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ORTHODONTIC FORCE DIFFERENCE ON ACTIVE COMPONENTS ACTIVATION OF REMOVABLE ORTHODONTIC APPLIANCES
(PERBEDAAN BESAR GAYA ORTODONTI PADA AKTIVASI KOMPONEN AKTIF PERANTI ORTODONTI LEPASAN)

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ABSTRACT

Orthodontic treatment is performed by moving the malposition teeth into a good position in the dental arch with a removable or fixed orthodontic appliance. In this regard, the removable orthodontic appliance has an active component to transmit the orthodontic force that will result in orthodontic tooth movement. The orthodontic force used must be optimal in the sense of being able to produce tooth movement without causing side effects that endanger the periodontal tissue. It is necessary to activate the active components of the appliance, which in orthodontic treatment can be done several times until the desired tooth position is achieved. This study aims to explain the differences in orthodontic force in activating active components of removable orthodontic appliances. The research method was an experimental laboratory. A total of 24 removable orthodontic appliances used in this study were divided into two groups. The first group has a Z spring or single cantilever spring active component, and the other group has a labial bow. Each active component is activated by opening the loop by

1mm, 1.5mm, and 2mm, and in each activation, the magnitude of the force generated is measured using a tension gauge. Data analyzed by Mann Whitney (p<0.05). The result showed different activations carried out in this study resulted in significantly different forces with p=0.029. The force generated in each activation increases as the loop opening increases. Based on that results, it can be concluded that there is a significant difference in the force magnitude generated by the activation of the removable orthodontic appliance active component.

Keywords: orthodontic force; removable orthodontic appliance

ABSTRAK

Perawatan ortodonti dilakukan dengan menggerakkan gigi geligi yang malposisi ke posisi yang baik di dalam lengkung gigi dengan peranti ortodonti lepasan atau cekat. Dalam kaitan ini, peranti ortodonti lepasan memiliki komponen aktif untuk menyalurkan gaya ortodonti penggerak. Gaya ortodonti yang digunakan harus optimal dalam arti mampu menghasilkan pergerakan gigi tanpa menimbulkan efek samping yang membahayakan jaringan periodontal. Untuk menghasilkan gaya tersebut perlu dilakukan aktivasi komponen aktif peranti yang dalam perawatan ortodonti dapat dilakukan beberapa kali sampai diperoleh posisi gigi yang diinginkan. Tujuan penelitian ini adalah untuk mengetahui perbedaan besar gaya ortodonti dalam aktivasi komponen aktif peranti ortodonti lepasan. Metode penelitian adalah eksperimental laboratorik. Sebanyak 24 peranti ortodonti lepas digunakan dalam penelitian ini dibagi dalam dua kelompok. Kelompok pertama memiliki komponen aktif Z spring atau single cantilever spring dan kelompok lainnya memiliki komponen aktif labial bow. Masing-masing komponen aktif diaktivasi dengan cara membuka loop sebesar 1mm, 1,5mm dan 2mm dan dalam setiap aktivasi dilakukan pengukuran besar gaya yang ditimbulkan, menggunakan tension gauge.Data dianalisis dengan Mann Whitney(p<0,05) Aktivasi berbeda yang dilakukan dalam penelitian ini menghasilkan besar gaya berbeda dan perbedaannya cukup bermakna (p=0,029). Gaya yang ditimbulkan *dalam setiap aktivasi bertambah besar seiring dengan bertambah besarnya pembukaan loop yang dilakukan dalam aktivasi. Berdasarkan hal itu, dapat disimpulkan bahwa terdapat perbedaan bermakna (p<0,05) dalam besar gaya yang ditimbulkan oleh aktivasi komponen aktif peranti ortodonti lepasan.*

