The morphology of canines in relation to preadjusted appliances

By Nicholas Germane, DMD; Bruce Bentley, DDS;
Robert J. Isaacson, DDS, PhD; and James H. Revere, Jr., DDS

Preadjusted or straight wire appliances are designed to reduce or, as claimed by some, eliminate the need for placing bends in fully engaged, straight archwires. This goal is achieved by engineering a variety of shims and angulations into the brackets which three-dimensionally position the bracket slot on the bracket pad. The intended result is a predetermined alignment of any tooth's facial surface relative to adjacent tooth facial surfaces when a straight wire is engaged in the bracket slots. This concept presumes that this predetermined alignment of facial surfaces will result in proper arch alignment and proper dental occlusion. Based on this concept it is difficult to understand the rationale for the wide variety of different bracket prescriptions commercially available today.

This study is designed to examine the contours of the facial surfaces of canines which contribute to their faciolingual inclination. Clinically, faciolingual tooth inclination is often referred to as torque and is termed positive where the root is lingually positioned and negative where the root is facially positioned relative to the crown. Common commercial prescriptions offer canine brackets with slot torques ranging from minus seven degrees[1] to plus seven degrees.[2] Others advocate fabrication of an ideal archwire for a standard appliance with no torque in the canine region.[3] These diverse values will result in variation between the long axis of various canines with associated changes in the positioning of the incisal cusp ridges and therefore variations in the resulting canine occlusion.

Variations have been noted in the amount of facial surface curvature at different heights on the same tooth. If this is true, any constant

Abstract

The canine occupies the transition from anterior to posterior occlusion. Following orthodontic treatment the canine's incisal edge occlusion demonstrates the tip and torque present in the appliance that was used. The effective torque of the bracket, however, is influenced by the tooth morphology at the bracket's base. The morphology of the facial surface can be described by an angle formed between the tangent at the point of bracket placement and the long axis of the crown. In this study, tangent angles at four millimeters and five millimeters from the cusp tip of 100 maxillary and 70 mandibular canines were determined. There was a significant difference between tangent angles at the same location on different canine teeth and also at different locations on the same canine tooth. Proximal collum angles were also measured in this study and there was a significant negative proximal collum angle in maxillary canines and a significant positive proximal collum angle in mandibular canines. The presence of these normal biologic variables will either enhance or minimize the torque supplied by preadjusted appliances, depending on a combination of prescription used and biologic variable present.

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Key Words

Canines • Morphology • Tangent angle • Collum angle • Preadjusted appliances

Figure 1

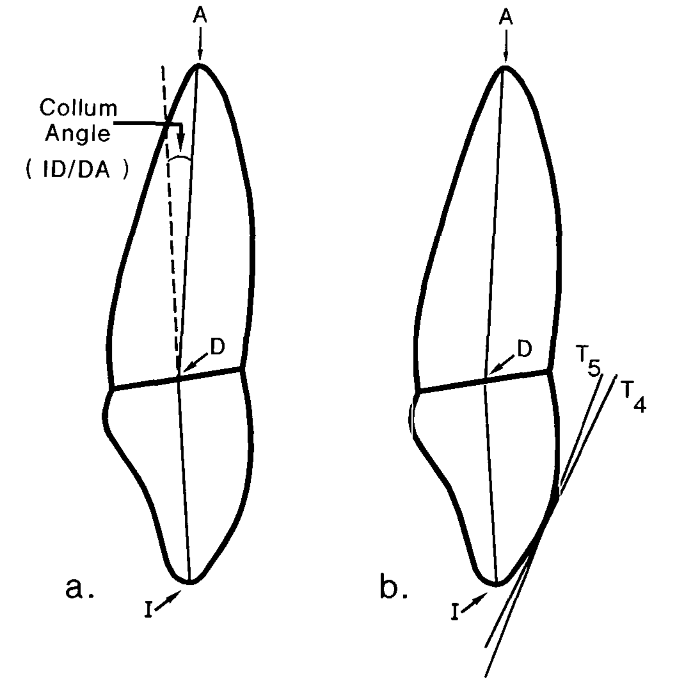


Table I
Tangent Angle for Maxillary and Mandibular Canines (measurements are in degrees).

