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Original Article

Velocity of Canine Retraction in Angle Class I Treated with First Premolar Extraction: Effect of Facial Pattern

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Abstract

Recently, new methods have been applied to increase velocity of tooth movement. A standard mean of tooth movement velocity remains to be established, however. Moreover, to our knowledge, no studies have investigated the effect of factors affecting this velocity. The aim of the present study was to investigate the effect of facial pattern on the mean velocity of canine retraction in selected cases of orthodontic treatment carried out at this hospital. A total of 112 patients with Angle Class I crowding treated with extraction of the bilateral maxillary and mandibular first premolars and a conventional edgewise bracket were selected at random. The canine retraction period was defined as that between the end of leveling and the beginning of anterior retraction, and was obtained from medical records. Calipers were used to measure how far the canine cusps moved between pre- and post-surgically on superimposed cephalometric tracings. The velocity of canine retraction was significantly slower in the maxilla of male patients with a brachyofacial pattern ($p<0.01$). Canine retraction is the longest stage of orthodontic treatment. Here, movement was slowest in the maxilla of male patients with a brachyofacial pattern. This indicates that treatment may take longer than average in male patients with a brachyofacial pattern, and that this should be explained prior to commencing such work.

Key words: Velocity — Canine retraction — First premolar extraction — Facial pattern

Introduction

In orthodontic treatment involving tooth extraction, the part that takes the longest to complete is canine retraction. Recent studies have investigated the relationship between velocity of canine retraction and friction[20,25]. Various types of orthodontic appliance have been developed aimed at increasing the velocity of tooth movement. One study found that the low friction bracket was successful in this respect[8]. Another study, however, found no difference between this type of bracket and the conventional pre-adjusted type[24],

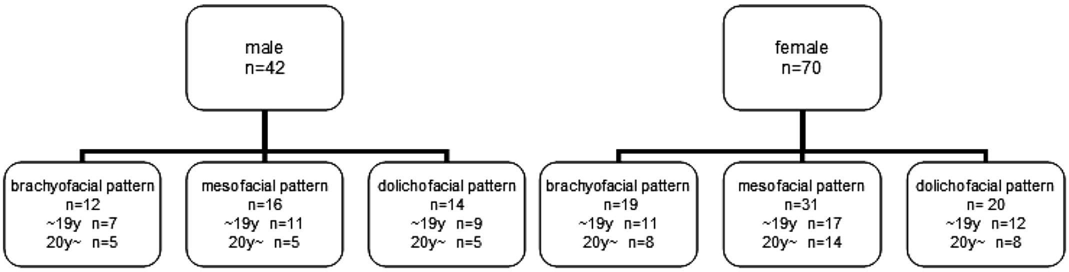

Fig. 1 Distribution of sex and facial pattern among total patients

while another reported that the low friction bracket was even slower[4]. A number of other approaches have also been taken to solving the problem of how to increase velocity, including the use of a low-level laser[30] and corticotomy[1] in conjunction with orthodontic treatment. As yet, however, few of these approaches have achieved widespread clinical application.

Sliding or closing loop mechanics are usually employed in the conventional edgewise technique for canine retraction in cases of tooth extraction. The results of this technique, however, have been inconsistent, as have the conditions imposed in studies investigating it[3,9]. There have also been attempts to perform efficient anterior retraction through combining canine retraction with an orthodontic anchor screw[31].

The velocity of tooth movement is influenced by a number of factors, including muscle strength and occlusal force. However, while males and patients with a brachyofacial pattern are reported to have strong muscles and occlusal force[2,7,18,27,29], few studies have investigated the relationship between such factors and velocity of tooth movement. This suggests the need for more data on these phenomena to aid in our understanding of the mechanics underlying tooth movement. Moreover, we believe that a detailed study of canine retraction in full orthodontic treatment involving extraction of the first premolars would be particularly useful in this respect, as well as to future studies on tooth movement.

The purpose of the present study was to investigate the effect of facial pattern on the mean velocity of canine retraction in randomly selected cases of orthodontic treatment carried out at this hospital.