***Kata kunci**: gaya ortodonti; peranti ortodonti lepasan*

INTRODUCTION

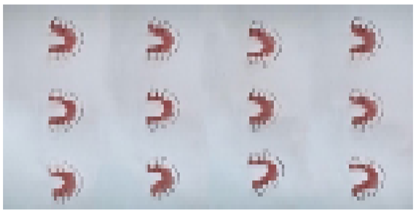
A removable orthodontic appliance generally has an active, retentive, and base plate.[1] The active component of the appliance is an element that provides the tooth moving force required in orthodontic treatment. It includes a labial bow, springs such as Z or single cantilever or bumper spring, or a double cantilever spring made of stainless-steel wire which is elastic and easy to shape. Generally, the wire used is 0.5 mm to 0.8 mm in diameter.[2]

According to Schwharz, the force applied to produce tooth movement should not exceed the capillary pressure, 20-30 g/cm^2, which is the optimal pressure to move the teeth without causing damage to the periodontal tissues. This force is said to be optimal because a smaller force does not produce tooth movement in optimal time, and a larger force can cause tissue damage and excessive pain.[1] This optimal orthodontic force is also understood as a force that is sufficient to stimulate cellular activity that results in tooth movement without causing damage to the periodontal tissue.[3.4.5] According to Christina et al. (2019), the optimal magnitude of force for orthodontic tooth movement can be described as the lightest force that produces a maximal or near-maximal response. In this regard, the best understanding adopted is that with the optimal orthodontic force, a tooth can be moved through the alveolar bone due to the remodeling process of the bone and periodontal ligament. Thus, if the applied force is heavy, then the risk of side effects such as external resorption at the root apices, uncontrolled tipping movements, increased hyalinization associated with decreased clinical efficiency of treatment, and patient discomfort has the potential to occur.[6,7,8] Therefore, controlling the magnitude of the force in orthodontic treatment is very important.

The study was conducted to determine the difference in force resulting from the activation of the active components of removable orthodontic appliances, which are still widely used in orthodontic treatment by students of the professional program at the Faculty of Dentistry. Prof. DR. Moestopo University.

METHOD

This research was an experimental laboratory and has received approval from the research ethics committee of the Faculty of Dentistry, Prof. DR. Moestopo University, through a scientific research commission decree numbered 110 / KIP / FKGUPDMB / VIII /2019. Twenty-four (24) removable orthodontic appliances were used in this study, divided into two groups, each consisting of twelve (12) removable orthodontic appliances with an active component of labial bow and another twelve (12) removable orthodontic appliances. With an active component of Z spring (figure 1). Both types of appliances use Adams clasp for retention and have an acrylic base plate.



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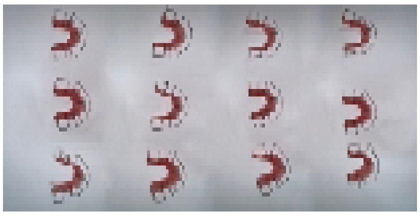

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Figure 1. (a) Twelve removable orthodontic appliances with the active component of labial bow and (b) twelve removable orthodontic appliances with the active component of Z spring.

This removable orthodontic appliance is brand new and has never been activated. Activation in this study was carried out three (3) times by opening the loop by 1mm, 1.5mm, and 2mm. Measurement of the magnitude of the force at each activation was done using a tension gauge (figure 2). The typodont model with an Angle Class I malocclusion (figure 3) was set up with tooth 31 linguo-version and tooth 11 labioversion. The tooth 31 linguo-version in the mandibular model allowed researchers to activate the active component of Z spring.

In contrast, the tooth 11 labio-version in the maxillary model allowed the researcher to activate the labial bow determination of the classification of Angle class I. Malocclusion in typodont is based on the consideration that it is in line with the types of cases carried out in the integration clinic of students of the RSGM FKG

UPDM (B), where orthodontic treatment of mild cases is still used removable orthodontic appliance. At the same time, the active components of the labial bow (Figure 4,5) and Z spring were chosen because they are the types of active components that are most widely used in orthodontic appliances.