	Maxillary N=100		Mandibular N=70	
	T_4/ID	T_5/ID	T_4/ID	T_5/ID
Mean	25.98	22.93	20.45	16.11
S.D.	4.20	4.17	3.91	3.89
Minimum	8.50	10.50	12.00	7.0
Maximum	35.00	34.00	29.00	23.50

Figure 1
Proximal view of a maxillary canine as radiographed in this study. A is the apex of the root. D is the midpoint of a line connecting the lingual and facial projection of the cementoenamel junction. I is the cusp tip. Figure 1a shows the collum angle as being the arch angle between ID and DA. Figure 1b shows the tangent angle T_4 and T_5 width, the long axis of the crown, ID.

preadjusted bracket will produce variation in the faciolingual long axis or torque position when placed at different heights on the same tooth.

Taylor[4] reported that the range of variation among upper canine teeth negates the concept of a typical tooth. He noted that the facial surface of some canines showed a broad vertical ridge from the cusp to the cervix which was convex longitudinally and transversely. He also noted that this surface was a line almost continuous with the labial outline of the root.

Morrow[5] also studied the variation in facial surface contours in a relatively small number of canines and reported significant variation present.

Dellinger[6] and Vardimon et al.[7] studied the facial contours of canines in set-ups with idealized occlusion. They also noted that the presence of good occlusion resulted in substantial variation in the orientation of the facial surfaces of the teeth.

No studies, however, have documented the spectrum of facial contour present in a representative sample of canine teeth. This information is essential to determine the resulting variation in dental occlusion created when a preadjusted bracket with a fixed amount of torque is applied to a normal population of patients.

Materials and methods

In this study 100 extracted maxillary canines and 100 extracted mandibular canines were selected for measurement. Excessive wear facets on many mandibular canines precluded measurements of the labial surfaces and therefore only 70 of the 100 mandibular canines were included in the study.

Each tooth was radiographed at a target to film distance of 15.45 centimeters with the tooth positioned in its greatest faciolingual width parallel to a No. 2 radiographic film pack. The film was exposed with the mesial surface of the tooth in contact with the film pack. The radiographs were developed and projected to a magnification of 3.6 times their original size. The magnified image of each canine was traced and used to obtain measurements.

Using the 3.6 times enlargements, points were marked four millimeters and five millimeters from the incisal tip, I, on the outline of the facial surface of the crowns. A uniform curvature 0.5 millimeter (0.138 millimeter without enlargement) was assumed present on either side of each four millimeter or five millimeter point and a cord was drawn between a point 0.5 millimeter above and a point 0.5 millimeter below each tangent point. This cord was defined as the tangent line and its orientation to the crown long axis and tooth long axis was used to describe the facial contour.

The magnified image of each canine was traced and measured using the following definitions (Figure 1):

Points

I — Cusp tip or midpoint of the cusp tip wear facet.

A — Root apex. In cases when a dilaceration produced an apex lateral

Table II
Difference in Tangent angles from T_4 (4 mm) to T_5 (5 mm) for Maxillary and Mandibular Canines.

	(T_4/ID—T_5/ID) Maxillary	Mandibular
Mean	3.05	4.34
S.D.	2.60	2.37
Minimum	-3.00	-0.50
Maximum	11.50	11.00
T	6.42	15.27
p-value	0.0001	0.0001

Table III
Collum Angle for Maxillary and Mandibular Canines (measurements are in degrees).

	Maxillary Canines	Mandibular Canines
N	100	70
Mean	-2.46	4.83
S.D.	4.43	3.21
Minimum	-13.00	4.00
Maximum	12.00	10.00
T	-5.56	12.58
p-value	0.0001	0.0001

to the long axis of the root, the root was bisected at the level of the dilaceration.

D — Midpoint of a line connecting the lingual and facial projection of the cementoenamel junction.

T — Tangent points located on the facial surface at four millimeters and five millimeters measured directly from I.

Lines:

ID — Long axis of the crown formed by a line from I to D.

DA — Long axis of the root formed by a line from D to A.

T_4 — Tangent to a point four millimeters from I.

T_5 — Tangent to a point five millimeters from I.

Angles:

T_4/ID — Angle formed by the tangent line at T_4 and ID, the crown long axis.

