Original Article

A Formula to Determine the Amount of Retraction of Mandibular Canines

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Abstract: Moderate to severe protrusion of anterior teeth often necessitates the extraction of 4 premolars to retract anterior teeth into their space. We present a formula that determines how far the mandibular canines should be retracted to provide adequate space for correction of lower incisor protrusion. To test the accuracy of the formula, 23 mandibular setups were made and the results of the formula were compared with those of the setups. Paired *t*-tests at a confidence level of 95% did not show any statistically significant differences between the results. (*Angle Orthod* 2000;70:154–156.)

Key Words: Formula; Incisor protrusion; Canine retraction; Cephalometric correction factor; Diagnostic setup

INTRODUCTION

The retraction of anterior teeth is a critical part of extraction treatment and should be precisely controlled. In the case of protrusion, different strategies are used to reinforce anchorage.[1] When the anterior teeth are already upright, other strategies are employed to minimize incisor retraction.[2] But how far should the canines be retracted to provide sufficient space for incisor retraction?

Until now, many different geometric forms and mathematical functions have been proposed as mathematical models of the human dental arch. These include the ellipse,[3,4] parabola,[5,6] Bonwill-Hawley model,[7,8] modified spheres,[9] trifocal ellipse,[10] catenary,[11–14] cubic spline function,[15,16] other polynomial functions,[17,18] and beta functions.[19]

In all of these models, the curvature of archwire between canine and first premolar is so slight that this portion of archwire can be considered as a straight line. It is possible to consider the curvature of this portion of the arch and go on with calculations, but the final formula would be too complex for clinical use.

Considering this part of archwire as a straight line introduces a very small error into the calculations, but allows for derivation of a simple final formula that can be used by clinicians.

MATERIALS AND METHODS

When the canine is retracted toward the position previously occupied by the first premolar, it moves posteriorly and laterally at the same time. The posterior movement of the canines provides space for retraction of incisors and the lateral movement of the canine increases intercanine width. This lateral movement provides additional space for potential incisor retraction.

In Figure 1, it is supposed that the needed amount of canine retraction is equal to CC′. Therefore the anterior teeth would be retracted a distance as great as CC′ Cos a and the increase in intercanine width would be equal to 2 CC′ Sin a. This increase can retract the anterior teeth as great as 2KCC′ Sin a. The values of K are shown in Table 1.[20]

If the desired amount of incisor retraction is shown by IR, it can be said that

$$IR = CC' \text{ Cos } a + 2KCC' \text{ Sin } a \quad \text{or}$$

$$CC' = \frac{IR}{\text{Cos } a + 2K \text{ Sin } a}.$$

Now the final formula can be written as follows:

Canine Retraction

$$= (2K \text{ Sin } a + \text{Cos } a)^{-1}(\text{desired incisor retraction}).$$

To test the accuracy of the formula, 23 mandibular casts were selected. Each cast contained 14 teeth without any anterior crowding, asymmetry or midline deviation. The casts exhibited different degrees of incisor protrusion. The 6 anterior teeth and the first premolars were removed from the casts and reset on the casts with different amounts of retraction in comparison with their primary positions. The

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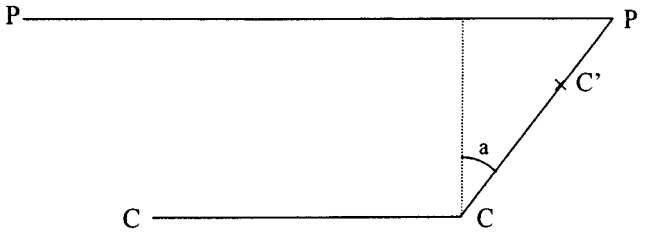

Figure 1. C indicates distal contacts of lower canines before retraction, P: Distal contacts of lower first premolars before canine retraction; C′, distal contact of canine after retraction. In this figure, sin a = [(pp − cc)/2cp].

Table 1. Different Values of *k*

AAP[a], mm	*k*
AAP ≥ 36.5	0.622
30.7 < AAP < 36.5	0.655
AAP ≤ 30.7	0.714

[a] AAP indicates anterior arch perimeter. The AAP is the sum of the mesiodistal widths of 6 anterior mandibular teeth.

canines were distalized to provide space for incisor retraction. The distance between canine cusp tip and buccal cusp tip of second premolar was measured before and after setup to determine the amount of canine retraction. The distance between the mesial contact of the central incisors and a line connecting the buccal cusp tips of the second premolars was also measured before and after the setups to determine the amount of incisor retraction.

