	*No Sinificance*
		T3	48	0.250	*No Sinificance*
	T2	T3	48	0.500	*No Sinificance*

Table 5: Pain source investigation results according to group and time

T	Group	N				Percentage			
		Laser intervention	Screw Activation	Laser intervention and Screw Activation	Total	Laser intervention	Screw Activation	Laser intervention and Screw Activation	Total
T1	S.Group	14	0	10	24	58.3	0	41.7	100
	C.Group	0	24	0	24	0	100	0	100
T2	S.Group	0	18	0	18	0	100	0	100
	C.Group	0	22	0	22	0	100	0	100
T3	S.Group	0	10	0	10	0	100	0	100
	C.Group	0	18	0	18	0	100	0	100

Table 6: Chi square test results of differences significances study between groups according to time period

Variable= Expansion Protocol*Pain source				
T	**n**	**Chi square value**	**df**	**P value**
T1	48	48.00	2	0.000**
T2	40	-	-	-
T3	28	-	-	-

Table 7: Independent T test results of differences significances in pain degree, pain degree changes and pain changes percentage between groups

variable	Study Group					Control group					dif	Significance (*P*-value)
	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max		
Pain degree at T1	24	1.50	0.67	1	3	24	2.00	0.85	1	3	-0.50	0.125ns
Pain degree at T2	24	1.00	0.74	0	2	24	1.25	0.62	0	2	-0.25	0.379ns
Pain degree at T3	24	0.42	0.51	0	1	24	1.00	0.74	0	2	-0.58	0.035*
Pain degree changes at T2	24	-0.50	0.52	-1	0	24	-0.75	0.45	-1	0	0.25	0.223ns
Pain degree changes at T3	24	-1.08	0.51	-2	0	24	-1.00	0.60	-2	0	-0.08	0.719ns
Pain changes percentage at T2	24	-36.11	43.13	-100	0	24	-36.11	28.28	-100	0	0	1.000ns
Pain changes percentage at T3	24	-76.39	32.92	-100	0	24	-51.39	35.15	-100	0	-25	0.086ns

Table 8: nondependent T test results of paired differences significances in pain degree mean between three times according to group.

Treatment Protocol	n	mean	SD	Min	Max	n	mean	SD	Min	Max	Difference between means	Significance (*P*-value)
	T1					T2						
LARME Group	24	1.50	0.67	1	3	24	1.00	0.74	0	2	-0.50	0.007**
RME Group	24	2.00	0.85	1	3	24	1.25	0.62	0	2	-0.75	0.000**
	T1					T3						
LARME Group	24	1.50	0.67	1	3	24	0.42	0.51	0	1	-1.08	0.000**
RME Group	24	2.00	0.85	1	3	24	1.00	0.74	0	2	-1.00	0.000**
	T2					T3						
LARME Group	24	1.00	0.74	0	2	24	0.42	0.51	0	1	-0.58	0.012*
RME Group	24	1.25	0.62	0	2	24	1.00	0.74	0	2	-0.25	0.082ns