T_5/ID — Angle formed by the tangent line at T_5 and ID, the crown long axis.

ID/DA — Collum angle formed the long axis of the crown, ID and the long axis of the root, DA.

The mean, standard deviation and range were calculated for each of the above angles. Also the differences between the values obtained at four millimeters and five millimeters were calculated.

The error in the radiographic technique was measured using a known metallic standard and was calculated as less than one percent. Errors in the tracing and measurement technique were estimated by randomly selecting 10 teeth and repeating the radiographic, projection and tracing process. The angular error measurement was determined as ±1.3 degrees.

Results

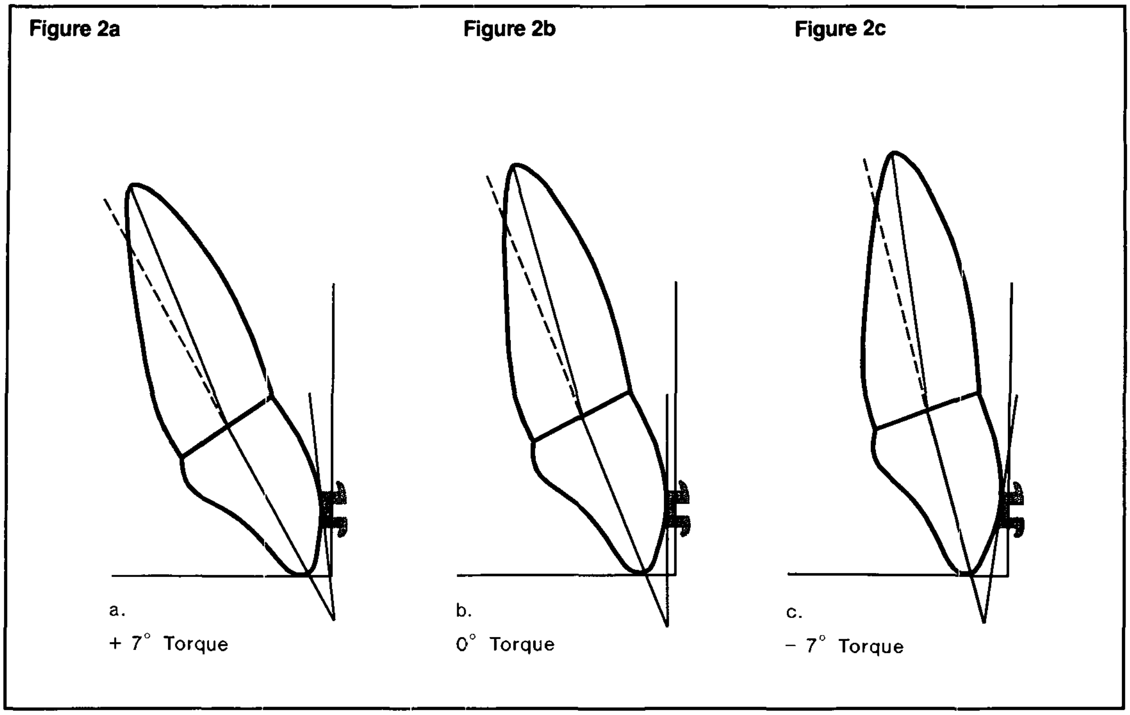
Table I shows the means, standard deviations and ranges of the angles formed by the tangent lines at four millimeters and five millimeters and the long axis of the crown for the maxillary and mandibular canines.

Table II shows the means, standard deviations and ranges for the differences between the tangent angles at four millimeters and five millimeters for the maxillary and mandibular canines. A comparison between the mean tangents at four millimeters and five millimeters was made using the student *t*-test (Table II). This shows that there is a significant difference between the tangent angles at four millimeters and five millimeters ($p<0.0001$).

Table III shows the mean collum angles for both the maxillary and mandibular canines which were compared statistically against the null hypothesis of a collum angle of zero degrees ($p<0.0001$).

The collum angles for the proximal view of the maxillary and mandibular canines show a mean value of -2.46° and 4.83°, respectively (Table III). This means that the root of the maxillary canine is buccal to the crown whereas the root of the mandibular canine is lingual relative to the crown.

