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THE RELATIONSHIP BETWEEN PALATAL WIDTH, MAXILLARY ARCH WIDTH, AND VELOCITY OF CANINE RETRACTION IN PATIENTS WITH CLASS II DIVISION 1

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ABSTRACT:

Objective: This study explored the use of palatal and maxillary arch width as indicators to predict velocity of canine retraction during treatment with maxillary first premolars extraction on patients with Class II division 1 malocclusion.

Material and Methods: The sample consisted of 24 Class II division 1 patients (8 males and 16 females) with mean age 20.29 ±2.82. All patients were treated with bilateral extraction of the maxillary first premolars with the PEA (MBT) technique. Maxillary canines were retracted with 9 mm NiTi closed coil spring applying (150 g) as initial force and reactivated every 21 days. Acrylic guide was used to evaluate the distance of canine retraction. Pre-treatment palatal and maxillary (inter-canine and inter-first premolar) widths were measured on dental casts using a digital caliper of 0.01 accuracy.

Results: The mean rate of the teeth was 0.93±0.15 mm / month. There was weak passive correlation between velocity of canine retraction and MICW (R= - *0*.481, p > 0.01) and PICW (R= - 0.463, p <0.05). Whereas velocity of canine retraction was highly passive correlated with MIPW (R= -0.924, p >0.001) and PIPW (R= -0.836 , p> 0.001). No significant difference of arch width parameters or rate of tooth movement was observed between males and females (p >0.05).

Conclusion: It was concluded that arch width is not associated with gender. The rate of canine retraction can be predicted through the equation depends on MIPW or PIPW.

Key words: class II div 1, Velocity, canine retraction, inter-canine, inter-first premolar, width

INTRODUCTION:

Over the last decades, there has been a marked rising numbers of patients who seek orthodontic treatment.[1] Class II division 1 malocclusion demonstrate the most popular case which be faced with orthodontists in daily practice.[2] Most of non-growing patients need teeth extraction to solve over jet problem.[3] The extraction of only two maxillary premolars is indicated when there isn't skeletal discrepancy or crowding in the mandibular arch.[4] Extraction space can be closed by two basic strategies, including one step or two-step technique. Two-step technique begin with canine retraction, then retraction of incisors. Canines can be retracted by either friction or frictionless mechanics. Several mechanisms for canine retraction have been introduced including Elastomeric chains, lace backs, and NiTi closed coils.[5]

Shia, linked the success of orthodontic treatment to accurate prediction duration. [6] In a 2003 orthodontic practice survey, finishing a case in the predicted time was considered an important practice building method. [7]

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Also patients who are given accurate information also appear to be better consumers of services, with more reasonable expectations of treatment outcomes, [8] and more greatly satisfied dental with their overall treatment.[9] The British Orthodontic Society recommends that patients should receive sufficient information about the proposed treatment, including a realistic estimate of the timescale involved and the retention phase of treatment.[10]

In order to obtain a greater amount of knowledge to predict the duration of treatment, it is necessary to identify the factors affecting this period. Previous studies were conducted to scrutinize various factors that may have an effect on duration of orthodontic treatment. [11-15] Which can be classified into seven groups: sociodemographical frictional, technical, personal, Patients' behavioral, Morphological, and physiological factors.

- sociodemographic characteristics; age, sex.[11,12]
- Frictional factors which consist bracket's design (profile – width), bracket's material (metal or ceramic), arch wire size, ligation method, viscosity of saliva, and many other factors.[15-19]
- Technical factors: closed coil, elastomeric chain, amount and type of force.[20,21]
- Personal factors: initial malocclusion severity, patient's oral hygiene, and public health condition.[22-24]
- Patients' behavioral factors include; broken brackets, and missed appointments.[25]
- Morphological factors involve; facial type, bone density.[26,27]
- Physiological factors: mechanical stress of masseter muscle, bone remodeling.[27,28]

However, while patients with a wide arch width are reported to have brachyofacial pattern and strong muscles, [29, 30] there is not any study has investigated the relationship between such factor and velocity of tooth movement. This suggests the need for more data on this subject to aid in our understanding of the mechanics underlying mechanism tooth movement. Moreover, we believe that a detailed study of canine retraction in full orthodontic treatment involving extraction of the first premolars would be particularly useful in this respect, as well as to future studies on tooth movement.

