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The effect of passive self-ligating system on maxillary expansion comparing to conventional straight wire orthodontic appliance

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Tüm doktora öğretim hayatım boyunca hep yanımda olan, benimle her daim bilgilerini, tecrübelerini paylaşan, ne zaman başım sıkışsa yardımıma koşan bazen bir ağabey, bazen bir hoca olarak bana her zaman destek olan tez danışmanım ve çok değerli Sayın hocam Doç. Dr. Ulaş Öz'e;

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ÖZET

Rahmani, A. Kendinden bağlanan pasif sabit mekanikler ile yapılan ortodontik yavaş maksiller ekspansiyonun alveolar dokular üzerine olan etkilerinin geleneksel yöntemlerle karşılaştırmalı olarak incelenmesi. Yakın Doğu Üniversitesi Sağlık Bilimleri Enstitüsü Ağız, Ortodonti Programı, Doktora Tezi, Lefkoşa, 2019.

Kendinden bağlanan pasif braket sistemi, süper elastik teller ile daha hafif kuvvet ve daha az sürtünme prensiplerine dayanmaktadır. Bu araştırmanın amacı da kendinden bağlanan pasif braket sistemleri ile beraber süper elastik tellerin maksiller ark üzerindeki transversal etkilerini, geleneksel sabit mekanik teknikler ile karşılaştırmaktır.

Araştırmaya 40 birey dahil edilerek, rastgele iki gruba ayrılmıştır. Deney grubu: kendinden bağlanan pasif braket sistemi ve kontrol grubu ise geleneksel sabit mekanikler ile tedavi edilmiştir. Kendinden bağlanan pasif braket sistemi ile, (Damon Q 0.022-inç slot), 0.014, 0.016 inç yuvarlak, bakır nikel-titanyum (CuNiTi) ve 0.014×0.025, 0.018×0.025 inç (CuNiTi) köşeli ark tel dizisi takip edilerek ortodontik tedavileri gerçekleştirilmiştir. Kontrol grubu için Roth braket sistemi (0.018-inç slot) ile 0.014, 0.016 inç yuvarlak, nikel-titanium (NiTi) ve 0.016×0.016, 0.016×0.022 inç (NiTi) köşeli ark tel dizisi takip edilerek ortodontik tedavileri tamamlanmıştır. Araştırmada kullanılacak ölçümler için sadece deney grubunda her 6 haftada maksiller ark ölçüleri alınıp, alçı modeller elde edilmiştir. Transvers boyutlar, kaninler arası, premolarlar arası ve molarlar arası genişliğin dijital pergel kullanılarak ölçülmesi ile kaydedilmiştir.

İki grup karşılaştırıldığında, kaninler arası genişlik gruplar arasında anlamlı bir fark göstermezken, birinci premolar, ikinci premolar ve molarlar arası

genişliklerde önemli ölçüde farklılıklar ortaya çıkmıştır (p<0.005). Deney grubunda kaninler arası, birinci premolarlar arası, ikinci premolarlar arası ve molarlar arası genişliklerde, 0.014 (CuNiTi) ark telinin ekspansiyon etkisi, diğer ark tellerinden önemli ölçüde daha fazladır (p<0.005).

Maksiller kaninler arası, birinci premolarlar arası, ikinci premolarlar arası ve molarlar arası genişlik hem deney hem de kontrol grubunda artmıştır. 0.014 inç (CuNiTi) ark teli kendinden bağlanan pasif braket sistemi ile, birinci premolar, ikinci premolar ve molarlar arası genişlikte diğer tüm uygulamalardan daha fazla ekspansiyona sebep olmuştur.

ABSTRACT

Rahmani, A. Comparison the effect of passive self-ligating system on maxillary expansion comparing to conventional straight wire orthodontic appliance. Near East University, Institute of Health Sciences, Department of Orthodontics, Ph.D. Thesis, Nicosia, 2019.

Passive self-ligating system is based on a low friction and light forces; using less amount of force delivered by super elastic wires. The purpose of this study was to evaluate the effect of passive self-ligating system at transverse maxillary arch changes to the effects of conventional straight wire orthodontic appliance implemented on the control group by dental cast measurements.

Forty individuals included in this study, were divided randomly into two groups: experimental group passive self-ligating system and control group conventional straight wire orthodontic appliance. passive self-ligating system, Damon Q brackets, had bonded and an arch-wire sequence comprising of 0.014, 0.016-in round copper nickel-titanium (CuNiTi), 0.014×0.025, 0.018×0.025-in CuNiTi. The arch wires sequence for the control group was 0.014, 0.016-in round nickel-titanium (NiTi), 0.016×0.016, 0.016×0.022-in NiTi. Dental impressions were collected from the experimental subjects every 6 weeks in order to establish the measurements. The transversal dimensions were recorded with digital calipers from inter-canine width, inter-premolars widths and inter-molar width.

When the two groups were compared, the inter-canine width had no significant difference between the groups. But there were significant differences in the inter-first premolar, inter-second premolar and inter-molar widths. ($p<0.005$). The expansion effect of 0.014 CuNiTi wire in experimental group was significantly greater than the other arch wires ($p<0.005$).

Maxillary inter-canine, inter-premolars, and inter-molar widths increased with passive self-ligating system and traditional system. The width of inter-first premolar, inter-second premolar and inter-molar increased significantly with the use of the passive self-ligating system and the 0.014 CuNiTi arch wire is the most effective in a transversal dimensional changes.

CONTENTS

INDEX OF ICONS AND ABBREVIATIONS

°	Degree
ANS	Anterior nasal spine
CT	Computerized tomography
CSWA	Conventional Straight Wire Appliance
gr	Gram
kg	Kilogram
mm	Milimetre
Ni-Ti	Nikel Titanyum
Cu Ni-Ti	Copper Nikel Titanyum
PDL	Periodontal ligament
PSLS	Passive Self Ligating System
RPE	Rapid palatal expansion
SARPE	Surgically assisted rapid palatal expansion
SESA	Sonlu elemanlar stres analizi
SME	Slow maxillary expansion
TPA	Transpalatal arch
β	Beta

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1. INTRODUCTION

In order to initiate regular orthodontic tooth movement, application of a continuous force is a necessity. Orthodontic force can be applied by using arch-shaped super elastic wire alloys (Betts, et al. 1995). The substitution of copper for some nickel can maintain the shape-memory properties, which makes the wire more stable and less sensitive to exact proportion in the alloy (Birnie,2008, Chung and Font 2004).

NiTi arch-wire alloy consisting of 55% Nickel and 45% titanium possesses low elastic modules and high range (Gil, 1999). NiTi wires behave in a super elastic manner is suppressed by the amount of cold working, which may be caused by its stabilized martensitic structure (Malik, 2015). NiTi wires generally show two different phases when exposed to temperature variability, namely martensite and austenite (Santoro, et al. 2001).

These phases enable the arrangement of the molecular bases of the alloy. Martensite is the pliable, low-temperature state, and austenite is the stiffer, high-temperature state. The superelastic properties and thus the clinical performance of NiTi arch-wires are directly dependent on the transition temperatures of the alloy and the alloy's potential to undergo molecular changes after mechanical (deflection) or thermal (temperature) stimuli (Santoro, et al. 2001).

Therefore, if the addition of copper into the NiTi alloy allows for more consistency in the transition temperature of the produced wires, that should also be directly related to better consistency in clinical performance (Pandis, et al. 2009). It is well known that the amount of elements are extremely sensitive to the alloy ratio.

This can change the NiTi crystal matrix and therefore its transformation behavior (Pompei, et al. 2014 and Santoro, et al. 2001).

Likewise, there is a notable lack of evidence on the widely suggested combination of NiTi arch wires and passive self-ligating bracket systems or in other words, less frictional forces between the arch-wire and metal body as braces. Therefore, these brackets or Passive self-ligating system have been proposed to take full advantage of the properties of NiTi arch wires (Pandis, et al. 2009).

According to the passive self-ligating system theory, using less amount of force delivered by super elastic wires, the facial and lip musculature would limit anterior expansion and allow greater lateral expansion by restricting the buccal musculature (Birnie, 2008 and Damon, 1998). The passive self-ligating system brackets have been proposed as a technique to streamline clinical procedures and reduce overall treatment times. The theory suggests that this method of expansion could be used to alleviate large amounts of crowding and correct posterior cross-bites. The light forces would not occlude the blood vessels and would allow the formation of new bones (Gil, 1999 and Pompei, et al. 2014).

However, although there is such evidence indicating that the method of expansion with light forces can cause more physiologic forces on biologic tissues and advantages related to chair-side assistance, there is a lack of evidence suggesting that shorter treatment times can be achieved with the systems (Tecco, et al. 2009). It is accepted that the maxillary transverse arch changes, especially tipping movements of the posterior teeth, are not very stable (De-Clerck, et al. 2015 and Handelman, 1997). Besides, there are defined limits to the excessive incisor proclination and negative esthetic implications with it. Therefore, a bodily movement of maxillary posterior expansion instead incisor protrusion would be more acceptable application with contemporary present orthodontic treatment approaches.

To date, no study has evaluated and compared the effect of each CuNiTi wire implemented in passive self-ligating system at transverse maxillary arch changes to the effects of conventional straight wire orthodontic appliance implemented on the control group. The aim of this randomized controlled trail was therefore to quantify and to elaborate on each specific arch wires' effect on maxillary arch dimensional changes during orthodontic alignment by directly comparing a passive self-ligating system (Damon Q; Ormco, Orange, Calif), and conventional appliance system (Mini Master Series; American Orthodontics, Sheboygan, WI).

2. GENERAL INFORMATION

2.1 Force in Orthodontics

The force, tension and strain have a very important place in orthodontics. The forces and stresses that occur within the body from the very beginning of the individual's growth and development determine the morphology of the individual. The functional matrix theory, which Moss describes as “bones do not grow, but are grown up, defines that the pressure and tension of the surrounding tissues on bones play a role in the growth and development of the morphology of bones (Moss and Salentijn, 1969).

Our current knowledge shows that our genes are the main determinants of the growth and development process, while environmental factors are the agents that can affect growth and development. Functional maxillofacial orthopedics is based on the fact that cell activity can be altered by externally applied forces and development can be directed by these forces (Huiskes, 2000).

The relationship between form and function, created and maintained by mechanical forces in the bones, was established by Wolff's law. In his book published in 1892, Wolff mentioned that bone forms its architecture with external forces and has the capacity to adapt it. Wolff stated that the distribution of force, pressure and tension can change the shape and structure of the bone. Roux stated in 1881 that the ability of the trabecular architectural structure of the bone to adapt to the new functional needs are done through mechanical stimulus at the cellular level. Frost stated that osteoblasts and osteoclasts are under the control of stress caused by mechanical forces acting on local bone mass (mechanostatic theory). Generally, it is thought that the magnitude of the strain, the frequency of the applied force and the duration of the application affect the response of bone metabolism (Huiskes, 2000).

