The Rate of Corticotomy-assisted Orthodontic Tooth Movement toward Recent and Healed Extraction Sites in Rats

อัตราการเคลื่อนฟันร่วมกับการกรอกระดูกทึบเข้าสู่แผลที่เพิ่งถอนฟันและแผลถอนฟันที่หายดีแล้วในหนู

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ABSTRACT

To compare the rate of tooth movement, thirty two adult male Wistar rats were split mouth into corticotomy-assisted tooth movement toward recent and healed maxillary first molar extraction sites which then randomly divided into 4 subgroups depend on tooth movement period which consisted of 0,7,21 and 60 days. The midalveolar two-point decortications mesial to second maxillary molar were done and molar protractions were generated with nickel-titanium close coil spring. The mean rate of tooth movement after the corticotomies in every period was not significantly faster on the recent side than on the healed side. Therefore, corticotomy-assisted tooth movement could stimulate tooth movement toward different socket types. This might be advantage to consider appropriate timing of extraction and corticotomy which would be done together or separately.

บทคัดย่อ

การศึกษาครั้งนี้มีจุดประสงค์เพื่อเปรียบเทียบอัตราการเคลื่อนฟันร่วมกับการกรอกระดูกเข้าสู่แผลที่เพิ่งถอนฟันและแผลถอนฟันที่หายดีแล้วในปากเดียวกันในรูปแบบสปลิทเมาท์ (split mouth) โดยมีกลุ่มตัวอย่างหนูขาวใหญ่เพศผู้จำนวน 32 ตัว จากนั้นจึงแบ่งกลุ่มเป็นสี่กลุ่มย่อยตามช่วงเวลาที่ใช้ในการเคลื่อนฟันเป็น 0, 7, 21 และ 60 วัน หลังจากกรอกระดูกทึบกึ่งกลางสันเหงือกที่ถอนฟันกรามบนซี่ที่หนึ่งและให้แรงเคลื่อนฟันกรามบนซี่ที่สองมาทางด้านหน้าด้วยสปริงแบบปิด พบว่าอัตราการเคลื่อนฟันร่วมกับการกรอกระดูกทึบเข้าสู่แผลที่เพิ่งถอนและแผลถอนฟันที่หายดีแล้ว มีอัตราการเคลื่อนฟันที่ไม่แตกต่างกันในทุกๆช่วงเวลา จากการศึกษานี้สรุปได้ว่าการกรอกระดูกทึบสามารถกระตุ้นการเคลื่อนฟันเข้าสู่แผลถอนฟันที่ต่างชนิดกันได้ด้วยอัตราเร็วที่ไม่ต่างกัน ดังนั้นในการตัดสินใจแผนการรักษาในผู้ป่วยที่จำเป็นต้องได้รับการถอนฟันในการจัดฟันจึงสามารถทำก่อนหรือพร้อมกับการกรอกระดูกทึบได้

Key Words: Corticotomy, Extracted socket types, Rat

คำสำคัญ: การกรอกระดูกทึบ ชนิดของแผลถอนฟัน หนู

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Introduction

Corticotomy-assisted orthodontic tooth movement is surgical buccal and lingual cortical plate penetration with intact spongy bone. (Kole, 1959) This technique has been based on the concept to stimulate remodeling process as conventional orthodontic tooth movement, which called "regional acceleratory phenomenon (RAP)". This process activates temporary physiologic bone healing of injured tissue, buccal and lingual plate, and surrounding surgically treated tissue, bone marrow and periodontal ligament space that causes reduced bone density and remained bone matrix. (Frost, 1989) It is temporary stage of localized soft and hard-tissue remodeling that resulted in rebuilding of the injured sites to a normal state through recruitment of osteoclasts and osteoblasts via local intercellular mediator mechanisms involving precursors, supporting cells, blood capillaries and lymph. (Yaffe et al., 1994) There are many clinical case reports of decortications which accelerated tooth movement 3-4 times faster than conventional technique. (Wilcko et al., 2009; Wilcko, 2001)

As a result of corticotomy-assisted tooth movement's satisfactory results, histological background to describe and confirm this phenomenon have been examined. Sebaoun et al. (2008) reported the surgical injury to alveolus in the rat induced a three-fold increase in anabolic and catabolic remodeling by the third week after the corticotomy, while Wang et al. (2009) indicated that bone resorption production around moving teeth was raised up in 21 days after corticotomy. To measure rate of tooth movement, Mostafa et al. (2009) showed a double rate of tooth movement in dogs and observed increase in bone turnover and RAP phenomenon. In another animal study by Iino et al. (2007), the third molars were mesialized significantly faster than the control side in 12 dogs.