Therefore, it is to the advantage of both the specialist and the patient to have dependable information about the duration of treatment. This study target was to discover if there is correlation between palatal width, maxillary arch width and velocity of canine retraction in class II div 1 patients. If so, the practitioner will be able to calculate the duration of canine retraction would help

predict the total duration of treatment in extraction cases.

To the best of our knowledge, the present study for the first time investigated the relationship between arch width and rate of tooth movement.

MATERIALS AND METHODS:

2.1. Subjects:

The study sample comprised of 24 patients with class II div 1 (16 females and 8 males) with age ranging from 16 years to 26 years (mean, 20.29 ±2.82). Treatment plan involved extraction of the bilateral maxillary first premolars and retraction of the maxillary canines in all cases for overjet correction and camouflage of skeletal disappearance. This study conducted in the Department of Orthodontics of the Faculty of Dentistry, Tishreen University between 2015 and 2018.

1.2. The inclusion criteria were:

1. Subject's age at the start of treatment was between 16-26 years.
2. Full complement of permanent dentition (all maxillary teeth except 3rd molar are fully erupted).
3. Skeletal class II div 1 with (ANB < 4o, overjet < 5 mm (.
4. Canine relationship of class II ½ unit or more; have class II/1 incisal relationship according to BSI classification.
5. All subject had dolichocephalic (Bjork sum = 396o ± 6).

1.3. The exclusion criteria were*:*

1. Morphological abnormalities of the upper canine's roots visible on the initial patient's panoramic radiograph.
2. Previous treatment with fixed, removal, or functional orthodontic appliances.
3. Oral habits like thumb sucking, oral breathing, etc.
4. Diabetes or any metabolic disease.
5. Pregnant females
6. Patients with syndromes, orofacial clefting or special needs.

During the retraction stage, patients were informed to avert take any NSAIDs except paracetamol if they had toothache. Well oral health was carried out in all subjects before onset the active treatment Phase. Initial records included clinical examination, diagnostic models, intraoral and extraoral photographs, lateral cephalograms and Panoramic radiographs (T0).

Patients' rights were respected, so they were told about duration of treatment, teeth extraction, uncomfortable feeling associated to TPA, and accompanying pain to apply separating elastic. Then Informed consent was obtained from the patients (above 18) or the parents of

patients (under 18) before to the commencement. The research protocol was approved by the scientific research council at Tishreen University by resolution No.3021. Session 15. 20\5\2105.

1.4. Intervention protocol:

All patients received fixed PEA (American Orth ,USA MBT prescription) with 0.022 ×0.028 inch bracket slot which bonded by (Ormco®enlight kit) to the vestibular surface of the maxillary teeth . Anchorage was provided through ligation second molar, first molar and second premolar with 0.010-inch SS ligatures, in addition to fabricate 0.9 mm-passive TPA between first molars to enhance anchorage (Figure 1). All teeth were prepared by pumice paste and washed in running water, prior bonding or banding.

Leveling and aligning stages were achieved according to the following sequence: 0.014-inch NiTi archwire for initial alignment, 0.016-inch NiTi archwire, 0.016×0.022 inch NiTi archwire, 0.017×0.025 inch NiTi archwire, 0.019×0.025 inch NiTi archwire. The working archwire (0.019 ×0.025 inch SS archwire ،American Ortho, USA) was applied and left in place for a month to grant neutrality of the archwire before bilateral maxillary first premolars extraction.

At extraction appointment, working archwire and first premolars brackets were removed. Brackets were covered with orthodontic wax to take (T1) impression, which expresses the end of leveling and aligning stage. Maxillary first premolars were then removed by researcher himself, ensuring safety of procedure and excluding any case accompanied by a root or adjacent bone plate fracture.

After one week of extraction, canine retraction begun by utilizing (9 mm NiTi closed coil spring American Ortho, USA) Which attached directly on the hook of the canine while attached backward by a loop of (0.010 inch) ligation wire on the first molar's hook, where we could control the magnitude of applied force by reducing or enlarging the posterior ligation loop (figure 2).