Different force analysis methods are used in order to see and understand how mechanical stimulus and forces acting on the bone are dispersed in the bone, where and to what intensity they have affect and where the stresses accumulate. These analysis methods are the methods developed and applied by engineering, applied mathematics and similar branches fields (Borchers and Reichart, 1983).

These methods are frequently used in the examination and understanding of biomechanical systems today and present us in an understandable manner the distributions of force that are difficult to understand in the field of orthodontics as well as in many other fields (Borchers and Reichart, 1983).

2.2 Bone Physiology

The displacement of teeth within the bone is a physiological result of catabolic and anabolic modelation. Orthodontic movement is dependent on the adaptive physiology of the periodontium according to bone modelation particularly in the periodontal ligament and subperiosteal compartments (Roberts et al., 2004).

In addition to subperiosteal bone modelation, facial orthopedics include sutural responses and temporomandibular adaptation. For the predictable manipulation of the stomatognathic system, a practical knowledge of bone physiology on the biomechanical response of the forces exerted on the function is required.

Frost, 1984 found the method of using tetracycline to examine bone mineralization in humans. Kinetic markers for living bone formed the physiological basis of bone histomorphometry. This method enabled the “turnover” measurement of mass, geometric distribution, surface adaptation and skeleton (McNamara, 2008, Parfitt et al., 1987).

Epker, 1980 examined Frost's concept of bone modelation and remodelation (Roberts et al., 2004). Roberts et al. 1996 applied these modern principles of bone physiology to the mechanisms of orthodontic and orthopedic treatments (Goodacre et al., 1997, McNamara, 2008, Roberts and Hartsfield, 1996).

2.3 Airway and Breathing

Dentists need to be more involved in managing airway development and craniofacial formation in growing children. Already, dentists are increasingly involved in managing the care and airways of patients of all ages with sleep-related breathing disorders, which are common and often associated with vascular complications such as arterial hypertension, coronary heart disease and stroke (Mattar et al, 2004).

Impaired respiration can cause craniofacial malformation, malocclusion and jaw deformity. A Research also shows that abnormal craniofacial formation can lead to airway obstruction, impaired respiration, impaired nasal breathing, chronic mouth breathing, sleep apnea and sleep disorders (Mohsenin, 2003).

It is certain that dysfunction of the human airway and breathing can cause malocclusion and skeletal deformation. Prolonged oral respiration often results in dental and skeletal malformation in growing children. Some of these negative changes included excessive molar eruption, clockwise rotation of the mandible, increased anterior vertical face height, retrognathia and open bite (Principato, 1991).

2.3.1 Airway Obstruction and Mouth Breathing

Airway obstruction can cause breathing disorders, and craniofacial deformation and malocclusion. Upper airway obstruction can be subtle in children, but it can have long term consequences including failure to thrive, behavioral disturbances, developmental delay and sleep disorders (Defabjanis et al,2002).

Airway obstruction can occur for a variety of reasons, including congenital abnormality, adenoid hypertrophy, tonsil hypertrophy, retruded maxilla and retruded mandible. Obesity increases any present airway obstruction as the tongue, uvula and throat tissues enlarge (Page D.C. et al, 2010).

Characteristics of mouth breathing and respiratory obstruction syndrome include mouth breathing at rest, hypertrophied tonsils or adenoids, open-bite, cross-bite, excessive anterior face height, incompetent lip posture, excessive appearance of the maxillary anterior teeth and gums, narrow external nares, “V” shaped palate and venous pooling under the eyes, (Enlow DH et al,1997).

A Research shows there is a significant association between nasal resistance and increased overjet, open bite, maxillary crowding, Angle Class II malocclusion and posterior cross-bite (Lopatiene K et al, 2002).

2.3.2 Early Diagnosis and Treatment

Early diagnosis of airway obstruction, obligate mouth breathing and malocclusion, with identification of the underlying causes, is essential to prevent worse orofacial growth abnormalities (Page D.C. et al, 2010).

Diagnosis of dental malocclusions and skeletal deformities associated with mouth breathing requires comprehensive and frequent orthodontic examinations. Routine early examination and diagnosis should begin at birth or soon after birth. All infants should be screened for craniofacial deformities that can affect airway form and function (Limme M.1993).

At the age of two and three, subtle dental signs of nasal obstruction and mouth breathing can be seen. Some of the clearest signs include open bite, posterior cross-bite and excessive overjet. (Page D.C. et al, 2010) In between ages three to twelve, early airway obstruction and craniofacial deformations too often magnify themselves to such an extent that time inversely relates to the ease and options for correction. To better recognize dento-skeletal dysmorphism caused by oral breathing. cephalometric analysis should be used to evaluate facial architecture when obligate mouth breathing is suspected (Page D.C. et al, 2010).

Early treatment to reduce airway obstruction, obligate mouth breathing, craniofacial deformity and malocclusion is essential to normalizing growth and development (Page D.C. et al, 2010). Early treatment maximizes the success of corrective orthodontics and orthopedics. Dentists and otolaryngo-logists provide unique treatments that can reduce airway obstruction and craniofacial deformity (Gao H et al,2003).

Dental orthodontic appliances have been shown to improve the sagittal dimensions of the upper airway in children. Dental rapid maxillary expansion has been proven to be a simple, conservative method of treating impaired nasal respiration in patients 4 years to 30 years, but the younger the patient the better the long term results (Gray LP et al,1975).

2.4 Diagnosis and Treatment of Maxillary Deficiency

In a normal occlusion, the upper jaw tooth arch is wider than the lower jaw tooth arch in all three directions of space and covers the mandibular tooth arch as a box lid (Lagravere et al., 2006). In maxillary deficiency, the transverse relationship between the upper tooth arch and the lower tooth arch is disrupted. However, there may be obliquity and unilateral or bilateral transverse closure in the posterior region (Lagravere et al., 2006). In other words, the vestibule tubercles of the upper posterior teeth come into contact with the central fossa of the lower posterior teeth while the teeth are in centric occlusion in posterior cross bite (Harrison and Ashby, 2001).

Clinically the posterior cross bite is the most common anomaly in transversal direction (Lagravere et al., 2006). Haas 1980, declared the skeletal or dental posterior cross bite is important for treatment planning. Although there is a deficiency in the apical bone base in skeletal cross bite, if there is buccal direction tipping of the crowns of the teeth, the apical bone base should be expanded by opening the media palatine suture (Haas, 1980). In dental origin, there is no abnormality in size and shape of the apical bone base, but tipping can be seen on one or more teeth locally and dental expansion is required (Proffit, 2000).

Functional cross bite is mostly seen in primary and mixed dentition. In the rest position, the lower jaw is in the normal position in the transversal direction (Proffit, 2000). As the upper jaw tooth arch is narrower than the lower jaw tooth arch, the lower jaw shifts towards lateral due to early contact resulting in posterior diagonal bite while it is shifting from the rest position to maximum intercuspidation (Proffit, 2000).

In skeletal cross bite, the lower jaw is in the same position at rest and maximum intercuspation. That is, in both cases there may be single or double sided cross bite without side-shifting of the lower jaw. Skeletal cross bite may also occur when the maxilla develops normally but the mandible develops excessively (Bishara and Staley, 1987, Haas, 1980, Proffit, 2000).

In dental cross bite, it is characterized in that the teeth bend only to the palatine without deficiency in the tooth arches, and may occur on a single tooth as well as including a group of teeth. Dental posterior cross bite often occurs due to local factors (Proffit, 2000).

2.4.1 Etiology of Maxillary Transversal Deficiency

1. Genetic
2. Bad habits
3. Iatrogenic
4. Muscular
5. Obstructive sleep apnea
6. Mouth breathing
7. Multifactorial
8. Syndromes (Klippel-Feil, Marfan, Treacher Collins, Apert Syndrome)
9. Non-syndromic palatal synostosis (Lagravere et al., 2006).

2.4.2 Maxillary Anatomy and Treatment Mechanism of Upper Jaw Deficiency

Media palatine suture plays a very important role in enlarging the upper jaw. In 1975, Melsen examined the development of suture in her studies on cadavers and reported that sutural union in humans is specific to humans only and that studies on animals cannot yield accurate results (Melsen, 1975).

In childhood, suture is seen as “Y” in coronal sections and joins with the help of vomer and palatinal process. In adolescence, the joint area between the three bones increases and takes the form of ‘T’. In adulthood, the ossification is completed and the suture becomes mutual interdigitation resulting in a mechanical interlock (Melsen, 1975). The structural development of suture is of particular importance for rapid upper jaw expansion and it is necessary to know in detail when these developmental changes occur in case surgical support is needed (Melsen, 1975).

If the upper tooth arch is narrower than the lower tooth arch in the transversal direction and the lateral cross bite is present, the upper tooth arch must be widened (Proffit and White, 2003). The expansion to be made differs depending on whether the stenosis is skeletal or dental.

1. Only the dental expansion is not sufficient and the orthopedic forces and mid-palatinal suture should be extended in the case that the upper palate is deep, apical bone base is narrow, in addition, if there is tipping to the buccal on the crowns of the posterior teeth and cross bite together with emerging compensation. Thus, the cross bite also improves by extending the apical bone base. (Bishara and Staley, 1987, Proffit and White, 2003).

2. The existing problem can be eliminated by simply expanding the tooth arch in cases where the apical bone base is wide and posterior teeth are tipping to the palatine, that is, the crowns approach the middle line and the roots move away from the middle line. The dental widening can be achieved by moving the upper teeth by tilting movement in buccal direction by moving apparatuses or fixed apparatuses (Bishara and Staley, 1987, Proffit and White, 2003).

2.4.3 Maxillary Expansion Methods

The main objective of the upper jaw expansion is to open the media palatine suture. Therefore, the methods used in upper jaw expansion are classified according to the suture opening rate (Bishara and Staley, 1987). Maxillary expansion can be done in four different ways;

2.4.3.1 Rapid Palatal Expansion (RPE)

Rapid palatal expansion is used as a routine orthopedic expansion method in the treatment of patients with narrow maxillary (Haas, 1980). McNamara listed RPE indications as follows:

- Correction of axial inclinations of posterior teeth,
- Posterior cross bites,
- Class III malocclusions,
- Class II malocclusions,
- Mobilization of maxillary sutural system,
- Preparation of functional jaw orthopedics or orthognathic surgery,
- Increasing the arch length,
- Reduction of nasal resistance,
- Expansion of the smile (McNamara, 2000).