Materials and Methods

1. Study design

A total of 112 patients treated at the Department of Orthodontics of the Tokyo Dental College Chiba Hospital between 1990 and 2009 were selected at random for participation in the study. A diagnosis of Angle Class I crowding was made in all of these patients. Treatment involved extraction of the bilateral maxillary and mandibular first premolars in all cases. A 0.018 or 0.022 slot edgewise bracket was used. The slot was conventional and not a self-ligating system. No orthodontic anchor screw was used. The patients comprised 42 male and 70 female with age ranging from 10 years 2 months to 53 years 7 months (mean age, 31 years 4 months). The facial patterns were as follows: brachyofacial, 31 (12 male, 19 female); mesofacial, 47 (16 male, 31 female); and dolichofacial, 34 (14 male, 20 female) (Fig. 1). Facial pattern was classified according to the Ricketts VERT index (chin in space)[15,26]. This index categorizes the vertical facial pattern using the facial axis, facial depth, mandibular plane, lower facial height, and mandibular arc as follows (Fig. 1):

Facial axis: angle of intersection of line Pt-Gn and line N-Ba.

Facial depth: angle of intersection of facial plane and Frankfort horizontal plane.

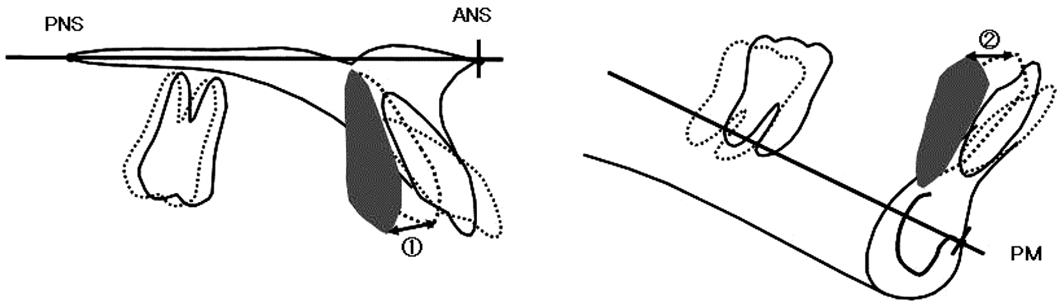

Fig. 2 Trace superimposition pre- (dotted line) and post-surgically (solid line)
Maxilla: superimposed on palatal plane at ANS; ① shows measurement of mesiodistal distance between canine cusps.
Mandible: superimposed on mandibular symphysis at PM; ② shows measurement of mesiodistal distance between canine cusps.

Mandibular plane: angle of intersection of mandibular plane and Frankfort horizontal plane.

Lower facial height: angle of intersection of ANS-Xi-Pm.

Mandibular arc: angle of intersection of mandibular and condylar axes.

The canine retraction period, defined as that between the end of leveling and the beginning of anterior retraction, was determined from medical records.

Calipers were used to measure how far the canine cusps moved between pre- and post-surgically on superimposed cephalometric tracings. The maxilla was superimposed on the palatal plane at ANS and the mandible on the mandibular symphysis at PM (Fig. 2). The velocity of canine retraction (mm/month) was calculated by dividing canine movement distance by canine retraction period as follows: Velocity of canine retraction = mesiodistal distance between canine cusps (measured value)/duration of treatment (months). This study was approved by the Tokyo Dental College Ethics Committee (approval no.284).

2. Statistical analysis

The patients were divided into 6 groups by sex and facial pattern. The Kruskal-Wallis *H*-test and Mann-Whitney *U*-test were used to evaluated velocity of canine movement during retraction (mm/month) between the maxilla and the mandible, male and female, and type of facial pattern.

Results

The mean duration of overall orthodontic treatment was 28 (±11) months. The leveling period was approximately 5 months, the canine retraction period approximately 8 months, the anterior retraction period approximately 7 months, and detailing period approximately 6 months.

The velocity of canine retraction in the male maxilla by facial pattern was as follows: brachyofacial, 0.24 (±0.01) mm/month; mesofacial, 0.89 (±0.03) mm/month; and dolichofacial, 1.00 (±0.04) mm/month. In the male maxilla, the velocity was significantly slower with a brachyofacial than a mesofacial or dolichofacial pattern ($p<0.01$); no significant difference was observed between the mesofacial and dolichofacial patterns. The velocity of canine movement was almost the same between the mesofacial and dolichofacial patterns. The velocity of canine retraction in the male mandible by facial pattern was as follows: brachyofacial, 0.40 (±0.01) mm/month; mesofacial, 0.86 (±0.03) mm/month; and dolichofacial, 0.71 (±0.04) mm/month (Fig. 3).