However there are many histological reports of corticotomy, most of them concentrate on recent extraction socket or non-extraction bone. In clinical application of extraction cases, which the priority purpose of tooth extraction is to reduce anterior teeth protrusion and to facilitate crowding correction; timing of extraction is also important consideration because of different socket bone feature and side effect of extraction timing. Even though tooth movement into recent sockets is advantageous on broader alveolar bone, decreased tendency of gingival invagination while in healed sockets have progressive horizontal atrophy of alveolar process. (Diedrich & Wehrbein, 2007) The delayed extraction to obtain recent extraction wound would be affected the anterior teeth proclination before canine retraction phase.

The concept of speed of orthodontic tooth movement into extraction site has still currently been controversial. A more accelerated tooth movement into recent site than into healed site has been reported. Tooth movement is increased from 1 mm/month to 6.5 mm/3 weeks in canine retraction into recent first premolar extraction socket by Liou and Huang (2008) report. Hasler et al. (1997) also found that in the activation period, tooth movement were more speedy into recent sites; however the total distance starting from the period of observation wasn't different in both groups. On the contrary, Diedrich and Wehrbein (2007) found greater tooth retraction velocity into healed socket than in recent socket which associated with low bone density, mature lamellar bone and gingival invagination in healed socket and high bone density, less mature lamellar bone in recent socket. In

animal study, Murphy (1970) observed the compression and tension area of 6 weeks healed and fresh sockets in monkeys. They concluded that there were more osteoclastic activities on compression site and new bone formation in healed sites; it could implies that tooth movement were more refrain into healed sockets than in recent sockets.

Therefore, the research question was focused whether corticotomy-assisted orthodontic tooth movement could stimulate the velocities toward different socket types.

Objective of the study

To compare the rate of tooth movement between recent and healed extraction sockets with corticotomy-assisted orthodontic tooth movement in rats at 0,7,21 and 60 days after orthodontic force application.

Methodology

This study was split mouth randomized control trial experimental design which had been approved by Animal Ethic Committee, Prince of Songkla University. Thirty two adult male Wistar rats, aged 3-4 months, weighing 150 to 250 grams were randomly divided into 2 groups (right or left side)

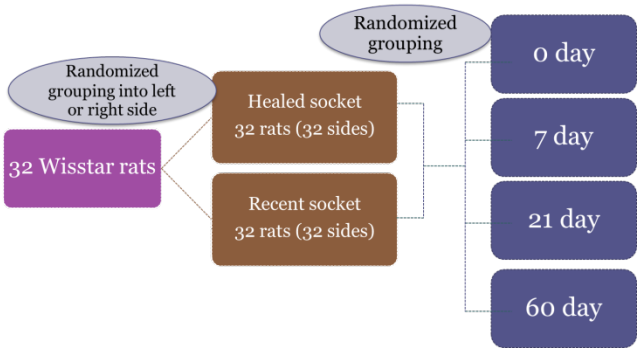
1. Heal socket group: extraction maxillary first molar at least 2 months until socket is completed healed before starting corticotomy + orthodontic tooth movement
2. Recent socket group: extraction maxillary first molar with corticotomy + orthodontic tooth movement

The sample size was calculated as one-tailed t-test formula based on the study of Sebaoun et al. (2008) and the sample size of each group was eight rats per group.