RPE is also used to correct existing cross bite as well as maxillary stenosis, or to increase arch length to eliminate crowding (Lamparski et al. 2003). The aim of this treatment protocol is to reduce the amount of orthodontic tooth movements by applying orthopedic forces to teeth and alveolar structures and increase the amount of orthopedic movement (Bishara and Staley, 1987, Timms, 1980). Bell reported that orthopedic opening will occur in the maxillary segments when the amount of force applied is greater than the bioelastic force that holds the suturas together (McNamara, 2000).

Figure 1 Rapid palatal expansion appliance.

The amount of force applied for rapid palatal expansion is 0.9-4.5 kg. and the expansion is 3 mm or more per week (Isaacson et al., 1964, Isaacson and Ingram, 1964, Zimring and Isaacson, 1965). The most controversial part of the rapid maxillary expansion was the rate of expansion, and various screw turning protocols have been proposed in the literature (Haas 1980, Zimring and Isaacson 1965).

Haas 1980, reported that he implemented the turning protocol of the expansion screw 4 quarters turn in 5 minutes intervals within 15 minutes on the first day and implemented the turning protocol 2 quarters turn in the following days (Haas, 1980). Zimring and Isaacson stated that the expansion obtained by making 2 quarters turn a day until the sutura opens (4-5 days in average) and the expansion obtained by making 1 quarter turn following the opening of the sutura would be more balanced in young individuals.

As for the elderly individuals, they proposed the turning program of 2 quarter turn on the first two days, and the turning program of 1 quarter turn per day until the next 5^{th} or 7^{th} day, that is, until the sutura opens (Zimring and Isaacson, 1965) and Ceylan et al. (Ceylan et al., 1996) reported that they performed the screw turning program of 3 quarter turn a day until the sutura opens and performed the screw turning program of 2 quarter turn a day after the sutura opens. The method generally recommended for rapid upper jaw expansion with different apparatus is turning the screw 2 quarter turn a day, in the morning and evening (Haas, 1980, Lima et al., 2004, McNamara, 2000, Oliveira et al., 2004, Timms, 1980).

In these studies, the effect of RPE on maxilla and mandible was examined. Filho et al. argued that the maxilla did not move in the sagittal plane as a result of RPE, and that it performed downward-backward rotation movement in the palatal plane (Filho et al., 2006).

In his study, Haas found that the maxilla was moving down-forward as a result of the expansion done with the banded Haas type expansion apparatus (Haas, 1980). Akkaya et al. reported that the maxilla moved forward and the mandible moved backward in their studies using glued RPE device (Akkaya et al., 1999).

It was reported that the points creating resistance in lateral extension of the midface during palatal expansion are apertura priformis in the front, zygomatic point of junction on the side, pterygoid junction at the back and sutura palatina media in the middle (Akkaya et al., 1998).

Apparatus used for rapid palatal expansion are as follows:

• **The Haas Appliance:** This apparatus, introduced by Andrew Haas in 1961, consists of soldering thick wires coming out of the acrylic plate to the bands placed in the upper first premolar and molars and a screw placed in the middle of the plate (Biederman, 1973).

• **Cap Splint Appliance:** This appliance, introduced by Timms in 1981, consists of a chrome cobalt cast plate covering the occlusal and incisal edges of all the teeth and a screw except the upper centrals. This apparatus was modified over time and instead of casting it was made from acrylic plate (Timms, 1981).

• **Rigid Acrylic Bonded Maxillary Expansion Appliance:** This appliance, which is easy to make clinically and apply to the patient, is a tissue-supported apparatus which consists of a screw which is placed midpalatal plane between premolar and which is inserted into the rigid acrylic, which covers the buccal, occlusal and palatinal faces of the posterior teeth and only the palatinal faces of the anterior teeth and the palatinal part of the maxilla completely. It has been reported that more durable results have been acquired with this apparatus by considering that it causes less tipping and more skeletal expansion on teeth thanks to its rigid structure (Howe R.P. 1982).

• **Hyrax Appliance:** This tooth-supported appliance consisting of a screw soldered solely to premolar and molar bands without acrylic support was introduced as "Hygienic rapid expander" by Biederman and determined to be more hygienic than Haas appliance (Fig 2),(Biederman, 1973).

• **Hyrax Modifications:** Modifications of the Hyrax appliance by adding acrylic to the occlusal surfaces of the posterior teeth or other surfaces in addition to that have been developed. The addition of these acrylic supports has been reported to have a number of advantages, particularly vertical direction control (Akkaya et al., 1998, Akkaya et al., 1999, Howe, 1982).

• **Smart Screws:** It was introduced by Wichelhaus et al. as Nickel Titanium (NiTi) rapid maxillary expander screw (Smart Screw) in 2004 and has NiTi open spiral (coin) springs in the screw chamber for continuous force application (Akkaya et al., 1999, Howe, 1982).

2.4.3.2 Semi-Rapid Maxillary Expansion

Mew expanded 1-1.5 mm weekly with a screwed removable appliance with acrylic base of the clasps he named “bioblock” and said that this amount of expansion is more physiological than slow and fast upper jaw expansion (Mew, 1983). This expansion is more physiological than slow and fast maxillary jaw expansion, he said. Mew, in his another study, called the upper jaw expansion process of 1 mm. weekly he made with the same appliance as a semi-fast upper jaw expansion (Mew, 1983).

In many studies, attention has been directed to the relapse tendency of RPE (Bishara and Staley, 1987). The researchers associated the rapid stability of upper jaw expansion with the factors such as the length of the retention period and patient cooperation in the retention process, degree of maxillary stenosis, the response of mid-palatal suture and surrounding tissues, patient age, amount of expansion, and adaptation of soft tissues to new positions (Bishara and Staley, 1987).

Bishara and Staley, 1987, indicated that the slower application of maxillary expansion will lead to less physiological force to the surrounding tissues and the surrounding tissues will better adapt to the new situation with the repair process during this time period and they reported that the changes that occurred after RPE procedure are maintained after 3 years of reinforcement (Bishara and Staley, 1987).

Appliance used for semi-fast upper jaw expansion can be listed as rigid acrylic bonded maxillary expander apparatus, quad-helix and minne expander.

2.4.3.3 Slow Maxillary Expansion

In slow upper jaw expansion, the treatment is performed between 2-6 months on average and the force between 450-900 gr is applied for expansion (Bishara and Staley, 1987, Lagravere et al., 2005).

Mew, 1997, argued that the expansion of 1/3 mm per week is aimed to be acquired with slow upper jaw expansion (Mew, 1997). Bell, 1982, found that 900 g force applied with slow maxillary expansion can provide early sutural separation at early ages, but this effect decreases with increasing age, moreover, relapse will be less as the tissue integrity does not deteriorate during repositioning and remodeling of the upper jaw (Bell, 1982).

In slow upper jaw expansion, the amount of orthopedic movement is low and the amount of orthodontic movement is high since the resistance of the suturas is not broken by 900 gr of force applied (Bishara and Staley, 1987, Lagravere et al., 2005). In addition to this, sutural opening is mentioned on the upper jaw with an orthopedic effect even when slow upper jaw expansion is done, especially during milk or mixed dentition periods (Hicks, 1978).

The mechanics used in slow maxillary expansion are:

- **Removable Plaques:** The removable plaques as the movable appliance that attach to the teeth with different types of clasps and apply force by means of a screw located in the acrylic base (Chenin D.A. 2003)

• **Quad-Helix Appliance:** The amount of front and rear expansion can be regulated and the rotations in molars can be corrected through helical twisted rustproof steel wires of 0.9 mm. diameter which apply average 400 gr. force. While orthopedic effect is achieved by separation of palatine suture media in early ages with mixed dentition, there are also authors who state that it causes orthodontic effect by causing bending of alveoli and teeth in adults (Lagravere et al., 2005, Donohue et al., 2004).

The "Porter appliance and the "W" appliance, which apply force by means of a thick wire as the quad-helix can be considered as modifications of the quad-helix appliance (Harberson and Myers, 1987).

• **Expansion Appliance Including Magnets:** This appliance was used by Darendeliler et al. on the patient in the form of appliances that apply force of 250-500 gr (Darendeliler et al., 1994).

2.4.3.4 Surgically Assisted Rapid Palatal Expansion (SARPE)

Surgical assisted rapid palatal expansion may be considered as part of the treatment plan in adult patients with maxillary transversal stenosis. The RPE procedure to be performed in adult patients without surgical support is avoided because the degree of ossification, which changes and completes in the maxillary bones, adjacent bones and media palatine suture with increasing age, limits the orthopedic movement (Melsen, 1975, Persson and Thilander, 1977). In addition, studies have reported that some limitations and complications arise when non-surgical RPE is applied on adults;

- Pain in response to expansion due to anatomic resistance,
- Recurrence
- Limited and only dental base expansion,
- Bending of the upper back teeth to the buccal,
- Compression of periodontal membrane,
- Buccal root resorption,
- Alveolar bone deformation,
- Palatal bone necrosis (Cureton and Cuenin, 1999, Karaman et al., 2001).

Surgical assisted expansion is recommended due to complications seen with RPE treatment with increasing age. Surgically, two interventions can be performed; rapid palatal expansion done with the help of surgery and repose of the maxilla in a larger position in the transversal direction during LeFort osteotomy in order to allow repositioning of the maxillary segments individually in a larger transverse dimension (Kutin and Hawes, 1969).

The indications for the administration of SARPE to the skeletally mature patients are as follows;

- Breaking resistance in the area of sutures that fail with RPE treatment.
- Increasing the arch length and eliminating crowding when the withdrawal treatment is not indicated.
- Eliminating the buccal corridors that occur during the smile.
- Correcting posterior cross bite and increasing maxillary arch width.

- Increasing maxillary arch width prior to additional orthognathic surgery planned and minimizing any stabilization problems (Woods et al., 1997; Koudstaal et al., 2005).

The diagnosis of maxillary transversal insufficiency in the patient, for whom SARPE administration is evaluated, is made with clinical evaluation, model analysis, occlusal radiographs and radiographic evaluation (Suri & Taneja, 2008). Today, the most advanced technique is 3D imaging. With these methods, it is possible to obtain detailed and precise information about hard tissues such as teeth, bones and suturas while evaluating both soft tissue thicknesses, their locations and relationships with each other (Suri and Taneja, 2008, Macchi et al., 2006).

In their study in 1984, Lehman et al. argue that occlusal graphs are necessary diagnostic tools for detecting the ossification of sutura palatina media. However, it is disadvantageous that there is not enough information about the superposition of the other bone structures and the posterior region. Monitoring the posterior region has gained importance after the scientific studies indicating that the greatest bite is in the posterior region (Suri and Taneja, 2008).