A force of 150 g was applied for canine retraction. To avoid sharp decay in force, closed coils were reactivated every 21days.Force was determined by Force Gauge Dynamometer (Tecnident tensiometro, Brazil)(figure 3).To reduce frictional effect of elastic ligation, canines were tied with 0.010 ligature wire to working archwire.

All patients received reminder messages, two days before periodically reviews, to eschew missing appointments problem. In addition, oral health was examined at each appointment, including monitoring plaque, sulcus grown on Teeth, and gingival hypertrophy as well as safety of brackets and ligation. So that we avoid side effects of these factors on retraction duration.

Canine retraction continued in each case until class I relationship was reached. At that moment ligation elastics, ligation wires and working arch wires were removed, brackets were covered with orthodontic wax to take alginate impression to obtain dental cast after retraction (T2).

1.5. Dental casts study ;

Linear parameters of arch width were recorded from diagnostic models using a digital caliper (Figure 4) and measurements were rounded to the nearest 0.01 mm. These variables involved (Figure 5) :

1- Maxillary inter-canine width: between the buccal cusp tips of upper canines.

2- Palatal inter- canine width between inner palatal points on the gingival margin of upper canines.

3- Maxillary inter premolar width between the central fossae of left and right maxillary first premolar.

4- Palatal inter premolar width between inner palatal points on the gingival margin of upper first premolars.

1.6. The amount of canine retraction :

Acrylic guide was fabricated in the dental cast in T1 (after leveling). It composed of palatal acrylic button with tow stainless steel arms extended over canines tips (Figure 6-a). Then the guide was transferred to T2 dental cast (Figure 6-b). The rate of canine retraction was measured between the metal extent and canine tip position in T2 cast.

The speed of canine retraction was calculated by the equation:

$$v = \frac{s}{\mathrm{d}} \times 30$$

Where :

V : velocity of canine retraction (mm/month)

S: space between T1, T2 canine tip position (mm).

d; duration of canine retraction (day).

1.7. Method error:

All casts were evaluated twice by two researchers. All reference points were removed after first measure, and then remarked after one month for second measure. Dahlberg formula was used to evaluate random error.[31] The maximum average absolute difference between replicate measures was <0.5 mm. Also, “Paired t-tests” indicated that no systemic error existed (P = 0.233)

1.8. Statistical analysis :

1. Kolmogorov-Smirnov (KS) was used to test normality of distribution of the variables.

2. Independent t-test was applied to compare difference between males and females.

3. Pearson correlation coefficient was used to asses association between arch width variables and retraction velocity.

4. Simple linear regression equations were used to generate prediction equations.

RESULTS:

Based on "Kolmogorov-Smirnov test" All variables were following normal distribution, either in total sample or separated in males and females groups where $p > 0.05$ (table 1 , table 2) . The descriptive statistics for the palatal and maxillary arch width, in addition to average of retraction velocity of total sample, males, and females groups are listed in. The P values (independent samples t-test) showed no statistically significant differences between males and females in arch width and tooth movement velocity ($p > 0.05$). (Table 3)

For total sample, there were significant passive correlation between palatal, maxillary arch width and retraction velocity ($p < 0.05$), but it R coefficient referred to weak relationship of palatal (R =0.463) and maxillary inter canine width (R = 0.481) with canine reraction velocity, where as it was strong correlation between palatal (R = 0. 836), maxillary inter-premolar width (R =0.9***24***) and canine reraction velocity (Table 4) . Accordingly, we adopted inter-premolar width values to generate regression equation. (Table 5)

The regression equation associating canine retraction velocity to Palatal inter premolar width (PIPW) was :

Canine retraction velocity $_{mm/month}$ = 2.65 – (0.07 × PIPW $_{mm}$) [total sample] (Figure 7-A)

The regression equation associating canine retraction velocity to maxillary inter premolar width (MIPW) was :

Canine retraction velocity $_{mm/month}$ = 3.59 – (0.08 × MIPW $_{mm}$) [total sample] (Figure 7-B)

DISCUSSION:

4.1. Age , techniques , force magnitude *:*

Long-term studies that evaluating arch width changes associated with the growth stages found that there were minor or no changes at arch width after the age of 13 years for females and 16 years for males.[32,33] Bishara noted limited changes in arch width between 13 and 25 years old.[34] In current study the age range of sample was between 16 and 26 years, so we can consider that the arch width was constant in selected cases for this study. On the other hand, Mavreas et al in a systematic review of the previous studies (1990-2005), which examined the factors influencing the duration of treatment, found that age differences do not play a role in the duration of treatment, provided that patients are in the stage of permanent occlusion,[35] this is consistent with the results of Melo and Carneiro, where they found that the patient's lack of cooperation (removal of brackets, Missed appointments) had the

greatest impact on treatment time, while age had no significant effect on treatment duration. [36] All patients in current study had permanent dentition and exceeded the growing stage so the age differences among patients have a lack, or minor effect on speed of orthodontic movement.

Nickel-titanium spring have been chosen among many options are available for canine retraction with sliding techniques because it provides the recommended type of orthodontic forces for extraction space closer , which is continuous light forces without showing a rapid force termination (especially if activated every 21 days) as observe with elastomeric chains.[37,38]

The force which applied in this study is estimated at 150 gm selected based on the results of several studies. Boester and Johnston found that the force of 150 gm gave the highest rate of canine retraction.[39,40]

4.2. Rate of canine retraction:

The rate of canine retraction in the present study was 0.93±0.15 mm/month which was in harmony with keng et al who evaluated the rate of space closure by using NiTi T-loop (0.91±0.46 mm/month) and TMA T-loops (0.87±0.34 mm/month)[41] and Aboul-Ela et al who used NiTi closed coil spring with 150 g force (3.38 mm/4 month).[42] However other authors reported slower rates of canine retraction reaching (0.68 mm / month) as reported by Watanabe and Miyamoto [43] , and (0.775 mm/month) reported by Makhlouf et al. [44] This may be explained by differences in spring design in terms of (material or thickness of the wire that makes up the spring) as well as the difference in the study design, sample size. Otherwise, other authors reported faster rates of canine retraction reaching (1.04 mm / month) as reported by Nightingale and Jones [45], and (1.85 mm / month) reported by Bokas and Woods.[46] This difference may be attributed to their use of circular wire arches section.

4.3. gender effect :

The impact of gender on arch width was controversial, as studies differed across races, geographical regions, and age groups. This study indicated that the difference in arch width was not statistically significant between males and females groups where ($p > 0.05$).This result comes into agreement with Filho et al [47], Patel et al [48], and Papagiannis et al who claimed that no shape sexual dimorphism was found, nevertheless, there was statistically significant size difference between males and females.[49] Contrariwise other studies showed that male arch widths were significantly larger than those of females as reported by Forster et al [50] , and Asiry et al [51] .

This difference may return to that, previous studies did not control growth type or due to variance in age group and sample size.

As for the effect of gender on retraction velocity, we did not find significant statistical differences between males and females which was agreed with Dudic et al [52] , who indicated that sex had no influence on the amount of tooth movement. Moreover this result was in line with other studies which

founded that patient sex had no impact on the duration of treatment.[53,54,55]

4.4. Relationship between arch width and velocity of canine retraction:

In general, the rate of tooth movement is inversely related to bone density . [27] Frost proposed ((mechanistic)) theory which talked about muscles mechanical stress effects on bone density; so According to Frost , increased strength and activity of the masticatory muscles should result increase bone density.[28] patients with thicker masseter muscles had a wider maxillary dental arch.[56,57] Taken together, this indicates that tooth movement will be slower in patients with a wide dental arch than narrow dental arch , as cortical bone is thicker and bone mineral density higher in wide dental arch. This is in line with the results of current study, where we found passive correlation between maxillary arch width and velocity of tooth movement. The relationship was clearer with inter-premolar width than inter-canine width.

CONCLUSION:

- Gender had no impact on maxillary arch width or canine retraction velocity.
- There was weak correlation between velocity of canine retraction and inter-canine width, but strong correlation with inter-premolar width.
- The rate of canine retraction can be predicted through the equation depends on maxillary inter-premolar width ($R^2 = 0.835$) or palatal inter-premolar width ($R^2 = 0.700$).