After randomly allocated the rats into 2 groups, then the thirty two Wistar rats in each group were randomly divided into 4 subgroups depend on the days after starting the corticotomy and orthodontic tooth movement

Therefore, there were 8 subgroups which were 4 subgroups of healed socket and 4 subgroups of recent socket. In each subgroup would contained 8 sides. (Diagram 1)

Diagram 1: study design in summary



The procedure of surgical and orthodontic were consisted of

1. Anesthetic protocol
2. Maxillary first molar extraction
3. Decortication protocol
4. Orthodontic protocol
5. Measurement of tooth movement

Step 1: Anesthetic protocol

Weighing the rat to calculate the dose of anesthetic drug and intramuscular injection at gastrocnemius muscle of 90 mg /kg of Ketamine hydrochloride (Ketaset III) and 10 mg/kg of Xylazine hydrochloride (AnaSed, Iowa) in ratio 7:3

Step 2: Maxillary first molar extraction

Elevated the molar with spatula number 7 and gentle extracted the first molar with artery forceps

Step 3: Decortication protocol

Five millmeters incision was done mesially to upper second molars, and then full-thickness periosteal flap was elevated and decorticated midalveolar ridge 2 points intramedullary in the size of 0.25 millimeters in diameter.

Step 4: orthodontic protocol

0.008-in ligature wires were placed at the second molar and incisors. The light nickel-titanium closed-coil springs (ORMCO) were extended 5 millimeters to generate 10 grams force.

Step 5: Measurement of tooth movement

Initially before begin surgical procedure, the impressions of initial reference models were taken with light body silicone.

The rate of tooth movement calculated by divided the distance between distal surface of second molar to mesial surface of third molar with days of protraction time. The amount of tooth movement was measured direct and indirect technique. The direct technique was measured with 0.01 millimeter accuracy veneer caliper intraorally, while the indirect technique was measured with reference model.

Statistical analysis

The statistical analysis was done to test normality with Shapiro-Wilk test which the data indicated nonparametric analysis. To compare the different between heal and recent socket group, Wilcoxon signed rank test was used. The determination of significant value was at $P < 0.05$.

Results

To confirm that the extraction procedure didn't affect the rats' health, weighting after extraction healed side was evaluated every 2 weeks. From descriptive data report, no any weight loss was detected and every sample was incremental increased in weight in twice month detection.

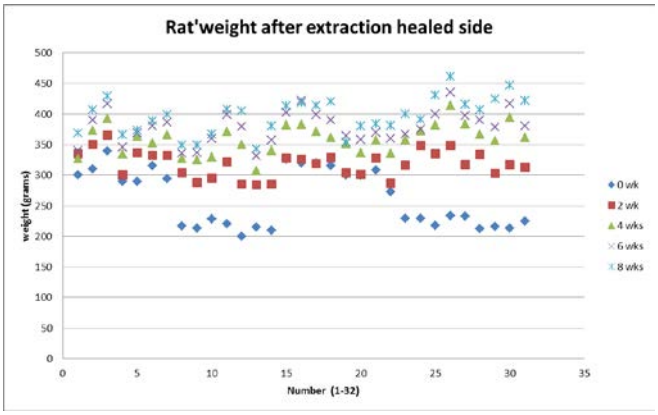


Fig 1 Rat's weight after extraction healed side (every 2 weeks)

Measuring the rate of tooth movement was tested the normality and indicated that the data distribution wasn't normal distribution. Therefore, the comparison between heal and recent socket group were non-parametric data. In the pretreatment phase, the mean distance between distal surface of second molar to mesial surface of third molar of both groups weren't significant different.

In the post-treatment phase, statistically, tooth movement velocities after the alveolar decortication 0,7,21 and 60 days were not significantly faster on the recent side than on the healed side.

Table 1 Comparison between the rates of tooth movement (mm /day) in post-treatment phase

Collection period group	Recent socket group (mm/day)	Healed socket group (mm / day)	P-value
0 day	0	0	0
7 days	0.035 ± 0.064	0.049 ± 0.71	0.345
21 days	0.029 ± 0.019	0.033 ± 0.024	0.500
60 days	0.018 ± 0.011	0.0089 ± 0.009	0.114

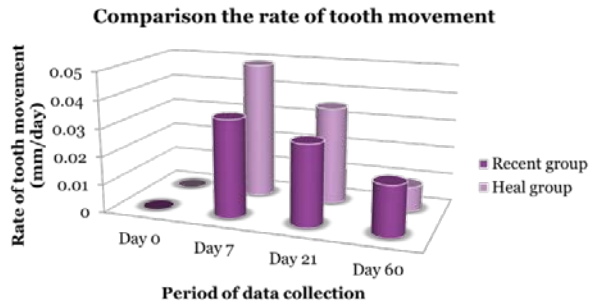


Fig 2 Comparison between the rates of tooth movement (mm /day) in post-treatment phase

Discussion

Selective alveolar decortication induces a localized increase in turnover of alveolar spongiosa which rising up the rate of tooth movement. However there haven't been any reports of decortication operated in recent compared with healed socket group. Most reports concentrated on corticotomy at edentulous area or recent extracted socket. Therefore, this study was stressed on comparison between the corticotomy assisted-tooth movement rates through the different socket types.