In 1995, Betts et al. reported that posteroanterior radiographs are the most convenient and easiest method to diagnose transverse skeletal mismatches. In this method, however, there are studies indicating that the examination of skeletal points that are quite far from dentition and apical bone base will not be very consistent (Suri and Taneja, 2008).

Another factor that should be taken into consideration when performing surgical assisted expansion is age. It would be appropriate to make a planning according to the skeletal development age of the person instead of his/her chronological age (Suri and Taneja, 2008).

2.5 Expansion with Arch Wires

It was found in the studies that when low forces are applied with brackets and arch wires, alveolar bone expansion is achieved without causing problems (Bassarelli et al., 2005, Dalstra and Melsen, 2004, Handelman, 1997). Additionally, the therapeutic effect of unpulled fixed orthodontic treatment has been reported to be arch development.

It has been reported in many studies that dentoalveolar expansion caused by the efficacy of fixed treatment on patients who receive orthodontic treatment leads to changes in arch form and size (BeGole et al., 1998, Kim and Gianelly, 2003). During the levelling process, visible changes occur in the arch form in the transversal direction at intercanine, interpremolar and intermolar distance. It is reported that the increase in intercanine distance is between 0.55-2.13 mm, the increase in interpremolar distance is upto 4.94 mm and the width in intermolar distance is between 1.53- 2.96 mm during leveling in unpulled treatments (BeGole et al., 1998, Kim and Gianelly, 2003). It has been reported that the increase occurred in the arch perimeter or arch length is 0.2-1.8 mm (Isik et al, 2005).

Due to the fact that the arch expansion is conventionally hard and rigid, it is believed to be supplied with steel thick round or steel cornered wire because it is more effective in providing buccal movement of posterior teeth. It has been reported that Copper Nickel Titanium arch wires, which are flexible and wide form, provide arch expansion in transverse direction (Damon, 1998a, Damon, 1998b, Fortini et al., 2005).

2.6 Orthodontic Fixed Therapy Mechanics

2.6.1 Historical Development of Fixed Treatment Mechanics

The first fixed orthodontic treatment mechanics in history was introduced by Pierre Fauchard in 1728. This mechanic which is called ‘Bandeau’ is a simple expansion apparatus with a horseshoe-shaped metal strip and ligatures with holes on it. It is based on the principle that the ligatures passed through the holes are connected to the curved teeth and activated at certain intervals by moving the teeth (Wahl, 2005a).

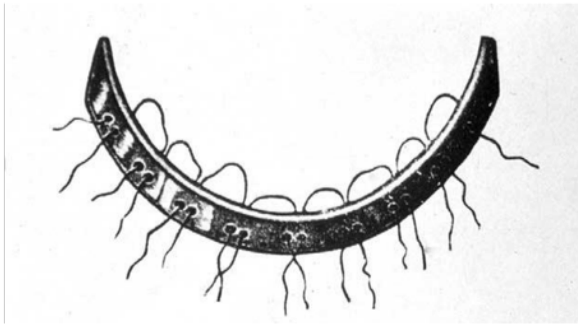

Figure 2 Bandeau System (Asbell M.B. 1990).

Fauchard's apparatus was reinterpreted by Etienne Bourdet. Bourdet was on the books as being the first to propose the elimination of crowding by serial and premolar extraction in orthodontics. Furthermore, lingual orthodontics was first performed by Bourdet by applying mechanics from lingual to expand the arch and lingual arches, expansion apparatus and screws are still in use today (Asbell M.B. 1990).

However, although Fauchard's methods were reinterpreted afterwards, the idea of a fixed orthodontic apparatus remained in the background for a long time due to the lack of a method for fixing the apparatus to the teeth. Later Schange in 1841, introduced the screw band and this idea gained popularity again. With the introduction of the screw mechanism developed Dwinelle in 1849 for the purpose of moving the teeth, the popularity of fixed orthodontic treatment mechanics increased and led to the emergence of many different band and screw fixed orthodontic apparatus (steiner C. 1933).

Kingsley's (1861) introduction of extraoral forces and anchorage, and in the same year, Coffin's attempts to correct teeth using the flexible piano wire and the ability to bond the bands to the teeth with cements found by Magill in 1870 were the other important steps in the development of fixed orthodontic apparatus (Asbell M.B. 1990, Wahl 2005a, Wahl, 2005b).

2.6.1.1 Angle System

Angle, who closely followed the developments in orthodontic mechanics, used many different apparatus from 1878 to 1887, when he introduced his first system, and after the disappointment he experienced with these apparatus, he put forward five principles that should be in an ideal orthodontic apparatus before creating his own system;

1. Simplicity; can push, pull and rotate teeth,
2. Stability; can be fixed to the tooth surface,
3. Efficiency; can work according to Newton's physics and anchorage rules,
4. Should be small and polite; should be compatible with the tissues,
5. Should be aesthetic (Phulari, 2013).

In the light of these principles, Angle 1887, introduced and developed the Angle system, the screw tapes that can be glued around the teeth by soldering screws and he developed a fixed orthodontic system that can apply rotation force to the teeth for the first time by passing Coffin's wire through the sensitive metal tubes that it attaches to the tapes (Fig 3) (Phulari, 2013).

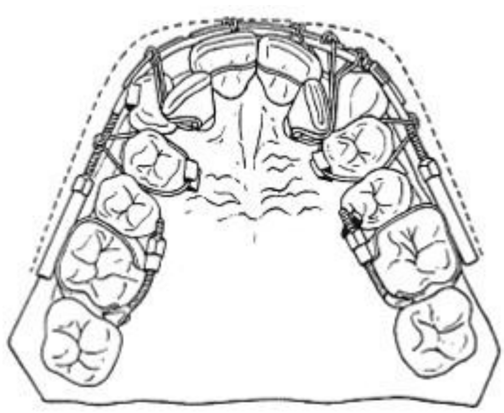

Figure 3 Angle System (Angle 1887).

Angle first introduced “the E-arch” apparatus in 1907, “the Pin and Tube” apparatus in 1912 and the “the Ribbon Arch” apparatus in 1915 before the Edgewise apparatus, which was introduced in 1928 (Phulari, 2013).

2.6.1.2 Edgewise Appliance

In 1928, Angle introduced the Edgewise Appliance including metal brackets, which can be more effective in moving the teeth one by one, by taking advantage of the experiences from the apparatuses he developed earlier (Kusy, 2002, Phulari, 2013).

Edgewise term means to place angular arch wires in brackets with horizontal slots. With this new apparatus, ease of application and the ability to have an effective root movement was revealed. While developing the Edgewise apparatus, Angle was working with his young student Charles Tweed at the time, and that apparatus would shape the basic principles of all orthodontic bracket systems used until today (Kusy, 2002, Phulari, 2013).

The Edgewise brackets had angular slots positioned in the labial where angular wires could be applied. Thus, controlled tooth movement was achieved in all three directions of space during treatment. The three-walled brackets, which could be positioned horizontally and which have four wings, two of them are on occlusal and two of them are on gingival, allowed more accurate and controlled tooth movement by increasing contact surface with the arch wire (Kusy, 2002, Phulari, 2013).

The reason why Edgewise technique is still valid today is due to the fact that controlled movement can be made not only in the mesial-distal direction but in three directions of space and has root (torque) movements in the vestibular-lingual direction (Sebance J, 1984).

2.6.1.3 Straight Wire Technique

In standard edgewise technique, in order to obtain a momentary effect (tie back, anti-rotation, toe-in, anti-type, torque, etc.) on the tooth, the wire must be bent and actively placed in the flat-standing bracket. In the straight-wire system, the straight wire brackets carrying angle values on them such as angulation and torque are used in response to bends to move teeth in standard edgewise technique and when the straight wire is placed in the already angled brackets, a moment occurs on the tooth and the tooth movement begins immediately.

If the slots of the brackets are angled, this provides the desired mesial-distal tooth slopes. When the brackets are angled for this purpose in other fixed apparatus techniques, the bracket contacts the tooth surface at two points, resulting in unwanted tipping movements of the teeth. Since the angulation is given to the bracket slot in this system, the bracket can be applied with a full surface contact on the tooth (Kusy, 2002, Phulari, 2013).

Although the bracket bases are contoured only in the horizontal direction in the angular wire (edgewise) technique, the bracket bases are positioned both horizontally and vertically in the straight wire technique ensuring the bracket adapt to the tooth surface optimally (Schwaninger, 1978).

The distance between the bracket bases and the slot bases is different for each tooth, which eliminates the required first order bends because of the difference in thickness in the labio-lingual direction and their position in an ideal tooth array. In this technique, angulation, inclination and first order twist requirements with brackets are provided from the very beginning, making the dental movements more controlled, shortening the time and treatment time at the bedside and increasing the durability of treatment results (Schwaninger, 1978 and Magness, 1978).

2.6.2 Brackets Used for Fixed Orthodontic Treatment

In fixed orthodontic apparatuses, the most important element that transmits the force to the tooth is undoubtedly the brackets. The production of orthodontic brackets is a complex process involving a large number of raw materials (metal alloys, ceramics, plastics), various designs and different methods. There are various kinds of brackets on the market that differ in wing designs, slot angles and dimensions (Nanda R. and Tosun Y.S., 2010).

- **Stainless Steel Brackets**

Angle used the gold prototype of the edgewise brackets for the first time. Brusse in 1933, introduced the first stainless steel fixed apparatus system. Stainless steel then replaced gold, because it is harder and more durable than gold, can be produced in smaller sizes and is more aesthetic due to the reduced dimensions. Its friction property is satisfactory enough to form today's standards (Matasa, C.G., 2005).

Stainless steel brackets are usually made of stainless steel including 18% chromium and 8% nickel. Stainless steel brackets are the most commonly used brackets because they are quite durable, hygienic and inexpensive. Its main disadvantage is the release of nickel and chromium; therefore, brackets made of other materials are preferred for people with nickel allergy (Matasa, C.G., 2005).

- **Titanium Brackets**

In individuals with nickel sensitivity, stainless steel brackets can cause an allergic reaction. Therefore, titanium alloy brackets which are resistant to corrosion and have high histocompatibility have been produced as an alternative to stainless steel brackets (Hamdan and Rock, 2008).

- **Plastic Brackets**

Plastic brackets began to be produced in the 1970s by injection molding technique from polymer-polycarbonate material as a result of efforts to produce brackets from different aesthetic materials in order to meet the aesthetic demand of adult patients. However, these brackets have been reported to create problems such as discoloration, cracking, deforming and causing odor (Reicheneder et al., 2007).