The velocity of canine retraction in the female maxilla by facial pattern was as follows: brachyofacial, 0.55 (±0.01) mm/month; meso-

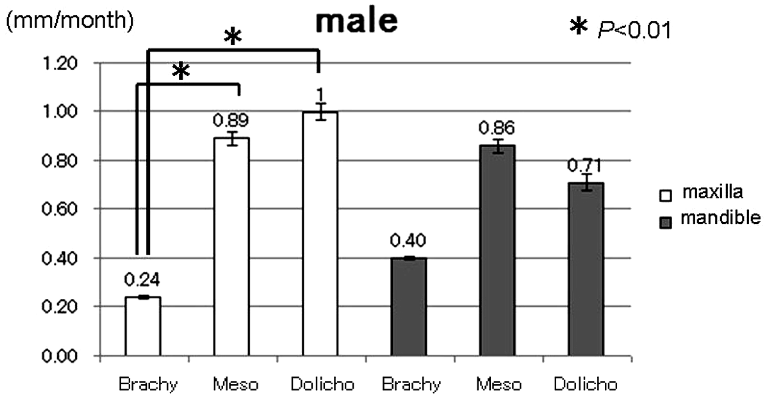

Fig. 3 Velocity of canine retraction (mm/month) in male patients

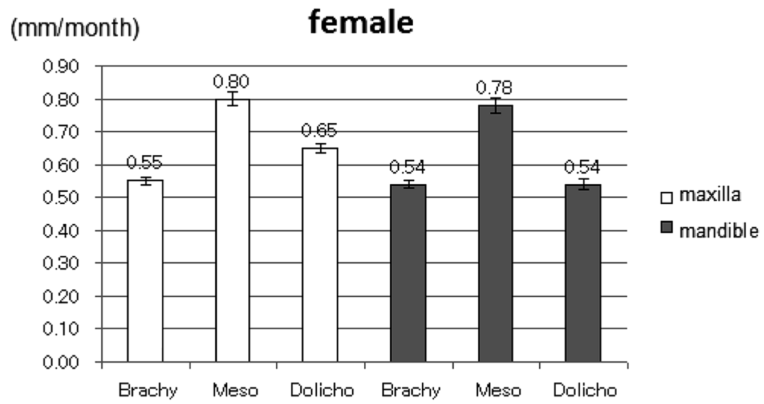

Fig. 4 Velocity of canine retraction (mm/month) in female patients

facial, 0.80 (±0.02) mm/month; and dolichofacial, 0.65 (±0.01) mm/month. Thus, the mesofacial pattern showed the greatest velocity, followed by the dolichofacial and then brachyofacial, but no significant difference was observed. The velocity of canine retraction in the female mandible by facial pattern was as follows: brachyofacial, 0.54 (±0.01) mm/month; mesofacial, 0.78 (±0.02) mm/month; and dolichofacial, 0.54 (±0.02) mm/month. Thus, the mesofacial pattern showed the greatest velocity, but no significant difference was observed (Fig. 4).

The velocity of canine retraction in the maxilla in all patients was as follows: brachyofacial, 0.43 (±0.01) mm/month; mesofacial, 0.83 (±0.02) mm/month; and dolichofacial, 0.79 (±0.02) mm/month. The velocity in the mandible in all patients was as follows: brachyofacial, 0.49 (±0.01) mm/month; mesofacial, 0.80 (±0.02) mm/month; and dolichofacial, 0.61 (±0.03) mm/month. Thus, the brachyofacial pattern showed the lowest velocity in both the maxilla and mandible (Fig. 5).

Discussion

1. Methods, data, patients

All the patients enrolled in this study were classified as cases of Angle Class I. The bilateral maxillary and mandibular first premolars were extracted in all cases. Although there were higher proportions of females