In the pretreatment phase, the distance between upper second and third molars weren't significantly difference which could be indicated that the preliminary data between two groups were similar. Moreover, the important thing to be considered was the upper second molars movement into the upper first molars extracted sites in the healed socket group before alveolar decortication which would impact on the measurement of tooth movement distances. Fortunately, the timing of tooth extraction wasn't affected the distance of tooth movement, thus the comparison could be done accurately.

To compare the rate of tooth movement in each time period, the consideration was based on the study of Astrand et al. (1969) to investigate the healing process of the molar extraction sockets in rats which there are three phases of healing. The first 1-5 days was blood clotting and granulation tissue formation phase. Then in the next 5-20 days, a bone formation phase was occurred. Finally a bone remodeling phase extended to complete bone healing was 20-60 days after the extraction. Therefore, in this study the seventh, twenty-first and sixty day were chosen to be presenter of each healing stage. Seventh day represents the peak of bone resorption, while the twenty first day represents the maximum bone formation. At last the sixty day refers to complete bone remodeling.

In the post-treatment phase, the velocities of tooth movement in each time period between recent and healed group weren't difference extended in short to long term period of tooth movement. This finding would be represented that the decortication could potentially induce a significant increase in tissue turnover in every period of alveolar bone healing as presented as regional accelerated phenomenon (RAP).

The rate of tooth movement had been reported in Beagle animal model (Kim et al., 2011). The six

maxillary incisors en masse retraction with and without perisegmental corticotomy against single palatal miniplate was done. The retraction was markedly faster and retraction amount greater in decorticate group which in average 0.07 mm/day when compare with control which was 0.0385 mm/day after 56 days retraction.

In addition, the incremental velocities measurement had also been done in beagles. (Ren et al., 2007) The extraction of mandibular second premolar and alveolar surgery to reduce the osteal resistance on the mesial side of the extracted socket were performed on the experimental side to compare with nonsurgical alveoloplasty. The first molar retraction with third molar anchorage in experimental side were faster than control side in every period of measurement which were first, second, third and fourth week. These results were coincided with the study of Mostafa et al. (2009) which the retraction of first molar was operated toward extracted second molar socket with mini-implant anchorage. The corticotomy-assited technique could double the rate of orthodontic tooth movement.

Although the tooth movement velocities had been reported in animal model, the sample size was limited less than 10 samples and the period of tooth movement was limited within one months. Therefore, our study was more reliable in method protocol which included the sample size calculation, period of study based on extracted bone remodeling period and be split mouth design. Moreover, the comparison of surgical assisted tooth movement toward different socket type hadn't been demonstrated.

For clinical application, the malocclusion such as anterior teeth protrusion or crowding, the extraction is needed to gain space. The appropriate treatment time of extraction is one factor to consider in treatment planning. For example, in crowding case which required extracted space, the timing of extraction first premolar would be extraction before or after the leveling phase. Therefore the socket wounds are different between recent and heal extraction sites. In healed socket, the tendency of alveolar ridge atrophy would happened which obstruct the tooth movement passing through this defect. On the other hands, waiting for extraction after leveling phase would cause anterior teeth proclination which would be unsatisfied for esthetic and the undesired direction of tooth movement.

From our study results, the timing of extraction mightn't be considered as indicated factor which affect the rate of tooth movement when combined with alveolar bone decortication. Consequently, the extraction and decortication time would be mainly depended on the treatment sequence which most effective to the patients.

Conclusion

Corticotomy-assisted tooth movement could stimulate tooth movement into heal extraction sites in the same rate as recent sites in animal study. This study might be advantage to consider appropriate timing of extraction and corticotomy which would be done together or separately.

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