บทวิทยาการ

การศึกษาการเปลี่ยนแปลงของอัตราการไหลของกระแสโลหิตในโพรงรากฟันเขี้ยวแท้ของมนุษย์ที่ถูกแรงดึงในระหว่างการรักษาทางทันตกรรมจัดฟัน

Pulpal Blood-flow Changes in Human Permanent Maxillary Canine During the Orthodontic Retraction Period

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Abstract

The purpose of this study was to determine the effect of the external load of elastic orthodontic traction force on human pulpal blood flow (PBF) in maxillary canines using a Laser Doppler Flowmeter (LDF).

Methods: Recordings were made from 9 maxillary canines, in 5 subjects who were to receive retraction of their teeth, after their upper first premolars were extracted, using a Moor type MBF3D/42 blood flow monitor with an opaque rubber dam covering all the gingivae around the teeth. The optic probe for LDF measurement was fixed to each tooth with an individual guiding fork constructed from 0.016x0.022 stainless steel wire soldered to a metal tube (int. diameter 1.75 mm). The probe was placed 2 mm from the gingival margin. The PBF was recorded before the force application as a baseline value. After that the traction forces of 300 gm from orthodontic elastic chains were applied from the hook of the maxillary molar band to the hook of canine bracket, and both the PBF and the traction force were measured again immediately and at day 1, 7, 21 and 28.

Results: Compared to the preload value, the mean PBF statistically significantly increased at day 1, 7, 21 and 28 (baseline: 4.0±2.9 P.U.; after loading: 4.8 P.U.; after day 1: 8.2±5.7P.U.; day 7: 9.7±7.5P.U.;day21: 8.9±5.5P.U.; day 28: 9.1±3.6P.U., $P<0.05$, One way RM ANOVA and Dunnett's method). However, the traction force significantly decreased at day 1, 7, 21 and 28 (base line : 300±0 gm; after day 1: 196.7± 26.5 gm; day 7: 161.7±35.9 gm; day 21: 140±28.9 gm; day 28: 125±30.6 gm, $P<0.05$, One way RM ANOVA and Tukey's test).

Conclusion: It is concluded that the continuous retraction force substantially causes pulpal vasodilation up to 28 days.

Key words: pulpal blood flow(PBF), Laser Doppler Flowmeter (LDF), individual guiding fork

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การศึกษาการเปลี่ยนแปลงของอัตราการไหลของกระแสโลหิตในโพรงรากฟันเขี้ยวแท้ของมนุษย์ที่ถูกแรงดึงในระหว่างการรักษาทางทันตกรรมจัดฟัน

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บทคัดย่อ

เพื่อเป็นการศึกษาผลที่เกิดขึ้นต่อการไหลของกระแสโลหิตในฟันเขี้ยวบนมนุษย์เมื่อรับแรงทางทันตกรรมจัดฟันโดยการใช้เครื่องเลเซอร์ดอฟฟ์เลอร์โฟลมิเตอร์

