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Dr. Kulsum Guroo
Department of Orthodontics and Dentofacial Orthopaedics, Bharati Vidyapeeth Dental College and Hospital, Pune, Maharashtra, India

Dr. Gauri Vichare
Professor and PG Guide, Department of Orthodontics and Dentofacial Orthopaedics, Bharati Vidyapeeth Dental College and Hospital, Pune, Maharashtra, India

Corresponding Author:
Dr. Kulsum Guroo
Department of Orthodontics and Dentofacial Orthopaedics, Bharati Vidyapeeth Dental College and Hospital, Pune, Maharashtra, India

Clinical efficacy of open and close loops in retraction

Dr. Kulsum Guroo and Dr. Gauri Vichare

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Abstract
Objective: To evaluate the clinical efficacy of open and closed loop during incisor retraction by comparing the rate of incisor retraction, the effect on incisors and anchorage unit.
Materials and Methods: This clinical study included 24 participants treated with first bicuspid extraction which were randomly divided into two groups. Group I received Open tear drop loop and Group II received closed vertical shaped loop for space closure mechanics. The duration of the study was four months. Study models and lateral cephalograms were taken at the start (T_0) and end of study period (T_4).
Results: Nasolabial angle increased significantly from T_0 to T_4 in the open loop group. The inter-canine width and arch length reduced more in open loop group. The rate of incisal retraction per day as calculated from arch length was more in open loop with 0.023 mm (0.0044), as compared with close loop 0.0194 mm (0.00475). The degree of molar rotation was more with open loop as compared with close loop.
Conclusion: The pattern of space closure was different in both the groups. There was a more controlled retraction of incisors in the closed loop group with no incisor torque loss but slower rate of retraction Whereas, the open loop shows faster retraction but at the expense of molar rotation and reduction in inter-canine width.

Keywords: Closing loop, open loop, retraction mechanics

Introduction

Space closure is one of the challenging processes in Orthodontics. The biomechanical basis of space closure enables clinicians to determine anchorage and treatment options, reach the prognosis of various alternatives, as well as decide specific adjustments that can improve the outcomes of care [1]. There are two mainstream methods of space closure in orthodontic treatment after tooth extractions. One is sliding mechanics, generally practiced in 0.22 slot prescription in which a plain archwire slides through the brackets and tubes on the posterior teeth. The other is loop mechanics, which is practiced in 0.18 Slot in which space closure is achieved by activation of closing loops incorporated into an archwire. Although sliding mechanics are quite advantageous in regard to reducing the amount of wire bending, which leads to simplified mechanics, improved patient comfort and oral hygiene, a great amount of friction could inhibit tooth movement during space closure. An essential characteristic's of loops is to move the group of teeth with more accurately defined force systems for more precise anchorage control to achieve treatment goals more readily. All closing loops have specific mechanical properties, and clinicians need to know these for optimally using them to move teeth or groups of teeth in predetermined directions. The main mechanical properties of the loop are the moment-to-force ratio (M/F), load/deflection, and vertical forces. Among these, the moment-to-force ratio can be considered the most significant because it has been related to type of tooth movement [2]. Researchers and clinicians, have therefore tried to design and refine loop geometry to obtain appropriate force systems. There is abundance of literature on mechanical testing of the various loops *in vitro*, the present clinical investigation was conducted with the objective to evaluate the efficacy of open and closed loop in retraction mechanics.

Materials and Methods

This clinical study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, Bharati Vidyapeeth University, Dental College and Hospital, Pune.

The Ethics committee approved the experimental protocols. Signed informed consent was obtained from all participants before participation in the study. The study consisted of twenty-four volunteers, who received alternately open and close loop retraction wires. (Fig.1 and Fig.2)