Figure 2
Comparing the root positions of the maxillary canine at T_5 with the collum angle (+2.46°) included at +7° torque (2a.), 0° (2b.) and -7° torque (2c.) in the bracket.



Discussion

When the contours of the facial surfaces differ between the various canine teeth, an archwire fully engaged in a bracket bonded to the facial surface will produce a different coronal long axis position among these teeth. Such differing coronal long axis orientation must result in different facial-lingual placement of the cusp tips and cusp ridges producing variations in dental occlusion.

In this study, the mean angles formed by the coronal long axis and the tangent to coronal surface of maxillary canines varied from 25.98 to 22.93 degrees for the two bracket heights studied (T_4/ID and T_5/ID respectively, Table I). For the mandibular canines the mean coronal-tangent angles varied from 20.45 to 16.11 degrees (T_4/ID and T_5/ID respectively, Table I). For the complete sample the coronal tangent angles ranged over a total of 26.5 and 23.5 degrees for the two bracket heights on the maxillary canines. Similarly, the coronal tangent angles of the whole sample ranged over a total of 17.00 and 16.50 degrees for the two bracket heights on the mandibular canines.

Andrews[8] identified facio-lingual torque as one of his six keys to normal occlusion. If this is true, what is the effect of a range of 26.5 and 23.5 (T_4/ID and T_5/ID respectively) of bracket rotation when projected at the incisal edge and dental occlusion of the maxillary canines? Are all of the cuspal positions within this range of normal variation ideal for canine guidance or dental occlusion? Or does this variation in canine position only mean that ideals were established from ideal occlusions and major variations in facio-lingual contours cannot produce ideal occlusions without appropriate recognition of the problem and requisite archwire adjustments?

Similarly, when the contours of the facial surface differ at different heights on the crown of the same tooth, a fully engaged archwire will also produce different coronal long axes among the teeth. This too can result in variations in incisal cusp position and dental occlusion. In this study the difference in the contours at T_4 and T_5 relative to the coronal long axis ranged over 14.5 degrees in the maxillary canines and 11.5 degrees in the mandibular canines. This difference is potentially additive to the previously demonstrated contour variance. Again, the obvious question is what is the effect on the dental occlusion (and cuspid eminence) when this amount of rotation is magnified at the incisal edge?

The tangent angles found in this study were generally in agreement with those determined by Morrow.[5] Morrow's tangent angles were determined at an "LA" point midway on the facial surface of the clinical crown. Morrow reported angles at the "LA" point of 18.46 degrees and 20.05 degrees for the maxillary and mandibular canines, respectively. The mean tangent angles at four millimeters and five millimeters for the maxillary canine in this study differed by 3.05 degrees. If uniform curvature is assumed, the tangent angle at six millimeters would be 19.88 degrees approximating Morrow's results.

In the mandibular canines, Morrow's results approximates the tangent angle at four millimeters (20.45 degrees at four millimeters for this study and 20.05 degrees in Morrow's study). It is impossible to equate the above results absolutely since Morrow's "LA" point was the center of the clinical crown incisal-gingivally and not measured from the incisal edge directly. This study looked at typical bracket positions on canine teeth relative to the incisal edge. As can be seen from this study, position of the bracket incisal-gingivally does make a difference.

As a related issue, Dellinger[6] and Meyer[9] noted that the effective torque supplied to the teeth is dependent upon the sizes of the working wires and slots. Therefore, the effect of bracket placement can be reduced somewhat by the absence of full bracket engagement when there is a difference in dimension of the wire relative to the dimension of the bracket. However, if the bracket is not filled and/or a smaller wire is activated to apply a true torque, the precision of the preadjusted appliance is lost in detailing the completion of individual cases.

In examining the collum angle, any variation in the crown/root angle would effect the position of the root following expression of torque in the bracket. This is significant when considering the relationship between the root and cortical plate. Variation could range from increased prominence of the cuspid root to perforation or development of a dehiscence.