วัสดุและวิธีการ โดยการศึกษาการไหลของกระแสโลหิตในฟันเขี้ยวบนจำนวน 9 ซี่ของผู้ป่วย 5 คนที่รับการรักษาทางทันตกรรมจัดฟันที่ต้องมีการถอนฟันกรามน้อยบนซี่ที่หนึ่งร่วมด้วยและทำการวัดโดยการใช้เครื่องเลเซอร์ดอฟฟ์เลอร์โฟลมิเตอร์และแสดงผลด้วยโปรแกรมมัวแลป เอ็มบีเอฟ 3 ดี/42 ในขณะที่ทำการวัดจะมีแผ่นยางกันน้ำลายสีดำหุ้มรอบฟันเขี้ยว สายแก้วใยแสงจากเครื่องเลเซอร์ดอฟฟ์เลอร์โฟลมิเตอร์จะยึดติดกับฟันโดยลวดยึดที่ทำจากลวดโลหะไร้สนิมขนาด0.016x0.022นิ้วที่เชื่อมกับท่อโลหะขนาดเส้นผ่าศูนย์กลางภายใน 1.75 มม และลวดยึดจะยึดติดกับแบร็คเก็ตของฟันเขี้ยวบน ลวดยึดทำขึ้นเพื่อฟันเขี้ยวที่จะวัดแต่ละซี่โดยเฉพาะและตำแหน่งของท่อโลหะจะอยู่ห่างจากขอบเหงือก 2 มม และทำการวัดการไหลของกระแสโลหิตภายในประสาทฟันเมื่อเริ่มต้นและวัดทันทีภายหลังจากใส่ยางดึงจากตะขอของแหวนครอบฟันกรามมายังตะขอของแบร็คเก็ตฟันเขี้ยว โดยให้มีขนาดเริ่มต้น 300 กรัม และทำการวัดต่อเนื่องทั้งการไหลของกระแสโลหิตและขนาดแรงของยางดึงในวันที่ 1 วันที่ 7 วันที่ 21 และวันที่ 28 ผลการทดลองทำการเปรียบเทียบกับค่าการไหลของกระแสโลหิตภายในประสาทฟันเมื่อเริ่มต้นพบว่าค่าเฉลี่ยที่วัดได้เพิ่มขึ้นอย่างมีนัยสำคัญ (ค่าเริ่มต้น: 4.0±2.9 P.U.; เมื่อเริ่มใส่แรงดึง: 4.8 P.U.; วันที่ 1: 8.2±5.7P.U.; วันที่ 7: 9.7±7.5P.U.; วันที่ 21: 8.9±5.5P.U.; วันที่ 28: 9.1±3.6P.U., $P<0.05$, One way RM ANOVA and Dunnett's method) ในขณะที่แรงของยาง จะค่อย ๆมีขนาดลดลงอย่างมีนัยสำคัญ (ค่าเริ่มต้น : 300±0 กรัม; วันที่ 1: 196.7±26.5 กรัม; วันที่ 7: 161.7±35.9 กรัม; วันที่ 21: 140±28.9 กรัม; วันที่ 28: 125±30.6 กรัม, $P<0.05$, One way RM ANOVA and Tukey's test)

สรุปผล ของการไหลของกระแสโลหิตภายในประสาทฟันจะเพิ่มขึ้นจากค่าเริ่มต้นตลอดระยะเวลาที่ทำการวัดในขณะที่แรงที่เกิดจากการใช้ยางดึงฟันจะลดลงจากค่าเริ่มต้น ซึ่งแสดงให้เห็นว่าในการจัดฟันนี้จะมีผลที่ทำให้เกิดการขยายตัวของเส้นเลือดและการอักเสบภายในประสาทฟันได้ต่อเนื่อง

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Pulpal Blood-flow Changes in Human Permanent Maxillary Canine During the Orthodontic Retraction Period.

Introduction

Orthodontic treatment is based on the principle that when prolonged pressure is applied to a tooth, tooth movement will concurrently occur with the remodeling of surrounding bone. The application of light sustained force to the tooth crown can cause degenerative and/or inflammatory responses within the dental pulp. Several histological studies show that the orthodontic force applications have an effect on pulpal reaction and can alter the cellular metabolism and blood flow in the dental pulp.[1, 2, 3, 4]

Early studies showed that the monitoring of pulpal blood flow (PBF) change of the tooth can be measured by the Laser Doppler Flowmeter (LDF) without causing any damage to the pulp.[5] PBF value, estimated by LDF, is the relative change during continuous measurement. LDF has been used for monitoring transient PBF changes produced by the brief intrusive force application[6] and by the application of continuous intrusive force.[7]

The continuous sustained force produced by fixed appliances that are not affected by what the patient does produces the most efficient tooth movement. Clinically, the premolar extraction site closure is one step in the fixed orthodontic appliance treatment by traction on the canine. The force within the range of 150 to 200 gm has proved favorable for bodily movement of premolars and canines.[8] The elastic chains are now widely used in the clinical orthodontic procedure for canine retraction. The force exerted per unit extension can produce light continuous translation force vectors.[9, 10]