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TABLES:

Table 1.Test of Normality of total sample			
	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
MICW	0.148	24	0.190
PICW	0.109	24	0.200*
MIPW	0.125	24	0.200*
PIPW	0.138	24	0.200*

Table 2.Test of Normality of males and females				
	Gender	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
MICW	Female	0.124	16	0.200*
	Male	0.232	8	0.200*
PICW	Female	0.135	16	0.200*
	Male	0.213	8	0.200*
MIPW	Female	0.142	16	0.200*
	Male	0.232	8	0.200*
PIPW	Female	0.103	16	0.200*
	Male	0.217	8	0.200*
velocity Average	Female	0.107	16	0.200*
	Male	0.128	8	0.200*

Table 3.Descriptive Statistics				
	Total sample (n=24) Mean± Std	females (n=16) Mean± Std	males (n=8) Mean± Std	P value
MICW	32.96±2.24	32.59±2.48	33.71±1.57	0.25
PICW	23.41±2.13	23.56±1.76	23.12±2.85	0.64
MIPW	34.48±1.91	34.13±1.74	35.18±2.16	0.215
PIPW	25.34±1.96	25.24±1.96	25.55±2.09	0.726
velocity Average	0.93±0.15	0.97±0.15	0.85±0.14	0.09

Table 4. person correlation coefficient between Palatal and maxillary arch width Measurements and Canine retraction velocity Average						
Palatal and maxillary arch width Measurements	Total sample (n=24)		females (n=16)		males (n=8)	
	Canine retraction velocity Average					
	R value	p value	R value	p value	R value	p value
MICW	-0.481*	0.009	-0.375	0.076	-0.69	0.029
PICW	-0.463*	0.011	-0.457	0.038	-0.698	0.027
MIPW	-0.924**	0.000	-0.956**	0.000	-0.883**	0.002
PIPW	-0.836**	0.000	-0.860**	0.000	-0.891**	0.002
*. Correlation is significant at the 0.05 level (2-tailed).						
**. Correlation is significant at the 0.01 level (2-tailed).						

Table 5 :								
	y= **dependent variable :** Average of Canine retraction velocity							
x= **independent variables**	Gender	Equation's Constants	Constants value	Std. Error	t	p value	R Square	Simple Linear Regression Equation [SLRE] ($\hat{y} = \alpha + b\,x$)
Maxillary inter premolar Width (MIPW)	males	b	2.9	0.445	6.516	0.001	0.779	$\hat{y} = 2.9 + -0.06 * x$
		α	-0.06	0.13	-4.604	0.004		
	females	b	3.91	.2430	15.13	.0000	0.913	$\hat{y} = 3.91 + -0.09 * x$
		α	-0.09	0.007	-12.15	.0000		
	Total sample	b	3.59	.2350	15.29	.0000	0.853	$\hat{y} = 3.59 + -0.08 * x$
		α	-0.08	0.007	-11.31	.0000		
Palatal inter premolar Width (PIPW)	males	b	2.41	0.325	7.416	0.000	0.793	$\hat{y} = 2.41 + -0.06 * x$
		α	-0.06	0.013	-4.8	0.003		
	females	b	2.71	0.277	9.788	.0000	0739	$\hat{y} = 2.71 + -0.07 * x$
		α	-0.07	0.011	-6.301	.0000		
	Total sample	b	2.65	0.241	11	.0000	0.700	$\hat{y} = 2.65 + -0.07 * x$
		α	-0.07	0.009	-7.158	.0000		

FIGURES:

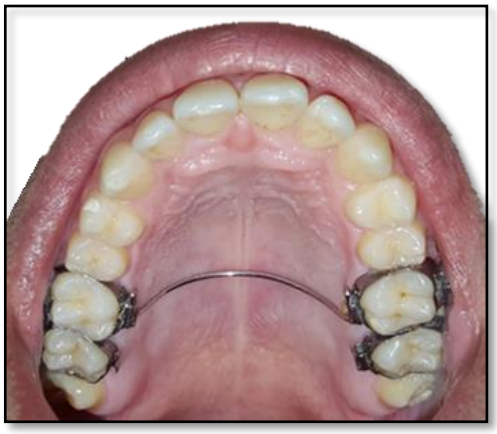

Figure 1: A picture showing the support system utilized, in the current study, where the second molars were banded , in addition to design of a transpalatal arch attached between the first molars on both sides

