A Histopathological Study of Physiologic Tooth Drift
(Mesio-distal Drift)

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Introduction

The stability of tooth position after orthodontic treatment is one of the purposes of the orthodontic treatment.

For the stability of dental arch, it is indispensable to keep the balance of forces and pressures from lips, cheeks, tongue, antagonists and neighbours. Dental arch changes due to a loss of this balance have been reported in previous literature.

Under the physiologic condition, it is generally known that teeth after eruption must have drifted toward one direction, as it were physiologic tooth drift. In case of humans the direction is said to be mesial and elongated. However physiologic tooth drift after eruption must participate in the tooth position after orthodontic treatment but little is reported about the mechanism of the physiologic tooth drift.

The purpose of this study is to research the influence of the forces presumed to be participating in physiologic tooth drift over the alveolar bone (cheeks, tongue, antagonists, neighbours and gingival fibers group) on the tooth drift histopathologically.

Materials and Methods

Twenty-two adult dogs (10–15kg body weight) were used in the experiment. The procedure of experiment is shown in Figure 1. The exact ages of the animals were not determined, and sex differences were not considered, and no significant weight changes occurred during the experimental period.

![Fig. 1 Experimental design](image-url)
Before the beginning of the experiment, lower right 1st molar was prepared as the abutment tooth for the cheek-and-tongue guard under anesthesia (solution of sodium pentobarbiturate injected intravenously). Alginate impressions were taken of each animal and plaster casts were made. Using these casts, cheek-and-tongue guards were made with 12 per cent gold-silver-paradium alloy.

At the beginning of the experiment, upper right 1st, 2nd molars, lower right 3rd molar and the distal root of the 1st molar were extracted under anesthesia. The gingival fibers group around the 2nd molar was cut down to the bone with a scalpel (Fig. 2). To eliminate the effect of the tongue, cheeks and occlusal force on the lower right 2nd molar, the guard was applied with the mesial section of the 1st molar as the abutment tooth but not touching 2nd molar (Figs. 3, 4). Seventeen dogs were divided into 4 experimental groups, each with observation periods at 7- 30- 60- and 90 days after appliance setting. The other 5 dogs were employed as the control group without extractions or appliance setting for the 90-day period.

All animals were injected with oxytetracycline, alizarin komplexon and calcein vital staining as follows;

7 days before start : Oxytetracycline (OTC) 25mg/kg
7 days after start : Alizarine komplexon (AK) 30mg/kg
30 days after start : Calcein (CAL) 10mg/kg
60 days after start : Alizarine komplexon (AK) 30mg/kg
90 days after start : Calcein (CAL) 10mg/kg

At the end of the study period, the animals were killed with an overdose of Pentothal Sodium, and the lower jaws were separated from the skull. They were then routinely fixed in 10 per cent buffered formalin. Specimens were then dissected out en bloc, each bloc containing the experimental tooth (M21), or non-experimental tooth (M22), and its surrounding tissues. The specimens were dehydrated by aetheton, and embedded in polyester resin without a previous step of decalcifying. Mesio-distal sections of the specimens were cut on a ‘thin sectioning machine (Type CT-1)’. The sections were microradiographed first on a soft X-ray unit, and then microphotographed under the fluorescence microscope to observe the labelling sites. The sections were stained with methylene-blue and fuchsin, and examined under the microscope.

The changes occurring on the right (experimental side) and left (non-experimental side) 2nd molars and periodontal tissues were compared with those of controls.

**Results**

A. Control group

The alveolar bone surrounding the control tooth did not exhibit definable fluorescence on the surface of the socket wall. Only in the Harversian canal the fluorescent line was observed. The microradiography and staining sections showed the stabilized alveolar bone (Figs. 5, 6, 7).
B. 7 days group  
The supporting bone which surrounded the sockets of the experimental and non-experimental teeth demonstrated only slight fluorescence, but the findings of microradiography were almost identical to those of the control section.

C. 30 days group  
<Experimental side> Fluorescent lines were observed in the surfaces of the distal socket wall and in the mesial bone to the mesial root (Fig. 8), while low calcifying area was observed, not in the distal bone to the distal root, but in the mesial bone to the mesial and distal roots (Fig. 9). In the periodontal tissues, many expanded blood vessels were observed (Fig. 10).

<Non-experimental side> Slight fluorescent lines were observed, in part of the socket (Fig. 11), and the microradiography demonstrated the same calcifying degree as in the control (Fig. 12). In the periodontal tissues, increased blood vessels were observed, but not as many as in the experimental side.

D. 60 days group  
<Experimental side> Well-defined fluorescent lines were observed on the mesial socket wall and on the interradical septum, parallel to the mesial and distal roots, and initial fluorescent lines were partly intermittent with bone resorption (Fig. 13). The low calcifying area was seen in the new bone between 30 to 60 days during the experiment in microradiography (Fig. 14). Marked trabeculation of the mesial socket wall was shown in the staining section (Fig. 15).

<Non-experimental side> Narrow fluorescent lines were observed on the mesial surface of the socket (Fig. 16), but the low calcifying area was not shown in the microradiography (Fig. 17).