This study shows a definite tendency for the center of maxillary canine root to be facial to the crown. This is a significant finding when considering the amount of torque to be placed in the canine bracket. Choice of a negative torque, as in the Andrew's appliance and as advocated by Dellinger,[6] and Morrow[5] and Vardimon,[7] results in a increase in the effective torque. If, on the other hand, one chooses a positive torque, as in the Bioprogressive appliance, the effective torque is decreased. Figure 2 compares the root positions at plus seven degrees torque in the bracket (Figure 2a), zero degrees torque (Figure 2b) and minus seven degrees torque (Figure 2c). The mandibular canines show a lingual position of the center of the root relative to the crown. This will increase positive torque and decrease negative torque in the appliance. Again, these effects will be tempered by the failure to fully fill the pretorqued slot with the wire, thereby not using the torque in the pretorqued appliance.

Torque in a preadjusted appliance can play an important role in the anchorage requirements of a case. Meyer and Nelson[9] reported that the posterior anchorage requirements are increased dramatically with torque present in the anterior brackets of preadjusted appliances. Lingual root torque on the anterior teeth tends to move the posterior teeth forward as it is expressed in anterior tooth lingual root movement. The tangent angle relative to bracket placement can either increase or decrease the anchorage demands of the treatment. This is dependent upon the clinician's prescription, as noted above.

Summary

The labial surface curvature relative to the coronal long axis is statistically significantly different among canine teeth, both in the maxilla and in the mandible. This is true when comparing the same site on different teeth or different sites on the same teeth. Therefore, any given pretorqued bracket will position the canine incisal edge of different canines in different positions resulting in different dental occlusions. The variation present in the canine labial surface of different teeth in this study differed over 26.5 and 23.5 degrees for the two bracket heights on maxillary canines. The corresponding values for mandibular canine variation were 17.00 and 16.50 degrees.

In the proximal view, the maxillary canines have a statistically significant negative collum angle. The mandibular canines have a statistically significant positive collum angle.

Preadjusted appliances offer the clinician greater efficiency of treatment. The inherent properties of the appliance must be understood in order that effects detrimental to individual patients not be realized. With the wide range of prescriptions available for maxillary and mandibular canines, the clinician should include the effects of variation in facial surface morphology in the choice of appliance prescription. This decision should be based on the occlusion desired. Based on the variation in biological morphology present in canine facial surfaces in various patients, archwire adjustments are inevitable with currently available appliances.

Author Address

Dr. Nicholas Germane
Dept. of Orthodontics
MCV Station, Box 566
Richmond, VA 23298

N. Germane is an Assistant Professor at Virginia Commonwealth University/Medical College of Virginia.

B. Bentley is in private practice in Lynchburg, Virginia.

R. Isaacson is a Professor and Chairman at Virginia Commonwealth University/Medical College of Virginia.

J. Revere is an Executive Associate Dean at Virginia Commonwealth University/Medical College of Virginia.

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References

1. Andrews, L.F: The Straight-Wire Appliance syllabus of philosophy and techniques. Lawrence F. Andrews Foundation of Orthodontic Research, 1975.
2. Ricketts, R.M., Bench, R.W., Gugino, C.F., Hilgers, J.J. and Schulhof, R.J.: Bioprogressive Therapy, Rocky Mountain Orthodontics, 1975.
3. Graber, T.M. and Swain, B.F.: Current Orthodontic Concepts and Techniques, Second Edition, Saunders Company, 1975.
4. Taylor, R.M.S.: Variation in form of human teeth: II. An anthropologic and forensic study of maxillary canines. J. Dent. Res., 48:173-182, 1969.
5. Morrow, J.B.: The Angular Variability of the Facial Surfaces of the Human Dentition; An Evaluation of the Morphological Assumptions Implied in Various "straight wire" techniques. Masters Thesis, St. Louis University, 1978.
6. Dellinger, E.L.: A scientific assessment of the Straight-Wire Appliance. A.J.O., 73:290-299, 1978.
7. Vardimon, A.D. and Lambert, W.: Statistical evaluation of torque angles in reference to Straight-Wire Appliances (SWA) theories. A.J.O., 89:56-66, 1986.
8. Andrews, L.F.: The six keys to normal occlusion. A.J.O., 62:296-309, 1972.
9. Meyer, M. and Nelson, G.: Preadjusted Edgewise Appliances: theory and practice. A.J.O., 73:485-498, 1978.