- **Ceramic Brackets**

Ceramics preferred for the production of brackets since it is solid, durable, aesthetic, hygienic, tissue-friendly and colour-resistant material. Although it is widely used, it has negative properties, such as being brittle, causing high frictional force, formation of enamel fracture during wear and dismantling of the opposite tooth contacting the bracket.

2.6.3 Wire Alloys Used in Fixed Orthodontic Treatment

Wires consisting of gold, stainless steel, chromium-cobalt, titanium molybdenum (beta titanium), fiber optic-plastic, composite and nickel titanium alloys are used in the orthodontic treatment (Brantley, 2002).

- **Gold Alloys**

Gold alloys are the first wire alloys used in orthodontic treatment. Platinum, chromium and palladium were added to this metal which is soft alone. However, it is not used today due to its high cost compared to other wire alloys (Burstone and Goldberg, 1980, Proffit, and Fields, 2000).

- **Stainless Steel Alloys**

Stainless steel alloys have played an important role in orthodontic practice since the 1950s. The low cost of these wires as well as their formability and flexibility let them keep their popularity. Steel alloys used in orthodontic treatment contain 70-75% iron, 18% chromium, 8% nickel and 0.2% carbon. While chromium alloy provides corrosion resistance, nickel provides stability and carbon gives hardness. Thanks to their chromium and nickel content, these alloys are also called as 18-8 (Brantley, 2002).

- **Chromium-Cobalt Alloys**

Chromium-cobalt alloy wires were developed in the 1950s and these wires contain 40% cobalt, 20% chromium, 15% nickel, 7% molybdenum and 15-20% iron. It is softer than steel wires. It can be easily shaped in soft state, its hardness and the force applied by it increases when heat treated (Kusy, 1997).

- **Titanium Molybdenum (Beta Titanium) Alloys**

Beta (β) titanium wires began to be used in orthodontics by Burstone and Goldberg in 1980s. It contains 77.8% titanium, 11.3% molybdenum, 7% zirconium and 4% tin in its composition. These wires are 40% more elastic than steel wires, and their operating range is also wide because their return spring values are higher than other wires. The zirconium and tin in it increase the hardness and strength of wire. The absence of nickel in the content of this wire provides corrosion resistance and biological compatibility (Burstone and Goldberg, 1980).

- **Fiber Optic - Plastic Alloys**

Fiber optic-plastic wires are transparent wires which were developed for aesthetic purposes and released to the market in the early 90s under the name of Optiflex for the first time. These wires are formed by coating an adhesive and a nylon layer around an internal structure of fiber optic glass with a diameter of 0.008'' (Proffit, and Fields, 2000).

- **Nickel Titanium Alloys**

Nickel Titanium alloy wires were first found by Buehler in 1968, but their use and development in orthodontics was carried out by Andreasen. The name Nitinol in its original form consists of Nickel Titanium and the initials of the navy laboratory in the United States (Naval Ordonance Laboratory), where it was discovered in the scope of studies related to space research (Brantley, 2002, s. 77-104). Ni-Ti alloys contain 52% nickel, 45% titanium, and 3% cobalt in their contents (Burstone and Goldberg, 1980).

The production of Ni-Ti wires is a very complicated process. Since there is a large difference between the melting temperatures of these two metals, melting process is usually carried out under vacuum. In order to achieve a homogeneous structure of the alloy, it must often be melted repeatedly. Powders are then obtained from this alloy. The alloy is converted into wire through hot isostatic pressure process. The cavities and cracks formed at the points where the powders do not mix well are eliminated by applying crushing and drawing processes and the wire is put into final form (Prososki et al., 1991).

It is distinguished from other wires by its high elasticity, shape memory and resistance to plastic deformation. The plastic deformation property is time-dependent, so plastic may deform as a result of the time it remains in the mouth. The shape memory, on the other hand, is the ability to remember and return to its initial shape when heated over a certain transition temperature while it can be formed at low temperatures. There is an allergy risk of nickel ions in Ni-Ti alloys by releasing (Kusy, 1997).

2.6.4 Connecting Orthodontic Arch Wires into Bracket

Stainless steel ligatures and elastomeric modules are frequently used for ligation in orthodontic practice. The thickness of stainless steel ligatures can be between 0.008 - 0.0014’’ diameters. While steel ligatures provide a fixed and stable ligation between the arch wire and the bracket, they cause significant friction in the mesialization and distalization mechanisms.

Elastic ligatures, on the other hand, are rough or flat in different diameters and thicknesses. In orthodontic practice, it is possible to talk about the use of two basic elastic materials, one of which is natural rubber and the other is synthetic polymers. The intra-jaw and inter-jaw elastics used for therapeutic purposes are mostly latex elastics of natural origin. Synthetic polymers are chain elastics, elastic yarns or elastic ligatures (elastomeric modules) developed from petrochemicals in the 1920s and used frequently in orthodontic practice today (Baty et al., 1994).

2.7 Passive Self Ligating

Passive self-ligating system is a new expansion method. This new method, created by Damon DH. He is used a principles from the "Straight-Wire appliance" and involves the use of super-elastic Nickel-Titanium (NiTi) wires together with passive self-ligating brackets (Fig 4). He theorizes that the light force produced by the arch wire will not overpower the lip musculature providing the opportunity for large amounts of posterior expansion. He believes that the orbicularis oris and mentalis muscles will create a "lip bumper effect", thus preventing the proclination of the anterior teeth. As anterior movements of the teeth are restricted, the posterior segments expand (Damon, 1990).

Figure 4 Pasive self-ligating braket system.

The posterior expansion will allow the tongue to lift and move forward, creating a new equilibrium with the cheeks and lips. This expansion creates arch perimeter to accommodate the teeth. The mechanics of the passive self-ligating bracket system make the expansion possible. The mechanics are a combination of super-elastic NiTi wires, passive self-ligating brackets, and bracket position (Damon, 2005).

Super-elastic NiTi wires play a major role in the mechanics involved with the passive self-ligating bracket system. Damon advocates the use of super-elastic Niti wires for the initial "arch developing" stages of treatment. The super-elastic NiTi wires have the advantage of being able to be greatly distorted but while retaining their resiliency.

The wires will return to their original shape if enough time is allowed and is not permanently deformated. This advantage allows NiTi wires to be used as the initial wires in severely crowded cases. Another advantage of NiTi wires is that they are able to exert a light continuous force (Santoro M et al., 2001).

Another important component in the mechanics of the passive self-ligating bracket system is the characteristics, passive ligation refers to the slide or clipping mechanism used to maintain the wire in the bracket. Passive self-ligation means that the clip or slide does not actively seat the wire in the bracket.

Passive self-ligating bracket system is relatively new, one theory that has been investigated is that the passive self-ligating bracket system can produce inter-molar expansion without excessive inter-canine expansion. Pandis evaluated the alleviation of mandibular crowding on non-extraction patients that were treated with the passive self-ligating bracket system and a conventional straight-wire appliance. They found that conventional brackets and the Passive self-ligating brackets produced similar amounts of inter-canine expansion, but the passive self-ligating system produced more inter-molar expansion (Pandis *et al*., 2007).

2.7.1 Passive Self Ligating Philosophy

The passive self-ligation system that was originally introduced in 1994.full description of the passive self-ligation philosophy and treatment techniques are given by Damon. The passive self-ligation is based on the principle of using just enough force to initiate tooth movement.

The underlying principle behind the threshold force is that it must be low enough to prevent occluding the blood vessels in the periodontal membrane to allow the cells and the necessary biochemical messengers to be transported to the site where bone resorption and apposition will occur and thus permit tooth movement (Damon, 2005).

A passive self-ligation mechanism has the lowest frictional resistance of any ligation system. The forces generated by the arch wire are transmitted directly to the teeth and supporting structures without absorption or transformation by the ligature system (Damon, 2005).

2.7.2 Comparison with Conventional Edgewise System

Comparison the passive self-ligating system with conventional edgewise system, it is suggested that the use of passive self-ligation results in a significant reduction in:

- Use of intraoral expansion auxiliaries such as quadhelices or W-springs because the force of the archwire is not transformed or absorbed by the ligatures and the necessary expansion can be achieved by the force of the archwires (Srinivas, 2008).

- Need for extractions to facilitate orthodontic mechanics because alignment is not hindered by frictional resistance from ligatures and can therefore largely expansion achieved with small diameter copper nickel titanium arch wires.

- Tooth alignment therefore places minimal stress on the periodontium as it occurs and so the possibility of iatrogenic damage to the periodontium is reduced.

- Alignment and space closure can be achieved more quickly with self-ligating brackets system due to reduced friction, then treatment times might be shorter (Harradine,2001).

Passive edgewise self-ligation system provides three key features: Very low levels of static and dynamic friction, Rigid ligation due to the positive closure of the slot by the gate or slide, and Control of tooth position because there is an edgewise slot of adequate width and depth (Thorstenson et al,2002).

Passive self-ligating brackets have been advanced as a technique to streamline clinical procedures and reduce overall treatment time. However, although there is limited evidence proving clinical time saving and advantages relating to inventory requirements and chair-side assistance, there is a lack of evidence suggesting shorter treatment times with these systems (Johansson K et al,2012).

2.7.3 Treatment Plan

Treatment plan should be based on etiology, and careful thought about why the presenting malocclusion occurred, and they should take into the individual's facial pattern and appearance, And the growth, maturation, and aging of the patient's face including the influence of genetic inheritance on their future facial appearance.

Clinician should consider the lip position and lip posture, tongue behavior, muscle tone, and mode of breathing. Patients with good oral health, excellent oral hygiene, and a normal gingival biotype seem to obtain better orthodontic results than those with compromised oral health.

Dental factors include space analysis, arch width analysis, and the inclination of labial and buccal segment teeth. In several years ago, tooth extraction was necessary to obtain dental alignment because of the relatively unsophisticated appliances available. Technically, it is often no longer necessary, except in a few cases, to extract teeth to obtain alignment or to facilitate orthodontic mechanics.

Cephalometry remains an important tool for the orthodontist, the response of the facial tissues to tooth movement, particularly proclination, is unpredictable and so tooth movements planned to achieve favorable, or prevent unfavorable soft tissue movements, should be executed with caution.

2.7.4 Bracket Selection

Obtaining the correct inclination of teeth during orthodontic treatment has always been challenging with orthodontic appliances based on the edgewise system. The passive self-ligating bracket system provides several torque options for incisor and cuspid teeth. In general, the torque selected in each bracket should be designed to over-correct tooth position (Pandis et al, 2006).

High torque brackets may be used on upper incisors or on upper cuspids are as follows examples:

- Extraction cases where treatment mechanics may excessively retrocline the upper incisors.
- Class II Division 1 malocclusions where treatment mechanics may excessively retrocline the upper incisors.
- Class II Division 2 malocclusions.
- First premolar extraction cases.