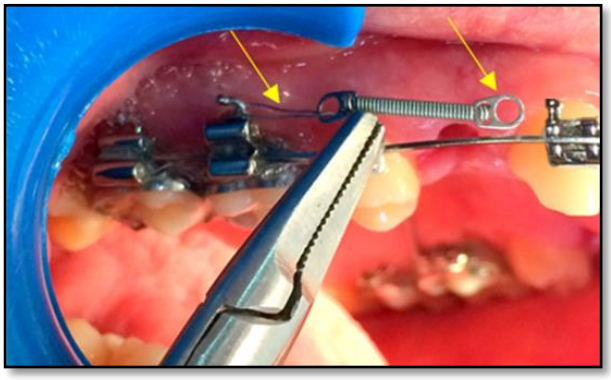

Figure 2: method of applying NiTi retraction spring, which was attached directly from the front ring to the hook of canine while connected with the hook of first molar's band with an adjustable ligation wire.

Figure 3: Activation NiTi closed coil spring by dynamometer to force of 150g.

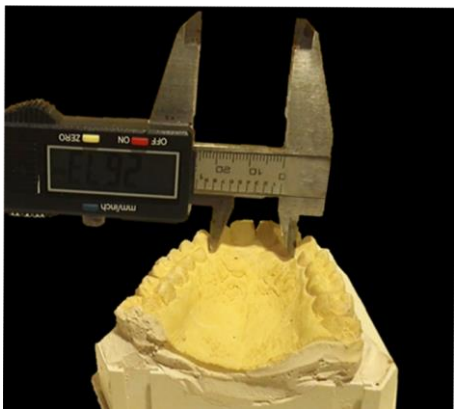

Figure 4: Measuring palatal intercanine width using digital caliper between inner palatal points on the gingival margin of upper canines.

Figure 5: reference's points for measuring palatal, maxillary (inter canine – inter premolar) width.

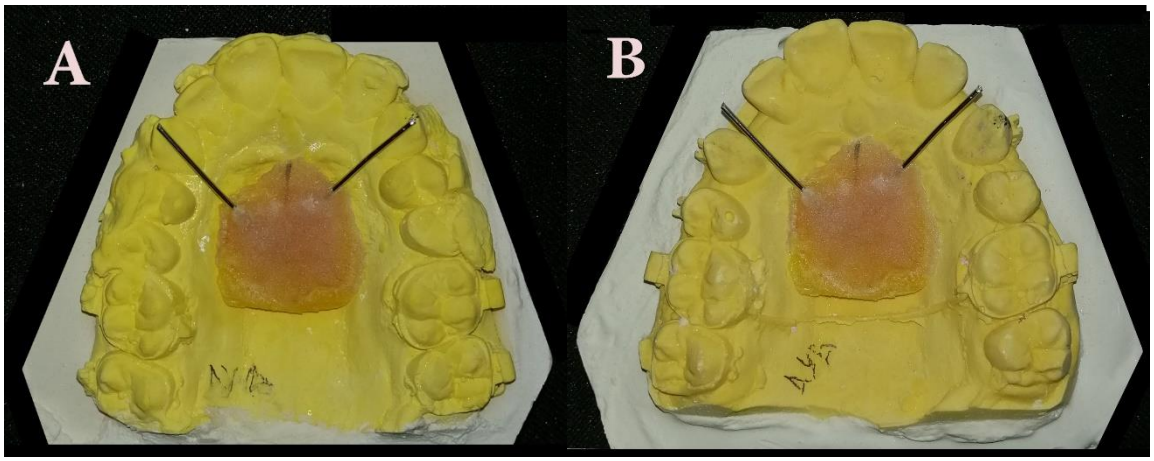

Figure 6 –a: Acrylic guide fabricated in the dental cast (T1). Figure 6 –b: The guide was transferred to T2 dental cast to measure the distance of canine retraction between the metal extent and canine tip in T2 cast.