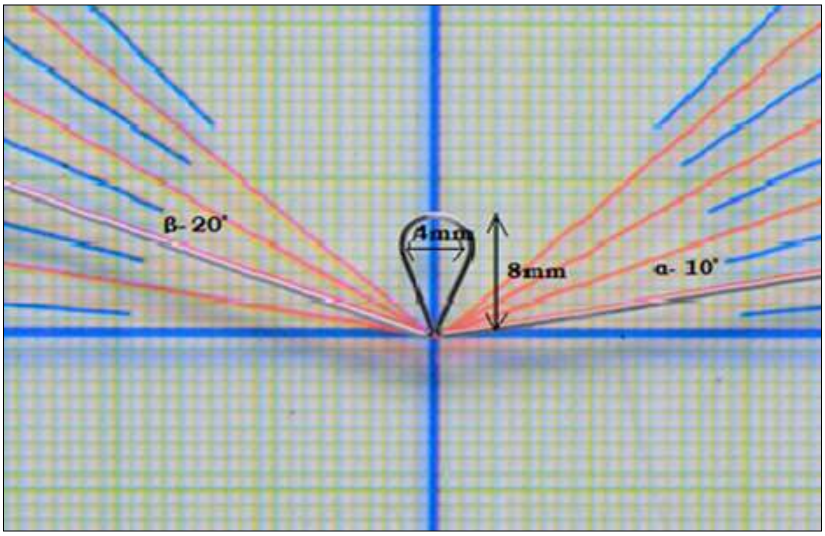

Fig 1: Open tear drop loop with standardized measurements

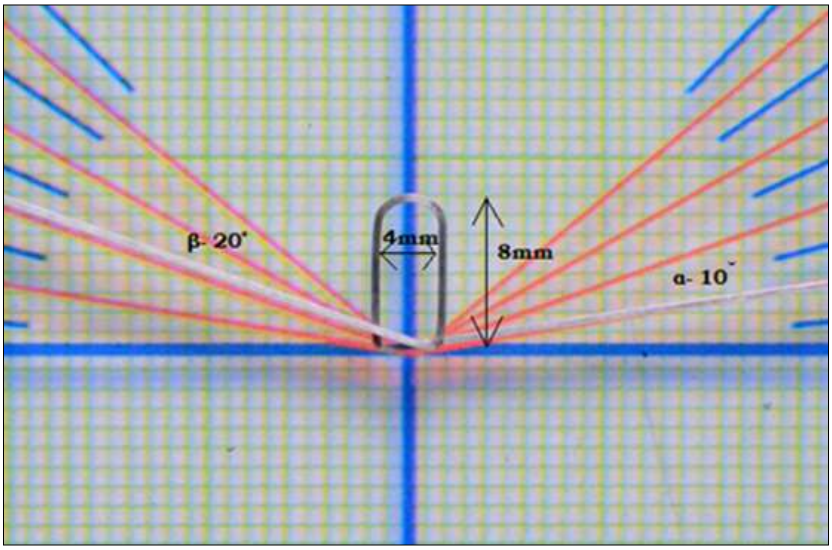

Fig 2: Closed vertical loop with standardized measurements**.**

2 Closed vertical loop with standardized measurements.

The inclusion criteria were as follows: Patients undergoing routine orthodontic treatment with 0.018 MBT- appliances by extraction of upper first premolar and between the age group of 15-25 years. Exclusion criteria included: teeth with root resorption, dilacerated roots, periodontal pathologies or any systemic disorders that contraindicate orthodontic treatment.

Study models and lateral cephalograms were collected at the beginning(T_0) and the end of study period after four months T_4). As a standardization protocol 0.016×0.022 SS 3M) wire was used for the fabrication of both the type of loops. The dimensions of both the type of loops were standardized. Closed vertical loops were 8mm in height and 4 mm in width. The open loop used was a tear drop loop with the dimension of 8mm height and 4mm width. The gable bends given in the loops were also standardized with α- 10° β- 20°. All the retraction loops were made by single operator. The participants were recalled after 1 month for the checkup and activation of loop by 1mm/month Fig.3 & Fig.4).

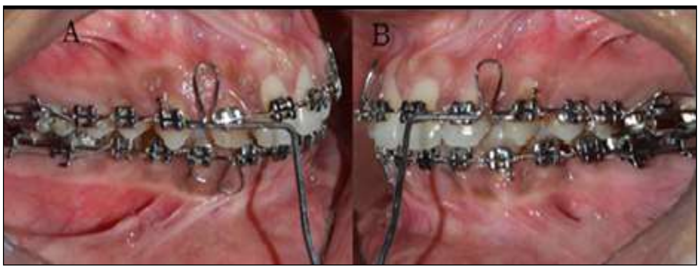

Fig 3: Showing activation of tear drop loop. A&B) Tear drop loop after activation of 1mm measured using a graduated probe. The wire is pulled distally and cinched behind the molar tube, until the vertical legs of the loop are 1mm apart).

Fig 4: Showing activation of closed vertical loop. A) A line is marked on the overlapping horizontal legs of the loop. B) Showing the markings after activation note the markings which are 1mm apart after activation) C) Closed loop after activation of 1mm the wire is pulled distally and cinched until the markings are 1mm apart).