- Cases where the crowns of the upper cuspids are palatally tipped. (Bourauel *et al*,2005)

Standard torque brackets are used where the inclination of the teeth is satisfactory before treatment and the treatment mechanics will not adversely affect the inclinations during treatment.

Low torque brackets may be used on upper incisors or on lower incisors are as follows examples:

- Excessively proclined upper incisors
- Isolated upper incisors with palatally positioned roots (eg, upper lateral incisor in the palate)
- Malocclusions where treatment mechanics may result in excessive upper incisor proclination
- Moderate and severe upper arch crowding
- Anterior open bite cases with proclined incisors
- Extreme lower labial segment crowding
- Cases using Class II elastics or fixed Class II correctors attached to the brackets
- Lingually placed lower incisors (Bourauel *et al*., 2005).

3. MATERIALS AND METHODS

Institutional review board approval for this prospective randomized controlled trail was obtained from the NEU IRB committee in Cyprus (YDU/17/46/-400). Subjects were recruited from the orthodontic clinic of NEU Dental Hospital. The patients were given written and verbal explanations about the study. Those agreeing to participate completed a written consent form.

3.1 Collection of Data

The sample included 40 patients aged between 14-21 years who were eligible for the study years, selected on the basis of having a pretreatment Class I skeletal with acceptable soft tissue facial profile, and a moderate crowding range 4±2 mm. None of them had received any orthodontic treatment before and nor had they had any extractions or congenital anomalies such as supernumerary teeth, but all permanent dentition with the maxillary second molars had erupted.

The sample was divided randomly by cases treated with conventional straight wire appliance and passive self-ligating system. Passive self-ligating brackets (Damon Q; Ormco, Orange, Calif) with standard values for tip and torque and 0.022-in slot were used for the experimental group and the conventional straight wire brackets (Mini Master Series; American Orthodontics, Sheboygan, WI) 0.018 Roth slot were used for the control group. An unstratified subject allocation sequences, patients distributed randomly to different clinician for their treatment at the orthodontic department. Therefore, multiple operators treated the participants in both groups.

3.2 Excluded patients

The following criteria were excluded:

- cleft lip and palate or other craniofacial anomalies
- previous orthodontic treatment
- complex medical history and medication
- congenital absence of teeth in the maxillary arch other than third molars
- patients with an angle classification of unilateral or bilateral full cusp Class II or Class III.

3.3 Treatment Plan and Arch Sequence

Passive self-ligating system bracket treatment consisted of an arch-wire sequence comprised of 0.014-in round CuNiTi, 0.016 in round CuNiTi, 0.014×0.025 in CuNiTi, 0.018×0.025 in CuNiTi (Damon; Ormco) of uniform arch form was placed in all patients with attachments placed on all teeth from the second molar to second molar. The arch wires sequence for the control group was 0.014-in round nickel titanium (NiTi), 0.016 in round NiTi, 0.016×0.016 in NiTi, 0.016×0.022 in NiTi (GC initialloy; Alsip, IL) of universal form. The conventional brackets were ligated with elastomeric modules or with stainless steel ligatures to permit complete engagement.

The arch wires were removed and replaced with new wires every six weeks for both groups. Dental alginate impressions were collected from the subjects every six weeks in order to establish the measurements. Dental and extra-oral pictures were additionally taken as part of the routine procedure in orthodontic documentation.

Models were measured and numbered in serial pairs for identification purposes and measurements were successively carried out on each cast. During data collection, each model was numbered for identification. Brackets were obscured with wax on the dental models to prevent identification of the bracket system used.

The following transverse dimensions were recorded with digital calipers (0-150mm ISO electronic caliper): from inter-canine width, the distance between the maxillary canine cusp tips, inter-premolar widths, the distances between the fossa of the maxillary first and second premolars, inter-molar width, and the distance between the mesio-buccal fossa of the maxillary first molars (Fig 5 and Fig 6).

Figure 5 Digital calipers.

The duration of the treatment and crowding was also taken into consideration. By the end of the data collection period, there were 5 maxillary dental casts belonging to each subject for the passive self-ligating system group, and 2 maxillary dental casts as pre-treatment and post-treatment for conventional straight wire appliance group, which were used during the evaluation and comparison processes as mentioned above.

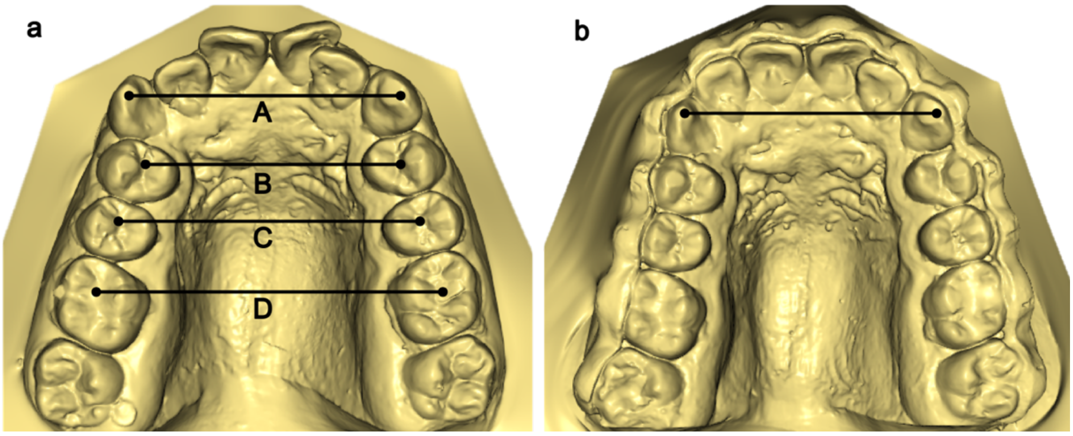

Figure 6 a.Transverse dimensions recording points A) Inter-canine width, B) Inter first-premolar width, C) Inter second pre-molar width, D) Inter-molar width. b. Inter-canine width decreased after initial arch wire.

3.4 Statistical Analysis

All statistical analyses were conducted using statistical software (The SPSS, release 13.0, SPSS for windows, SPSS, Chicago, IL) which had a pre-specified level of statistical significance of $p<0.05$. All dental casts for the subjects were measured twice by the same orthodontist. A t-test assessed the differences in the means of the paired samples between pre-treatment and post-treatment for the control group at T1 and experimental group at T2. An independent t-test was used to assess the differences between the experimental group and the control group at T2-T1.

A one-way ANOVA test was carried out to compare the effects of the 0.014, 0.016, 0.014×0.025 and 0.018×0.025 CuNiTi wires on the transverse dimensional changes of the maxillary inter-canine, inter-premolars and inter-molar widths in the passive self-ligating system group. Statistically significant differences in terms of the treatment time and crowding between groups was also noted.

4 RESULTS

Forty subjects were recruited for the study. Overall, 35 subjects (87.5%) completed the study. Two subjects in the passive self-ligating system, and 3 subjects in the conventional straight wire appliance group were omitted from the analyses because the patients were not able to complete the treatment. To assess the accuracy and reproducibility of the measurement, the repeated measures were compared for correlation and a paired *t*-test was performed. A mean absolute difference between measures of 0.09 mm was recorded with a correlation coefficient of r = 1, which indicated statistically and clinically acceptable accuracy in measuring.

Table 1 Descriptive statistics and statistical comparisons for age, crowding and treatment time in both groups.

	GROUP	N	Mean	Std. Deviation	t / Z	p
Age	Experimental	18	16,77	4,186	0.340	0.737 ^{NS}
	Control	17	16,18	5,114		
Crowding	Experimental	18	4,5846	2,60667	2.335	0.027*
	Control	17	2,8588	1,39421		
Treatment time	Experimental	18	14,0769	1,80100	-2.193	0.028*
	Control	17	16,8235	3,82811		

Table 2 Descriptive statistics and statistical comparisons between experimental and control groups (T2 - T1).

	Group	N	Mean	Std. Deviation	Std. Error Mean	T	P
Inter-canine comparisons	Control	17	1.8006	1.25598	0.30462	1.255	0.220^{NS}
	Experimental	18	2.6100	2.27663	0.60845		
Inter-premolar 1st comparisons	Control	17	2.7629	1.65919	0.40241	2.377	0.024*
	Experimental	18	4.3007	1.94373	0.51948		
Inter-premolar 2nd comparisons	Control	17	2.1676	1.20697	0.29273	3.307	0.003*
	Experimental	18	3.9850	1.83796	0.49121		
Inter-molar comparisons	Control	17	0.8512	0.86751	0.21040	4.767	0.0001*
	Experimental	18	2.8850	1.48009	0.39557		

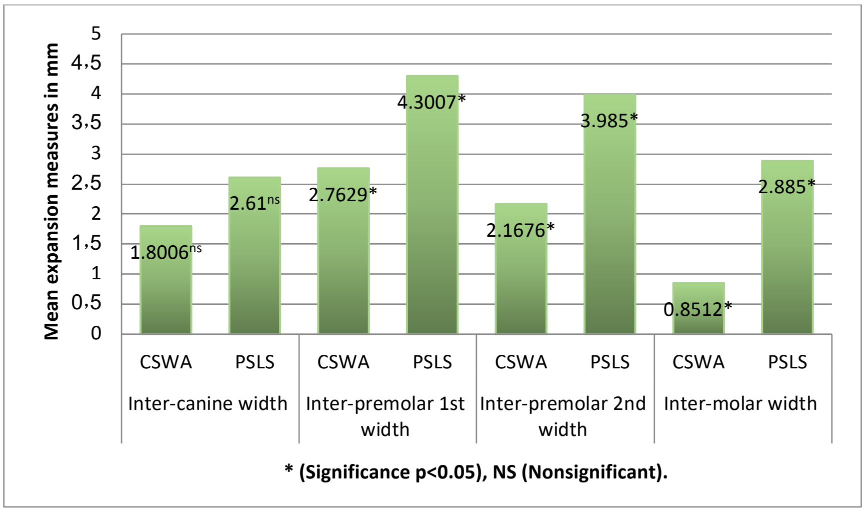

Figure 7 Comparison of mean transversal dimensional expansion effect on maxillary arch.

When the experimental and control samples were analyzed, the results showed that inter-canine, inter-first premolar, inter-second premolar and inter-molar widths were significantly larger after treatment (Table 2). When the two samples were compared, the maxillary inter-canine width had no significant difference between the groups ($p \geq 0.22$). Significant differences in the maxillary inter-first premolar, inter-second premolar and inter-molar widths were found between control and experimental group. The mean difference change in maxillary inter-molar width was significantly greater when compared to the inter-first premolar and inter-second premolar changes between the groups ($p \leq 0.001$), (Table 2).