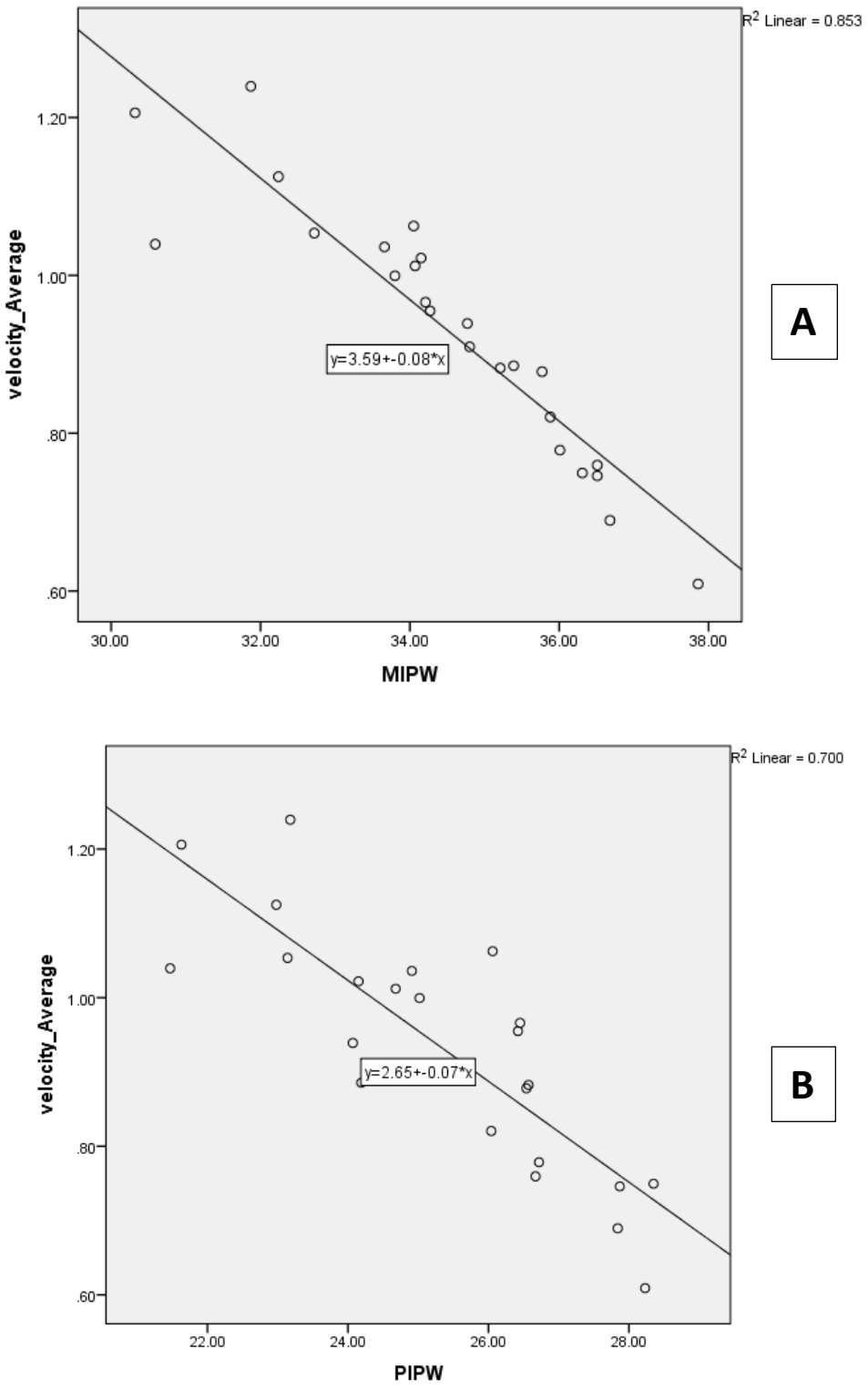

Figure 7 : (A) : The fitted line represents the correlation of canine retraction velocity with maxillary inter premolar width (R = -0.924 , R^2 = 0.853 , P < 0.001). (B)The fitted line represents the correlation of canine retraction velocity with paltal inter premolar width (R = -0.836, R^2 = 0.700, P < 0.001).