There is an important interaction between force magnitude and how rapidly the force declines as the tooth responds. After the tooth has moved a short distance, the force may drop all the way to zero. The duration of force and decrease in force, after a period in the mouth, have another aspect, related to the degradation characteristic of the elastic chain material. After exposure to the oral environment, many studies reported that about the 63%-77% of the initial force exerted by the elastic chains remained after the first 30 minutes and 39% - 60% remained after 21 days.[11, 12, 13]

From this perspective, an initial force of 300 gm from elastic chains (between 4-5 loops) is required and tends to decline as a result of the tooth distance and the mechanical properties of the elastic chains.

Usually the canine retraction period takes about 4 to 6 months and the force is activated every four weeks. However, due to the difficulty in accurately repositioning the LDF probe throughout the treatment period, and the control of the mechanical force system for anchorage preparation during the treatment, the measurement period for PBF change was studied immediately after loading the chain and at 1, 7, 14, 21 and 28 days. During the PBF measurement, it has been reported the laser light incidence on the tooth surface scatters to a wide area outside the tooth.[7] Therefore an opaque black rubber dam appli-

cation was suggested to eliminate the signal of PDL blood flow origin during the measurement of PBF.[14]

Very little is known about the pulpal blood flow responses under continuous retraction force application in orthodontic treatment. There are no previous reports on the effect of maxillary canine retraction force application during the premolar extraction site closure on PBF changes measured by LDF.

Therefore, the purposes of this study were to apply the amount of continuous retraction force to human maxillary canines in vivo and identify the PBF changes in using the Laser Doppler Flowmeter that might have been affected from these orthodontic elastic forces.

Materials and methods

A total of five orthodontic patients who are dental students of Srinakharinwirot University, two men and three women, aged 18-20 years, were tested. These patients had malocclusion, such as severe crowding and/or bimaxillary protrusion, and needed orthodontic treatment. The patients had healthy dental and periodontal tissue. The teeth were considered as healthy if they were free of caries, restoration, defect, attrition, and discoloration, and the gingiva had a normal appearance, the depth of the gingival sulcus less than 2 mm, and there was no symptomatic mobility. Extraction of upper and/or lower first premolars were included in treatment planning. The canines were then moved to close the spaces and to correct the crowding. The purposes and the procedure were explained to the patients and their informed consents for the experiment were obtained.

Recordings were made from the retraction of 9 maxillary canines after their upper first premolars were extracted. The measurements were made using a Moor type MBF3D/42 blood flow monitor with an opaque rubber dam covering all the gingiva around the teeth. The optic probe for LDF measurement was fixed to each canine with an individual removable guiding fork (IRGF) constructed from 0.016x0.022 stainless steel wire soldered with a metal tube (int. diameter 1.75 mm)(Figure 1). This IRGF controlled the optic probe at center approximately 2 mm from the gingival margin of each canine. The IRGFs were placed on and taken off from the canines before and after measurement in order to make the patients feel as comfortable as possible.

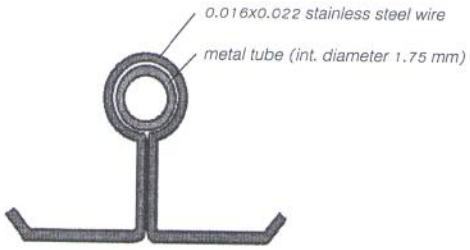

Fig. 1 An Individual Removable Guiding Fork (IRGF) constructed from 0.016x0.022 stainless steel wire and soldered with metal tube (int. diameter 1.75 mm).

The PBF was recorded before the force application as a baseline value. The traction force of 300 gm from the orthodontic elastic chain (Ormco® power chain) was applied from the hook of the maxillary first molar band to the hook of the canine bracket from the 1st day to the 28th day. Both the PBF and the traction force were measured again immediately after force application and at day 1, 7, 21, and 28 (Figure 2).