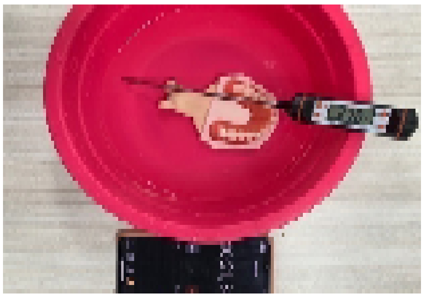


Figure 2. The tension gauge used to measure the force generated in the activation of the active components of the removable orthodontic appliance.

Figure 3. The Angle class I malocclusion refers to the relationship of the first permanent molars where the mesiobuccal cusp of the maxillary first permanent molar is in the buccal groove of the mandibular first permanent molar.

Figure 4. The design of the most used labial bow is the simple type, having two symmetrical "U" loops running between the left to right canines, which is also known as the short labial bow.[2]

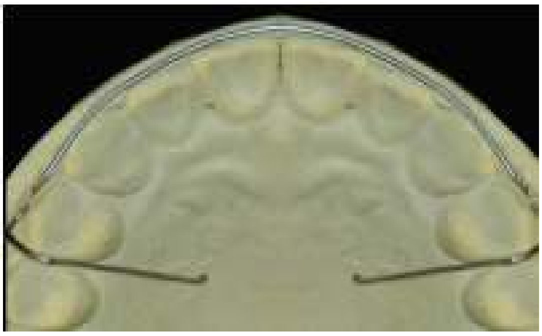


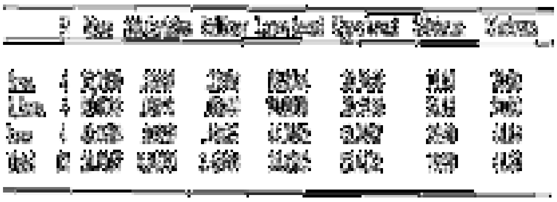
Figure 5. Another variation of the labial bow design is the long labial bow because the horizontal bar extends from the left first premolar to the right first premolar.

The active components of the labial bow and Z spring in this study were also newly made using stainless steel wire with a diameter of 0.8 mm and 0.6 mm, respectively. Since its introduction in 1929, stainless steel wire has remained popular and is still widely used today. Several characteristics of these materials contribute to their use in removable orthodontic appliances because they are positioned close to the oral mucosa for a long time to require good biocompatibility. Some of the qualities possessed by stainless steel wire include strong, corrosion-resistant, inexpensive, biocompatible, and easy to shape (high formability).[3,9,10,11]

RESULT

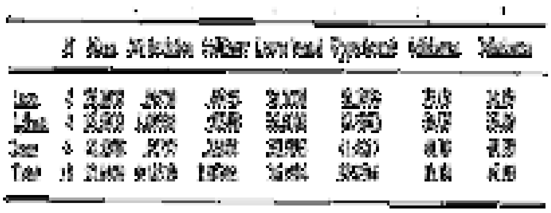
Activation of the active components was carried out three (3) times in each clasp, and the force's magnitude was measured at each activation. The magnitude of the force in three different activations the active component of the Z spring can be seen in Table 1.

Table 1. Magnitude of force generated from the activation of z spring data description



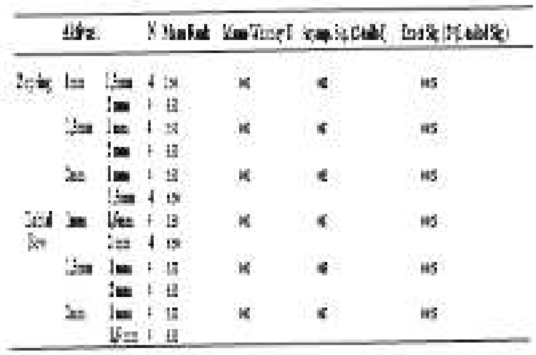
The magnitude of the force in three different activations the active component of the labial bow can be seen in Table 2.