E. 90 days group  
<Experimental side> The distal drift was observed on the experimental side as other groups. The new bone between 60 to 90 days was less than that between 30 to 60 days (Fig. 18). In the microradiography the low calcifying area was less than that of 60-day experimental side (Fig. 19).

<Non-experimental side> The slight fluorescent line was seen in the mesial surface of the mesial socket (Fig. 20), but the alveolar bone appeared relatively stabilized in the microradiography.

Discussion

I. Previous studies about physiologic tooth drift  
In human dentitions, attrition of the contact points and reduction of the dental arch length in proportion to growing older are well-known. Black (1908) \(^1\) and Lysell (1958) \(^2\) explained that these phenomena were caused by the mesial drift of the tooth after the eruption. Ainamo and Talari (1975) \(^3\) pointed out the tooth elongation with the mesial drift. In the investigation of Australian aborigines, Begg (1954) \(^4\) suggested
that the reduction of the dental arch length and the mesial drift were recognized in the
dentition with severe attrition and abrasion.

In other animals, tooth drift as in human is a well-known phenomenon. Hotta (1979)\textsuperscript{5} observed the permanent tooth drift after eruption in dogs.

The cause of the tooth drift, especially mesial and distal, was studied. Some causes
were as follows.

1. The forces at biting.
2. The inclination of the tooth axis.
3. The pressures from the surrounding soft tissues (cheeks and tongue)
4. The pressures by the distal molar eruption and the jaw growth.
5. The tension of the transseptal fibers.

About these notions Moss and Picton (1967)\textsuperscript{6}, using adult monkeys, reported that
biting force was not a cause of mesial drift. And Moss and Picton (1970)\textsuperscript{7} also reported
that cheeks and tongue pressures were not important factors of tooth drift, because the
resin cap was set for an experimental tooth to eliminate the cheek and tongue pressures
and clear difference was not observed between the experimental tooth and non-experi-
mental one. Sicher and Weinmann (1944)\textsuperscript{8} reported that distal drift of rat molars was
caused by the jaw growth. About transseptal fibers, Picton and Moss (1973)\textsuperscript{9} and Moss
and Picton (1974)\textsuperscript{10} using the hemisection tooth of macaca monkeys reported that parts
of tooth drifted together with cutting of the fibers, but parts of tooth separated from
each other without cutting them. They suggested that the transseptal fibers participated
in tooth drift. About relapse after rotation movement of dog tooth, though Reitan (1958)\textsuperscript{11}
and Schultz (1968)\textsuperscript{12} supported the effect of cutting transseptal fibers, some reports\textsuperscript{13}
were against it and a unified conclusion was not obtained.

At present the physiologic tooth drift is not explained totally by any one of these
causes. In this study, we investigated the tooth movement when all the factors
considered to participate in the physiologic tooth drift (occlusal force from antagonists,
contact force from neighbour teeth, forces from surrounding soft tissues and the tension
of the transseptal fibers) were eliminated and the tooth was left standing alone. The
previous studies were not sufficient, since they concluded that the forces affected the
tooth position, without referring to the tooth movement when all forces were eliminated.

In this study, we found the distal and elongation movements by eliminating the forces
presumed to be participating in physiologic tooth drift over the alveolar bone. In order
to study the forces participating in physiologic tooth drift over the alveolar bone, we
believe that conclusions can be made on each force after observing the tooth movement
over the alveolar bone with all supposed force eliminated, and then the individual force
added.

I. Histopathological changes in time

In the gingiva experimented, the inflammatory cells which were not recognized in the
control and the non-experimental gingiva increased in the lamina propria after appliance
setting. This change probably originated not from the tooth drift but from the decline in oral hygiene resulting from appliance setting.

In the periodontal ligament, the width of ligament was different in all animals, and there was no definite tendency. At 7 days the Sharpey's fibers were irregular, and expanded blood vessels were observed. This tendency further increased at 30 and 60 days and recovery to normalcy was not observed even at 90 days.

In the alveolar bone, the rough surface was recognized on the mesial socket at 30 days, and at 60 days the pillar from based on the new bone formation was recognized.

The tooth drift tendency judged from these findings was also recognized in the labelling method and the microradiography.

The experimental tooth (extracting the antagonists and neighbour teeth, setting the cheek-and-tongue guard and cutting the gingival fibers group) drifted to the distal and occlusal directions clearly. The fact that this drift still continued at 90 days is in agreement with the report of Konoo (1988)\(^2\) (observing the premolar elongation with the cheek-and-tongue guard setting).

**Summary and Conclusion**

Although it is generally known that human teeth must have drifted after eruption toward the mesial direction, little has been reported on the physiologic tooth drift. The purpose of this study is to research the influence of the forces presumed to be participating in the physiologic tooth drift over the alveolar bone (cheeks, tongue, antagonists, neighbours and gingival fibers group) histopathologically.