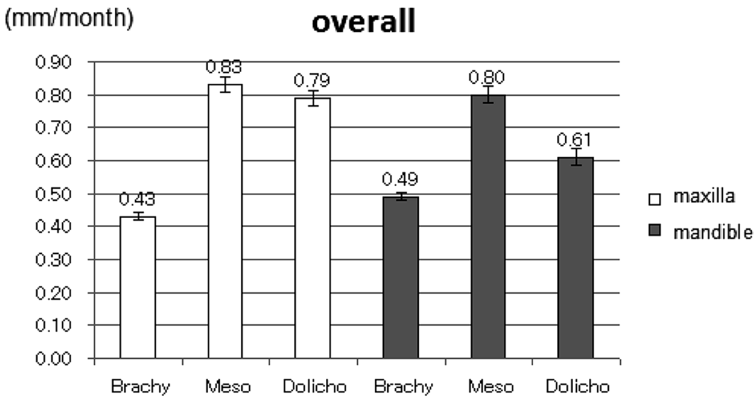

Fig. 5 Velocity of canine retraction (mm/month) in total patients of both sexes

and teenagers among this sample, attempts were made to balance patient characteristics as much as possible with regard to sex, age, and facial pattern.

2. Study period

Lai *et al.* reported that the mean duration of orthodontic treatment was 26 (±4) months[21]. However, Hamilton *et al.* found that the mean duration of orthodontic treatment was only 15.9 (±6) months with conventional pre-adjusted brackets and 15.6 (±5) months with self-ligating brackets based on statistics from cases of orthodontic treatment including extraction and non-extraction cases[11].

The mean duration of orthodontic treatment in the present study was 28 (±11) months, with a breakdown of approximately 5 months for leveling, approximately 8 months for canine retraction, approximately 7 months for anterior teeth retraction, and approximately 6 months for detailing. This suggests that canine retraction accounts for a large proportion of the treatment period in Angle Class I crowding treated with extraction of the bilateral maxillary and mandibular first premolars. If so, being able to calculate the velocity of tooth movement in the canine retraction period would help predict the total duration of treatment in extraction cases.

3. Sex, age, and other factors

Sex is a factor in determining occlusal force, with male generally considered to generate higher occlusal force than female due to differences in the size of the muscles and teeth[32].

The masseter muscle has a greater diameter and cross-section in male than in female. Moreover, hormones also have a bearing on the organization of the muscle fibers[18,29]. Other studies have reported greater density in bones subjected to mechanical stress, suggesting that higher occlusal force will result in greater bone density, with the result that more time is needed for the remodeling associated with tooth movement[6,12,13,19,22,23]. There has also been research to investigate whether BMI is related to occlusal force, but many studies have found no significant difference[18,29]. Young patients have been reported to exhibit greater distance of movement over the same period than adult patients[16]. This is probably because bone remodeling takes longer in adults than in younger individuals due to declining metabolism[5,14].

4. Facial pattern

Some studies have investigated the relationship between vertical facial pattern and anatomical structure and function of the masticatory muscles. Individuals with thick masseter muscles are reported to have vertically short faces[10,28], suggesting a correlation between the two. Tooth velocity was found to be slower in patients with a brachyofacial pattern in the present study. Tripathi *et al.* found that patients with a brachyofacial pattern had a strong bite force[32]. Moreover, Kim *et al.* noted that cortical bone was thinner in patients with a dolichofacial than brachyofacial pattern[17]. Taken together, this indicates that tooth movement will be slower in patients with a brachyofacial than dolichofacial pattern, as cortical bone is thicker and bone mineral density higher in the former.

The present results suggest that the velocity of maxillary tooth movement in male patients with a brachyofacial pattern is low due to the thickness of the cortical bone and high degree of occlusal force. The results also suggest that there is no difference between the mesofacial and dolichofacial patterns. In the male mandible, however, there was no significant difference between types of face, although velocity was lowest in patients with a brachyofacial pattern. This implies that facial pattern is not a determining factor in tooth velocity in the mandible. In female, although velocity was lowest in those with a brachyofacial pattern, the differences due to facial pattern were small. This is probably because the differences in functional factors were smaller in the female than the male patients.

The above findings showed that velocity was lower in patients with a brachyofacial pattern, suggesting that a longer treatment period is required in this group.

Conclusion

The canine retraction stage is the longest in the process of orthodontic treatment. Here, the velocity of canine retraction was lowest in the maxilla in male patients with a brachyofacial pattern. Very little difference was observed in velocity based on facial pattern among female patients. The difference was also only very slight in the mandible, regardless of sex or facial pattern. Taken together, this indicates that treatment may take longer than average in male patients with a brachyofacial pattern, and that this should be explained prior to commencing such work.

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Conflict of Interest

There is no conflict of interest in this study.

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