Table 2. Magnitude of force generated from the activation of labial bow data description



Then the average force magnitude in each group of active components underwent the Saphiro-Wilk test of normality because the total sample was less than fifty (50). The normality test with the active component of Z spring showed a value $p < 0.05$ ($p=0.034$), as well as for the group with the active component of the labial bow, which was $p=0.007$ which means that the data were not normally distributed. For this reason, the next statistical test will use a non-parametric test, the post hoc test with Mann-Whitney, to see the difference in the magnitude of the force in each group.

Table 3. The difference in the magnitude of the force in each group



Description:Mann-Whitney test, $^*p < 0.05$ significant.

As shown in Table 3, the test results show a significant difference in the group with the active component of Z spring and the group of the labial bow with $p=0.029$. It also proves a significant difference ($p<0.05$) for the magnitude of the orthodontic force produced by each activation of the active components of the Z spring and labial bow.

DISCUSSION

Orthodontic treatment generally takes time to achieve treatment goals. Various efforts have been made through various studies. In order to shorten the treatment time and at the same time minimize the risks that may arise, especially related to root resorption, pain, and alveolar bone loss.[12,13,14]

The essence of orthodontic treatment is the movement of the teeth through the alveolar bone to achieve a better occlusion.[15] Tooth movement is facilitated by tissue remodeling carried out by various cell types as a result of the application of mechanical forces received. In terms of orthodontic tooth movement, this remodeling is the basic principle.[17] So, the optimal orthodontic force applied can stimulate the inflammatory response, which will play an important role in tissue remodeling and move the teeth in the desired direction.

The concept of optimal force today is based on the understanding that a force is sufficient to produce maximum tooth movement speed without causing tissue damage or pain to the patient. Schwarz analogized the magnitude of this optimal force with the pressure in the capillaries and therefore recommended that orthodontic forces be applied to no more than 15–30 g/cm^2 so as not to harm the surrounding tissue.

In treatment using removable orthodontic appliances, the application of this optimal force is generated by activating the active components of the appliance. Some of the active components that are widely used include labial bow, Z spring, finger spring and simple spring. These active components are generally made of stainless-steel wire with diameters ranging from 0.5 to 0.8 mm. The 0.5 mm diameter stainless steel wire is used in active components to move one or two teeth, while 0.8 mm diameter stainless steel wire is more often used for active components that move more teeth, such as the labial bow that includes six anterior teeth. (short labial bow) or eight teeth to the right and left first premolars (long labial bow). Some of the superior qualities of stainless-steel wires that have made them widely used today are their corrosion resistance, affordable price, and formability, even when compared to orthodontic wires made of titanium. The stainless-steel wires are said to have lower ductility so that stainless steel wires tend to produce a greater force which will quickly dissipate over some time. Therefore, activation needs to be done repeatedly to produce effective tooth movement and maintain the same force level.[2,17] However, the low level of flexibility of stainless-steel wires can be overcome by heating at a certain temperature to help increase flexibility. This effort is expected to help reduce the magnitude of the force generated. Stainless steel is obtained by adding chromium to iron. However, excessive heating at a temperature above 400-900 degrees will cause the release of nickel and chromium, which decreases the corrosion-resistant quality of the alloy.[2]

Considering that the active components in removable orthodontic appliances are also made of stainless-steel wire, the activation of these components needs to get an important consideration, especially if this activation is carried out every week. Another factor considered in this case is the discomfort felt by the patient when the active component is activated, which in turn can affect cooperation and, therefore, the success of treatment.