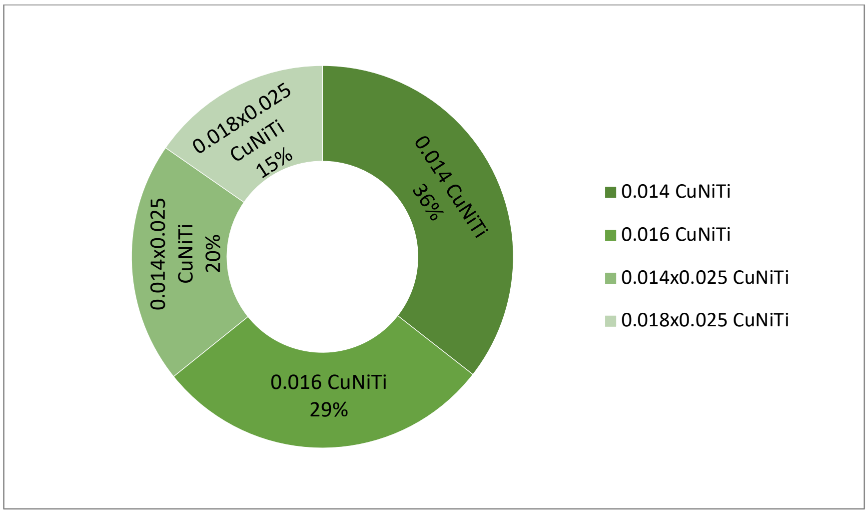

Figure 8 The percentage of expansion effect of CuNiTi arch wires on the experimental samples.

When the experimental samples were analyzed depending on the arch wires sequences 0.014, 0.016, 0.014×0.025 and 0.018×0.025 CuNiTi, the only significant difference among the arch wires was noted during the application of 0.014 CuNiTi ($p = 0.024$).

Table 3 Descriptive statistics and statistical comparison of transversal changes during CuNiTi arch wire sequence.

Arch wire	Transversal width	N	Mean	Mean Dif.	Std. Deviation	Std. Error	F	P
.014 CuNiTi	Inter-canine width	18	33.67	0.5589	0.91193	0.21494	3.335	0.024*
	Inter-premolar 1st width	18	34.65	1.6594	1.19371	0.28136		
	Inter-premolar 2nd width	18	38.98	1.1000	1.35542	0.31948		
	Inter-molar width	18	43.74	0.6850	1.10561	0.26059		
.016 CuNiTi	Inter-canine width	18	34.56	0.8850	0.67930	0.16011	0.462	0.710 NS
	Inter-premolar 1st width	18	35.53	0.8800	0.73300	0.17277		
	Inter-premolar 2nd width	18	39.82	0.8406	0.88139	0.20774		
	Inter-molar width	18	44.37	0.6233	0.79411	0.18717		
.014×.025 CuNiTi	Inter-canine width	18	35.25	0.6928	0.90773	0.21395	1.499	0.223 NS
	Inter-premolar 1st width	18	36.22	0.6933	0.64514	0.15206		
	Inter-premolar 2nd width	18	40.44	0.6222	0.64194	0.15131		
	Inter-molar width	18	44.66	0.2917	0.33846	0.07978		
.018×.025 CuNiTi	Inter-canine width	18	35.54	0.2906	0.48067	0.11329	1.176	0.352 NS
	Inter-premolar 1st width	18	36.59	0.3611	0.53912	0.12707		
	Inter-premolar 2nd width	18	41.04	0.6006	0.56732	0.13372		
	Inter-molar width	18	45.13	0.4756	0.53455	0.12599		

Table 4 Bilateral comparison of 0.014 CuNiTi arch wire transverse dimensional effect on maxillary arch width.

Tukey HSD Multiple Comparison			**Mean Difference**	**Std. Error**	**P**
0.014 CuNiTi	Inter-canine width	Inter-premolar 1st width	-1,10056*	0,38428	0,028*
		Inter-premolar 2nd width	-0,54111	0,38428	0,499 NS
		Inter-molar width	-0,12611	0,38428	0,988 NS
	Inter-premolar 1st width	Inter-premolar 2nd width	0,55944	0,38428	0,470 NS
		Inter-molar width	0,97444	0,38428	0,063 NS
	Inter-premolar 2nd width	Inter-molar width	0,41500	0,38428	0,703 NS

A greater expansional effect of 0.014 CuNiTi wire was observed especially in the first and second pre-molar widths (1.6594 mm, and 1.10 mm respectively) (Table 3). While the inter-canine and inter-molar widths (0.5589 mm, and 0.6850 mm respectively) increased almost half amount of pre-molar distances in comparison with 0.014 CuNiTi (p=0.024), (Table 3). With the bilateral comparison of each wire sequences of transverse dimensional effect on maxilla, only inter-canine and inter-first premolar comparison showed statistically significant difference with 0.014 CuNiTi (p=0.028), (Table 3). Inter-first and second premolar, and inter-molar widths showed no statistical differences among each other with any type of arch wire sequences (e.g. 0.016, 0.014×0.025 and 0.018×0.025 CuNiTi) (p>0.05), (Table 4, Table 5, Table 6, and Table 7).

The results showed a significant difference between groups in respect to the duration of the treatment. The duration of the passive self-ligating system was 2.8 months less than the group treated with a conventional straight wire appliance (p=0.028), (Table 1).

In other words, the inter-first premolar and inter-second premolar dimensions had increased considerably in both groups. The experimental group showed significantly greater increments in inter-premolar arch width (4.3 and 3.9 mm, respectively). The increment in the experimental group was significantly greater than the control group (2.7 and 2.1 mm, respectively).

Table 5 Bilateral comparison of 0.016 CuNiTi arch wire transverse dimensional effect on maxillary arch width.

Tukey HSD Multiple Comparison			**Mean Difference**	**Std. Error**	**P**
0.016 CuNiTi	Inter-canine width	Inter-premolar 1st width	0,0050	0,2585	1,000 NS
		Inter-premolar 2nd width	0,0444	0,2585	0,998 NS
		Inter-molar width	0,2616	0,2585	0,743 NS
	Inter-premolar 1st width	Inter-premolar 2nd width	0,0394	0,2585	0,999 NS
		Inter-molar width	0,2566	0,2585	0,754 NS
	Inter-premolar 2nd width	Inter-molar width	0,2172	0,2585	0,835 NS

Table 6 Bilateral comparison of 0.014× 0.025 CuNiTi arch wire transverse dimensional effect on maxillary arch width.

Tukey HSD Multiple Comparison			**Mean Difference**	**Std. Error**	**P**
0.014 × 0.025 CuNiTi	Inter-canine width	Inter-premolar 1st width	-0,0005	0,2215	1,000 NS
		Inter-premolar 2nd width	0,0705	0,2215	0,989 NS
		Inter-molar width	0,4011	0,2215	0,277 NS
	Inter-premolar 1st width	Inter-premolar 2nd width	0,0711	0,2215	0,988 NS
		Inter-molar width	0,4016	0,2215	0,276 NS
	Inter-premolar 2nd width	Inter-molar width	0,3305	0,2215	0,448 NS

Table 7 Bilateral comparison of 0.018× 0.025 CuNiTi arch wire transverse dimensional effect on maxillary arch width.

Tukey HSD Multiple Comparison			Mean Difference	Std. Error	P
0.018 × 0.025 CuNiTi	Inter-canine width	Inter-premolar 1st width	-0,0705	0,1771	0,978 NS
		Inter-premolar 2nd width	-0,3100	0,1771	0,306 NS
		Inter-molar width	-0,1850	0,1771	0,724 NS
	Inter-premolar 1st width	Inter-premolar 2nd width	-0,2394	0,1771	0,534 NS
		Inter-molar width	-0,1144	0,1771	0,917 NS
	Inter-premolar 2nd width	Inter-molar width	0,1250	0,1771	0,894 NS

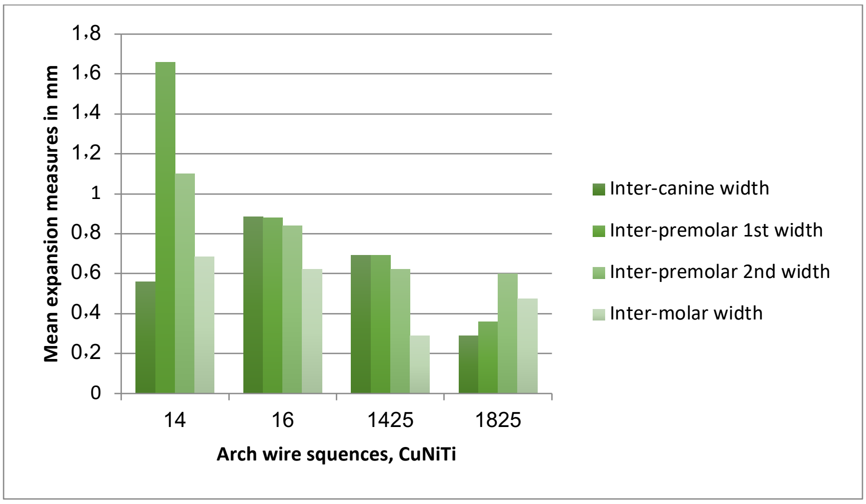

Figure 9 The mean expansion effect of each CuNiTi arch wire on the maxillary arch.

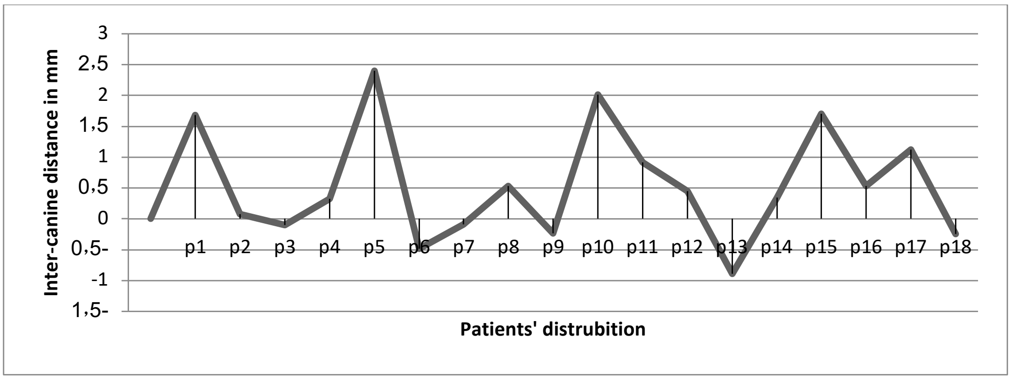

Figure 10 The effect of .014 copper nickel-titanium arch wire at inter-canine width.