In order to calculate the values of Sin a and Cos a, the distances between the distal contacts of the canines, distal contacts of first premolars and canine-first premolar distal contacts were measured before setup. Each distance was measured by 2 operators with a linear accuracy of 0.1 mm. When there was a difference between the measurements of the 2 operators, the mean value was used.

RESULTS

The results are shown in Table 2. The mean difference between the calculated and measured distances was less than 0.2 mm (SD < 0.3 mm). Paired *t*-test at confidence level of 95% did not show a statistically significant difference between the results of the formula and setups.

DISCUSSION

With the introduction of implants for anchorage reinforcement, it is possible to precisely control orthodontic tooth movement. Therefore, calculations can help us determine the anchorage requirements of patients. For example, suppose that mandibular first premolars are extracted to correct 4 mm of anterior crowding and 5 mm incisor protrusion in an average-size mandible. Suppose that the intercanine width, interfirst premolar width, canine-first premolar distance and mesiodistal width of the first premolars are 25, 35, 6.5, and 7 mm, respectively. In this patient,

Table 2. Calculated Data for 23 Mandibular Casts

Number of Cast	Formula-Based Canine Retraction, mm	Setup-Based Canine Retraction, mm	Difference, mm
1	1.9	2.3	0.4
2	1.5	1.8	0.3
3	2.1	2.0	−0.1
4	1.5	1.2	−0.3
5	2.5	2.8	0.3
6	2.3	2.5	0.2
7	1.8	2.0	0.2
8	1.2	1.0	−0.2
9	2.3	2.7	0.4
10	2.1	2.6	0.5
11	2.3	2.8	0.5
12	2.6	2.7	0.1
13	2.9	2.7	−0.2
14	3.1	2.5	−0.6
15	2.0	2.3	0.3
16	1.8	2.0	0.2
17	1.9	2.0	0.1
18	1.3	1.5	0.2
19	2.3	2.4	0.1
20	1.3	1.2	−0.1
21	1.9	1.8	−0.1
22	2.1	2.3	0.2
23	1.7	1.9	0.2

$$\text{Sin a} = \frac{35 - 25}{2 \times 6.5} = 0.769$$

$$\text{Cos a} = \sqrt{1 - 0.769^2} = 0.639$$

$$\text{Canine retraction} = (2 \times 0.655 \times 0.769 + 0.639)^{-1} \times 5 = 3.$$

Under these conditions, the canine should be retracted 3 mm to correct 5 mm protrusion, but 2 mm of space is needed in each quadrant to relieve the 4 mm of total anterior crowding.

Therefore, the total amount of needed canine retraction would be 3 + 2 = 5 mm and posterior teeth should be allowed to move forward 7 − 5 = 2 mm.

When the teeth are relatively big or the arch is constricted, Sin a decreases, but at the same time Cos a increases. On the other hand, in the case of small teeth or a wide dental arch, Sin a increases and Cos a decreases. As a result, the amount of $(2\ k\ \text{Sin a} + \text{Cos a})^{-1}$ does not change significantly in either case.

According to Tweed's calculations,[21] 0.8 mm space is needed for every 1° lower incisor retraction. Ricketts et al[22] suggested 2 mm change in arch perimeter for every 1 mm anteroposterior movement of incisors. This article deals with variations of the cephalometric correction factor. In this paper, the orientation is toward a smaller retraction of canines if expansion of mandibular intercanine width is to

Table 3. Different Amounts of Canine Retraction for Each 1–mm Lower Incisor Retraction in an Average Person

a[a], degree	Mean Increase in Intercanine Width, mm	Canine Retraction, mm
0–2	0.03	1
3–8	0.2	0.9
9–16	0.3	0.8
17–31	0.6	0.7
32 or more	0.7 and more	0.6

[a] See Figure 1.

occur. The amount of canine retraction is inversely related to the amount of increase in intercanine distance.

Different amounts of needed canine retraction for each 1 mm lower incisor retraction in an average person are presented in Table 3. Increasing mandibular intercanine width can cause instability,[23–26] but maintaining intercanine width does not guarantee incisor alignment.[27–29] Because is not always possible to maintain intercanine width in premolar extraction therapy,[30] many clinicians choose long-term retention for the mandibular anterior segment.

CONCLUSIONS

This formula determines the needed amount of canine retraction to correct incisor protrusion. Change in intercanine width is important in this regard. Space for correction of crowding, midline deviation, and other factors should also be considered. For ready access, the mathematical relationships are summarized in Table 3. Such calculations enable us to precisely determine anchorage demands of each patient.

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