Twenty-two adult dogs with permanent dentitions were selected. The upper right 1st, 2nd and lower 3rd molars, and lower right distal root of 1st molars were extracted. A cheek-and-tongue guard for lower 2nd molar was applied with the mesial section of lower 1st molar as the abutment tooth. Four experimental groups with 3 dogs or more per group were investigated at 7-, 30-, 60-, and 90-day intervals after appliance setting. Other 5 dogs were used as the control without extractions and appliance setting for the 90-day period.

Upon completion of the experimental period, the changes occurring in the right and left 2nd molars and in the periodontal tissues were investigated histopathologically and compared with those of controls.

The results obtained were as follows:

1. Setting the appliance to eliminate the antagonists, neighbour teeth, soft tissues and cutting the gingival fibers group displaced the teeth on the experimental side and caused changes in the periodontal tissues but did not displace obviously in the non-experimental side.

2. The direction of the tooth drift was mainly distal and elongation on the experimental side.

3. The tooth drift was observed at 7 days histopathologically and the tooth drift due
to elimination was observed at 30 days in the fluorescent findings after appliance setting.

4. The peak of alveolar bone changes to adapt to the tooth drift was observed at 30 and 60 days after the appliance setting, and stabilization of the alveolar bone in the new tissue environment was not yet observed at 90 days after appliance setting.

The above results histopathologically substantiate that some or all forces presumed to be participating in physiologic tooth drift (the soft tissues, antagonists, neighbour teeth and gingival fibers group) have something to do with the tooth drift as the inhibitory force. The results also prove histopathologically that the forces from these factors are indispensable to the stability of tooth position after orthodontic treatment.

References


歯の生理的移動についての実験的研究
(近遠心的移動について)

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ヒトの歯は萌出後も常に近心方向へ移動すると言われているにもかかわらず、いわゆる生理的歯牙移動についても、ほとんど報告がなされていない。本研究の目的は、対合歯、隣在歯、軟組織（顎、舌）の gingival fibers group が歯の移動に及ぼす影響について病理組織学的に解明することにある。

実験には22頭の成犬を用い、下顎右側第2後臼歯を実験歯として、対合歯（上顎第1，第2後臼歯）、隣在歯（下顎第1後臼歯遠心根，第3後臼歯）を抜去した。下顎第1後臼歯の近心根を支台として実験歯にかかる顎・舌圧を排除する装置を装着した。実験動物は実験群17頭を各経日最低3頭の4群に分けた。また、残る5頭は対照群として90日間飼育した。実験終了後、下顎右側（実験側）・左側（非実験側）第2後臼歯の歯周組織と対照群を比較観察し、次の結果を得た。

歯槽骨上で歯の生理的移動に関与していると考えられる口腔周囲軟組織、隣在歯、対合歯および gingival fibers group 等より歯に加わる圧や力を排除することによって、実験側では、歯周組織に変化を伴いながら歯は移動したが、非実験側では実験側と比較して明らかな移動はみられなかった。実験側における歯の移動形式は、遠心移動および鈍出移動が主体であった。歯の移動に伴う歯槽骨の改造は、装置装着後30、60日目で最も著明に認められ、90日目でも歯槽骨は安定しているとは認められなかった。

以上の結果は、歯槽骨上で歯を動かすと考えられる口腔周囲軟組織、隣在歯、対合歯および gingival fibers group 等のうち、いくつかの外力が歯の移動に対して抑止的な力として深く関与していることを示すものである。これらから受ける力が矯正治療後の歯列弓の安定に不可欠な因子であることを病理組織学的に示唆するものである。
Fig. 2 After extractions the gingival fibers group around the 2nd molar was cut down with a scalpel.

Fig. 3 The cheek-and-tongue guard

Fig. 4 The cheek-and-tongue guard was applied but not touching the 2nd molar.

Fig. 5 Control group fluorescent microscopic photograph ×3
M: mesial  D: distal

Fig. 6 Control group microradiography ×3

Fig. 7 Control group marginal area, mesial side of 2nd molar. methylene-blue & fuchsin staining ×13
Physiologic Tooth Drift (Fujita, et al.)

Fig. 8 30 days experimental tooth
fluorescent microscopic photograph ×3

Fig. 9 30 days experimental tooth
microradiography ×3

Fig. 10 30 days experimental tooth
marginal area, mesial side of 2nd molar
methylene-blue & fuchsin staining ×13

Fig. 11 30 days non-experimental tooth
fluorescent microscopic photograph ×3

Fig. 12 30 days non-experimental tooth
microradiography ×3
Fig. 13  60 days experimental tooth
fluorescent microscopic photograph ×3

Fig. 14  60 days experimental tooth
microradiography ×3

Fig. 15  60 days experimental tooth
marginal area, mesial side of 2nd molar
methylene-blue & fuchsin staining ×13

Fig. 16  60 days non-experimental tooth
fluorescent microscopic photograph ×3

Fig. 17  60 days non-experimental tooth
microradiography ×3
Physiologic Tooth Drift (Fujita, et al.)

Fig. 18  90 days experimental tooth fluorescent microscopic photograph ×3
Fig. 19  90 days experimental tooth microradiography ×3
Fig. 20  90 days non-experimental tooth fluorescent microscopic photograph ×3