In this study, the activation of the active component was carried out three times with different loop manipulation, namely 1mm, 1.5mm, and 2mm, both on the Z spring and the labial bow. The measurement results obtained also show that the activation of 1 mm and 1.5 mm for the active component of Z spring shows the magnitude of the force that is still within the optimal force range, according to Schwarz (table 1). In contrast, the activation of the active component of labial bow shows that the optimal force can only be obtained with an activation of 1mm. A 1.5 or 2mm activation will produce a force that exceeds the optimal force (table 2). Table 1 and Table 2 also show that the magnitude of force generated increases with increasing activation. The difference in the magnitude of force generated in three activations of the active components in this study proved to be significantly different (table 4), with a p-value of <0.05. It applies to both active components, Z spring, and labial bow. Based on the results of this study and referring to the optimal force that produces optimal tooth movement without endangering tissue health and patient comfort, the activation of the active component of the labial bow should not exceed 1mm in each control visit. It means that the labial bow "U" loop reduction is only 1mm. Unlike the case with the active component of Z spring, which in this study shows that activation of 1mm to 1.5mm still produces a large tolerable force because it is within the optimal value of the force, according to Schwarz.

The use of a light force is always preferred in orthodontic treatment. This light force can be understood as an optimal force that can cause tooth movement without tissue damage and discomfort to the patient. Excessive application of force can cause severe pain to the patient and damage the periodontal ligament and root resorption. However, inadequate force magnitude also leads to longer treatment times.[18] Serious consideration of the magnitude of the orthodontic force applied cannot be separated from the adverse effects that an orthodontic force may cause. Some of these effects can be explained in more detail: Effects on the dental pulp can result in a mild to moderate inflammatory response within the dental pulp, at least at the beginning of the tooth movement. Moreover, sudden and vigorous movement of the root can cause trauma to the blood vessels entering the pulp in that area. Several studies have shown that applying orthodontic force to endodontically treated teeth is at high risk of causing root resorption. More severe resorption should be anticipated when the tooth has characteristics such as conical roots, a distorted root shape, and a history of trauma. Effects on alveolar bone height include loss of crestal bone. Radiographically, it can be observed that the periodontal ligament space widens during orthodontic tooth movement. Tooth mobility may worsen if the orthodontic force applied is greater. If the mobility of the teeth reaches a dangerous level, then all forces should be discontinued until mobility is reduced to a moderate level. Another effect of being aware of is pain, although its degree varies from individual to individual. This pain occurs because the ischemic area developed in the periodontal ligament, so the greater the force, the more intense the pain. If the orthodontic force used is light, then the pain that may experience can be overcome by suggesting the patient chew for a while, especially during the first eight hours after the activation of the orthodontic appliance.[2,3] The rationale for asking the patient to chew for a while is the assumption that the chewing motion temporarily moves the tooth from its position and allows blood flow to return (fluently) to the stressed or compressed area to the application of orthodontic force.[3]

Based on the facts above, it is clear that the management of the orthodontic force magnitude applied in the treatment is very important, and this study has shown that the magnitude of the orthodontic force is significantly different at several different activation quantities and the activation of 1mm for the active component of the labial bow has been proven to be sufficient to stimulate tooth movement, while for the active component of Z spring, the amount of activation that can still be tolerated is 1 to 1,5mm

Like other medical treatments, orthodontic treatment is not a risk-free treatment. Various factors play a role in this connection, and the magnitude of the force should be taken into account because the risks associated with orthodontic force management may expose the patient to long-term risks. It is especially felt for pain, periodontal tissue damage accompanied by increased tooth mobility, root resorption to enamel damage, and impaired speech function. So, risk factor management will help minimize potential risks that may arise and, at the same time, maximize patient satisfaction and comfort.[19]

CONCLUSION

This study showed that there was a significant difference) for the magnitude of the orthodontic force produced in three different activations of the active component of labial bow and Z spring. Activation of 1mm on the two active components of removable orthodontic appliances in this study has also been shown to be sufficient to produce an optimal force capable of producing tooth movement without endangering tissue health.

CONFLICT OF INTEREST

The researcher does not have any conflict of interest with any party concerning this research.

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