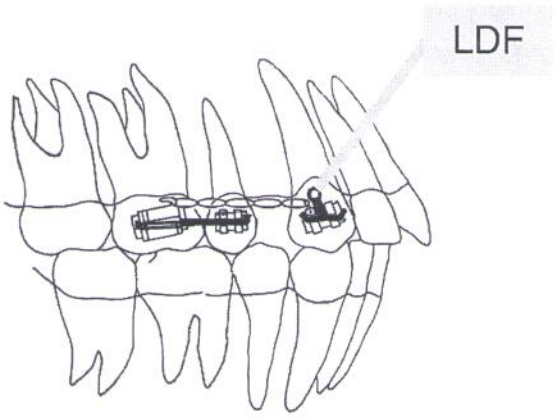

Fig. 2 This picture shows IRGF that was placed on the bracket of the maxillary canine and the elastomeric chain that was hang from the hook of the maxillary molar band to the hook of the maxillary canine.

Statistical Analysis

Comparisons between the overall mean values of sensory thresholds and blood flow recorded at each stage of the experiment were made using one-way, repeated measure analysis of variance (RM ANOVA). Where this showed that there were significant differences between the means, the Tukey test was used to make multiple comparisons between them. The P values of less than 0.05 were considered significant. Data are reported as means ±1 S.D.

Results

The total measurement period was 28 days. After the elastic chain was loaded on the canine, all of the experimental group experienced a slight pain, in particular for the first few days.

After loading the force of 300 gm from the first molar to the canine, there was a little but not significant increase in blood flow on the canine as measured with LDF. The increase in blood flow was still present at the first day through the 28th day of measurement (base line:4.0±2.9P.U.; after loading: 4.8 P.U.; after day 1: 8.2±5.7P.U.; day 7: 9.7±7.5P.u.;day21: 8.9±5.5P.U.; day 28: 9.1±3.6P.U., P<0.05, One way RM ANOVA and Dunnett's method), while the traction force also significantly decreased (base line : 300±0 gm; after day 1: 196.7± 26.5 gm; day 7: 161.7±35.9 gm; day 21: 140±28.9 gm; day 28: 125±30.6 gm, P<0.05, One way RM ANOVA and Tukey's test). Examples of Laser Doppler records and the traction force obtained are shown in figures 3, 4 and 5.

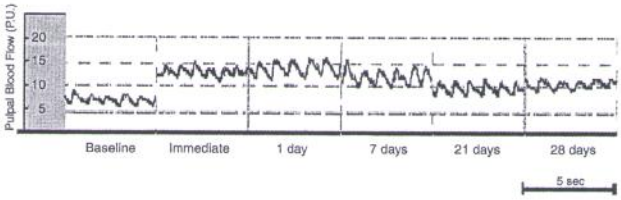

Fig. 3 An example of Laser Doppler records from the beginning to the 28th days.

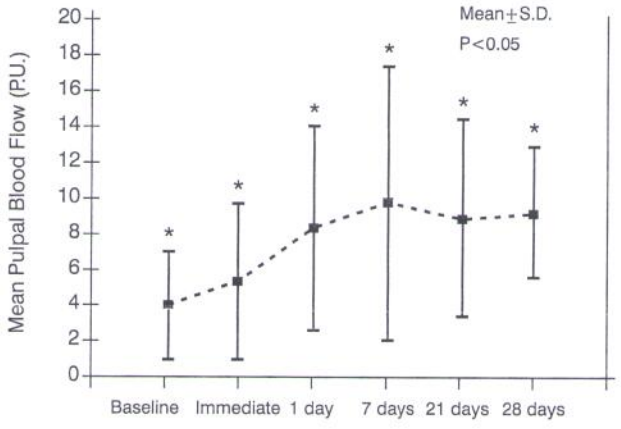

Fig. 4 The total measurement period was 28 days When compared to the preloaded value, the mean PBF significantly increased at day 1, 7, 21 and 28 after the force application. (baseline: 4.0±2.9P.U.; after day 1: 8.2±5.7P.U.; day 7: 9.7±7.5P.u.; day 21: 8.9±5.5P.U.; day 28: 9.1±3.6P.U., P<0.05, One way RM ANOVA and Dunnett's method)