Statistically, a significant difference was recorded between the inter-first premolar and inter-second premolar. It was noted that the inter-canine width of some of the subjects in the experimental group had decreased, especially when the initial arch wire 0.014 CuNiTi was applied (Fig 6 and Fig 10).

5. DISCUSSION

The expansion of the dental arch has a role of primary importance for the resolution of non-extraction orthodontic treatments combined with missing spaces. Proper diagnosis and case selection remain essential to following the correct therapy solution. In examining the available literature, it is possible to find some controversies regarding the possible benefits of therapy with the use of passive self-ligating appliances.

The passive self-ligating appliances possessed certain handling characteristics such as ease of ligation and consistent wire engagement without the undesirable force relaxation of elastomeric modules, thereby maintaining a constantly active status of engaged wires. This makes them suitable alternatives to conventional appliances. This is in agreement with the findings of previous studies (Harradine 2001, Turnbull and Birnie 2007 and Sayed et al. 2016).

Various studies have reported mean differences between self-ligating or passive and active self-ligating systems and conventional bracket systems such as in terms of treatment time as well as in relation to inventory requirements, chair-side time, assistance and stability of the claimed expansion of self-ligating treatments (Damon, 2004; Fleming, et al. 2009; Miles, et al. 2006; Vajaria et al. 2011; Lineberger et al. 2016).

As for expanding the transverse dimension, Damon 2004, and some authors believe passive self-ligating bracket can produce specific, uniquely stable arch width changes (Damon, 2004), especially for intermolar expansion without incisors labial movement and that this cannot be achieved by conventional bracket. Although a tendency to support passive self-ligating bracket for expanding maxillary intercanine, interfirst and intersecond premolar width was shown in the present study, there was no statistical difference.

There are also results that indicate a statistically greater increase in inter-molar width with the self-ligating bracket systems (Fleming, et al. 2009). Some have found that during the initial alignment phase of treatment, self-ligating brackets had greater irregularity, whilst which was interpreted no clinical advantage than conventional brackets (Miles, et al. 2006).

Vajaria et al. 2011, who compared orthodontics self-ligating brackets and conventional brackets by using digital casts, finding greater increase for the self-ligating group, which also presents evidence that the premolar area is responsible for the increase in transverse dimension (Vajaria et al. 2011). It is also in agreement with Lineberger et al. 2016, study on digital casts, which found significant increase in interpremolar distance in the group treated with the passive self-ligating system, compared to the control group (Lineberger et al. 2016).

Franchi et al. 2006, found 4 degrees buccal tipping of the molars and concluded that this may imply that molar expansion observed with self-ligating brackets is related to the displacement or tipping of molars rather than to bodily movement or basal maxillary expansion (Franchi et al., 2006). It is also in agreement with the results observed in a study by Mikulencak 2006, which showed that the maxillary arch expansion using the passive self-ligating system produced a 0.5 degree degrees buccal tipping of the maxillary molars during treatment (Mikulencak, 2006).

On the other hand, findings suggest that no time is saved by using self-ligating brackets and they are no more effective at relieving arch crowding when compared to conventional systems (Fleming, et al. 2010 and Fleming, et al. 2013). Fewer studies have investigated the real effect of arch-wire changes on the dental arches (Malik, et al. 2015). The current results demonstrate the effects of every single arch wire dimension effect on the alleviation of dental crowding and transversal arch expansion. Therefore, while typical changes involved an increase in arch width, some dimensional arch wire changes showed a decrease, especially in regard to inter-canine width (Fig 9).

Reddy et al. 2014, evaluating five ligation methods, including conventional, active and passive self-ligation. It claimed passive self-ligating is more efficient than conventional ligating brackets for initial leveling and alignment (Reddy et al. 2014). The results of the present study showed that treatment with a passive self-ligating system (DAMON) has more potential for producing a modest transverse dimensional expansion of the maxillary dental arches compared to that of the conventional straight wire appliance which the control group received. The experimental group's arch widening of the maxillary molar was 2.03 mm greater than the control group's arch widening ($p=0.0001$).

While inter-canine dimension was increased in both groups, it was slightly greater in the experimental group. The maxillary inter-canine width showed an increase of 2.5 mm in the experimental group compared with 1.8 mm in the control group. No statistically significant difference was noted when the two groups were compared.

When the preliminary cast models were examined, these individual canines were positioned buccally relative to the maxillary dental arch. This explained why the inter-canine width had become narrower. However, greater expansion of the inter-premolar's width was observed in these individuals.

Statistically, a significant difference was recorded between the inter-first premolar and inter-second premolar. It was noted that the inter-canine width of some of the subjects in the experimental group had decreased, especially when the initial arch wire 0.014 CuNiTi was applied (Fig 6 and Fig 10).

Most of the transverse expansion was observed at the level of the premolars, which could highlight how the passive self-ligating system achieves its crowding relief. This finding is in accordance with that of Mikulencak 2006, who found a clinically and statistically significant change in arch width dimension in the molar and premolar areas after treatment (Mikulencak, 2006). A significant change was not seen in the canine area. Al-Sanea 2008, Jackson 2008, Ehsani 2010, Vajaria et al. 2011, and Fleming et al. 2013, found a statistically significant expansion in premolars and molar area in both arches (Al-Sanea 2008, Jackson 2008, Ehsani 2010, Vajaria et al. 2011, and Fleming et al. 2013). Our current study is partial agreement with the results of previous studies.

While Tecco et al. (Tecco et al. 2009) measured the maxillary transverse changes on dental casts at the end of the levelling and aligning phase of treatment, (Vajaria et al.2011) and Lineberger et al. (Lineberger, et al. 2016) reported transverse changes when comparing pre- and post-treatment digital dental casts. Pre and post treatment increments in maxillary (from 0.8 to 2.9 mm) inter-molar and inter-premolar widths (from 2.1 and 3.9 mm and from 2.7 to 4.3) found in the current study were greater than those reported by Lineberger et al. (Lineberger, et al. 2016) inter-molar (from 0.9 to 2.2mm) and premolars (2.0 to 2.2 mm, respectively).

These differences in findings could be attributed at least in part to the fact that (Lineberger et al. 2016) evaluated the changes in maxillary transverse width by using points located more lingually on the tooth crowns (lingual distances) than the buccal points used in this study (cusp tips of the canine and central occlusal pits of premolars and molars).

Dental transversal changes in experimental samples produced by the passive self-ligating system and increments in transverse dimension in the experimental group could be explained by the use of CuNiTi arch wires during the treatment (Fleming, et al. 2013 and Vajaria, et al. 2011).

In this study, we focused on the effect of transversal changes of the maxillary inter-canine, inter-premolar and inter-molar resulting from the implementation of passive self-ligating system CuNiTi arch wires. Substantial differences in transversal changes were noted in the first months after the implementation of round arch wires 0.014 and 0.016 CuNiTi, especially in the premolar area (Fig 9).

Rectangular wires 0.014×0.025 and 0.018×0.025 also affected the maxillary transversal expansion, especially in the molar area. There are similar results of greater inter-molar width with self-ligating systems comparison of conventional systems even in the mandibular arch (Fleming, et al. 2009). The most significant statistical difference noted among the arch wires that were used was apparent upon the application of 0.014 CuNiTi at ($P=0.024$), (Table 2, and Table 3), (Fig 8).

According to the previous studies passive self-ligating brackets had significantly lesser frictional forces than active self-ligating brackets and conventional ligation brackets (Thorstenson et al. 2002, and Harradine, 2003). The passive clips did not apply any ligation force to the archwire and facilitates free movement of the archwire inside the bracket, these factors may account for the reduced frictional forces revealed by passive self-ligating brackets (Damon, 1998 and Trevisi et al., 2008). It was contrary to the popular belief that round wires generate less friction than rectangular wires because round wires make a point contact with bracket slot whereas rectangular wire make line contact (Frank et al., 1980). In the current study, the results show that the 0.014 CuNiTi rounded wire is the most effective wire. This present result with the 0.014 rounded wire could be cause of lesser friction in the bracket slot. Additionally, 0.014 CuNiTi wire might be taking advantage of applying first wire to the very irregular tooth crowding arch in the beginning of the treatment.

The duration of the treatment for the experimental group that was treated with passive self-ligating system was 2.8 months less than the treatment duration of the control group, which was treated with a conventional straight wire appliance, while the mean crowding in the passive self-ligating system group was 2.1 mm more than conventional straight wire appliance group (Table 7). For that reason, the current findings, contradict previous results (Fleming et al., 2009, Miles et al., 2006), and support the contention that bracket type influences alignment efficiency.

We should imply that total treatment time differs from one case to another, because not only the ligation technique but also many other factors such as patient cooperation variables and practitioner skills can influence the efficiency of treatment (Beckwith et al. 1999).

This study has a number of limitations. Comparing different bracket systems with different slot sizes might not be accurate. However, using either 0.022-inch slot or 0.018 slot bracket systems separately or a combination is very common practice in most orthodontic clinics. Therefore, we thought a comparison two main systems with each other might be concluding efficient clinical approach. Also, systematically reviewed results suggest that no available data confirmed the higher efficiency of the 0.022-inch system over 0.018 inch (Vieira, et al. 2017).

The mean crowding with the passive self-ligating system group was higher than the conventional straight wire appliance group, which might cause greater maxillary dental expansion. Therefore, a greater irregularity with the dental arches might have been greater expansion with conventional systems. We believe all these restrictions might have considered while interpreting the current results.

Lastly, we observe that passive self-ligating system has a greater transversal effect on the arches. This can be interpreting easily a rescue for cases with extraction. Besides this idea remains a common belief in practical orthodontic treatment. However, we should reconsider twice of a straight soft tissue profile and upright incisor position are prerequisite for nonextraction treatment. Moreover, a harmonious chin and lip position is the key leading to the successful treatment results with any type of orthodontic approaches.

6. CONCLUSION

The current study compared the effects of various types of CuNiTi arch wires on transversal dimensional changes with passive self-ligating system braces. Also the transversal dimensional changes were compared between passive self-ligating systems and conventional straight wire systems on maxilla at the time points of pre- and post-treatment.

- The 0.014 CuNiTi arch wire is the most effective in terms of transversal dimensional changes.
- Inter-first premolar, inter-second premolar and inter-molar widths increased significantly with the passive self-ligating system.
- The inter-canine width increased in both groups but there was no statistical difference.
- The duration period of the passive self-ligating system shorter than conventional straight wire appliance.

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EKLER

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EK 2: Magazine supplements:

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*Evaluate as very good, good, moderate, poor.