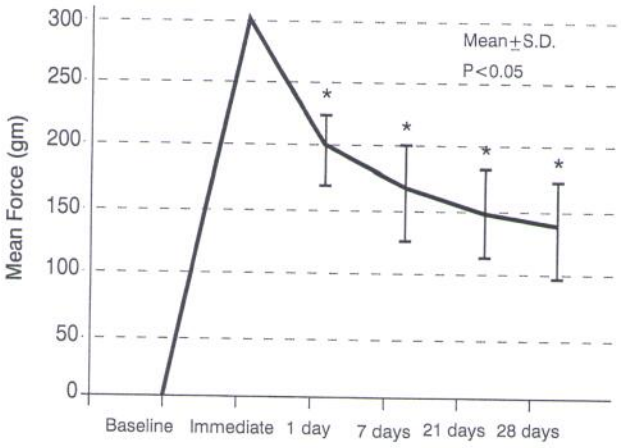

Fig. 5 The traction force significantly decreased at day 1, 7, 14, and 28 (baseline : 300±0 gm; after day 1: 196.7± 26.5 gm; day 7: 161.7±35.9 gm; day 21: 140±28.9 gm; day 28: 125±30.6 gm, P<0.05, One way RM ANOVA and Tukey's test)

Discussion

This experiment reported the pulp reaction of the patients' canines receiving a load of elastic chain for retraction. The length of the elastic chain was 5 rings of Ormco® power chain that produced approximately 300 gm of force at the beginning as in the clinical situation. It was indicated that the exposure of elastic chains to a simulated oral environment substantially alters their stress-relaxation characteristics. The effects of stressing elastic chain, such as when placing it on a bracket, introduced a permanent set of approximately 50% in the elastomer and significantly decreased its peak and residual force levels during stress-relaxation experiments. These changes in stress-relaxation characteristics may then have substantial consequences for the ability of the chains to initiate and maintain optimal rates of tooth movement.[15] As a result, this study showed the force initially decreased from 300 gm to 196.7 gm 24 hours later and lost approximately 10% of force on each following week.

The patients complained of slight pain in the first few days of loading the force on the teeth. This appeared to be a phenomenon, although the duration was variable, which often lasts for the first hours after fitting and, on occasions, the pain was prolonged for another few days. However, it has to be remarked that any pain induced was a combination of both periodontal and pulp reactions.[4]

The movement of the tooth by the orthodontic force was expected to produce a minimal reaction in the pulp. When the tooth was initially moved about one-third of the periodontal space, it was found that apical vessels were compressed and, hence, blood flows would reduce.[16] This further affected the pulpal blood supply by inducing inflammation and exudates capable of locally compressing vessels.[17,18]

This study showed that there was a significant increase in PBF on the 1st day after loading and through the 28th day. The PBF rose from the 1st day to the 14th day as a result of inflammation. After 14 days the PBF declined from the highest peak but the PBF on the 28th day was significantly higher than the baseline. It is possible that the traction force on the canines still remained, although the force of the elastic chain had decreased.

This result indicates that, in the clinical practice, there is alteration of pulpal blood flow in canines during traction period. The alteration will not induce vasoconstriction in pulpal tissue. In other words, there is an increase of blood flow caused by vasodilatation and inflammatory tissue reaction.

If the load applied by the appliance is more excessive than a major compromise to pulpal

perfusion, necrosis may take place. Subsequent to the reduction in blood flow there is often a reported phenomenon known as reactive hyperemia, capable of compensating for a lack of tissue perfusion. It is possible to hypothesize that if the loads applied to the teeth are sufficient to permanently compress the apical vessels then pulpal necrosis will occur.[19, 20]

Conclusions

It is concluded that the clinical practice of an initial loading of 300 gm of elastic chains on the canines increases blood flow and produces pulpal vasodilatation and inflammation. The pulpal blood flow increases most in the first week and decreases in the following weeks but not significantly near to the baseline on the 4th week.

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