Lateral cephalograms collected at T_0 and T_4 were traced manually by single operator and following measurements were recorded: Angular measurements: 1) Upper incisor to NA 2) Upper incisor to SN 3) Nasolabial Angle. Linear measurement: 1) Incisal exposure in relation to upper lip 2) Upper incisor to NA. 3) Centroid to pterygoid vertical horizontal) 4) Centroid to palatal plane vertical) 5) Palatal plane to incisal edge 6) Molar to PTV Fig.5).The study models were scanned and following measurements were done on the scanned images. 1) Reduction in extraction space 2) Arch width inter-canine width and inter-molar width) 3) Arch length & 4) Molar rotation (Fig.6).

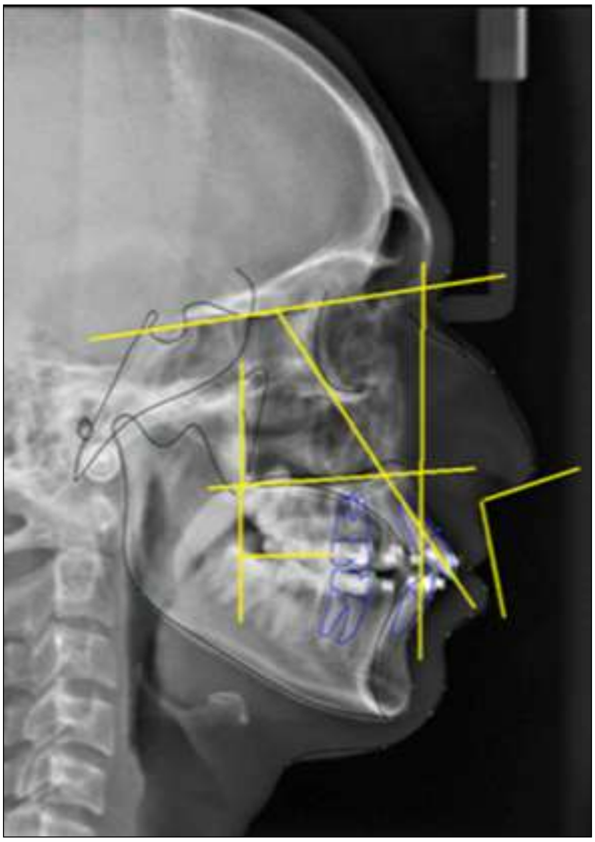

Fig 5: Angular and linear measurements recorded on lateral cephalogram.

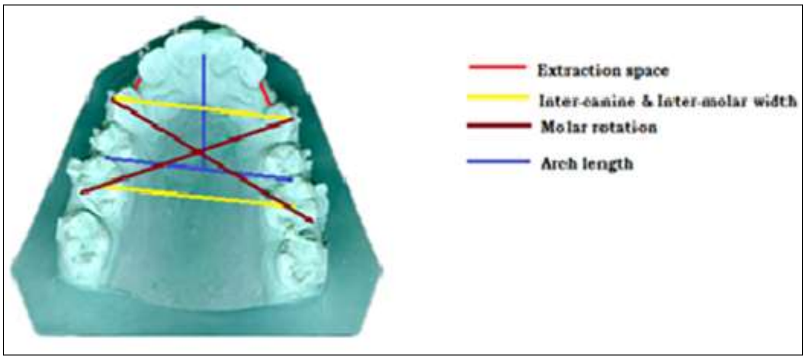

Fig 6: Angular and linear measurements recorded on scanned models.

After the data was collected following statistical software was used to analyze the data: SPSS Inc. Released 2007. SPSS for Windows, Version 16.0. Chicago, SPSS Inc software. Descriptive statistics such as Mean, and SD were used for representing quantitative data e.g. angular measurement recorded in degrees). Paired t test was used to compare means of measurements of the group at given intervals i.e. T_0 and T_4. Unpaired t test was used to compare the mean of two groups i.e. open loop group and closed loop group.

Results

The mean and standard deviation of various measurements in group I open loop) at T0 and T4 are shown in Table 1. The change in inclination of upper incisors was not significant from T0 to T4 in relation to SN plane and NA line. The nasolabial angle changed from T0 to T4. The incisal exposure in relation to upper lip reduced significantly. The horizontal and vertical distance of centroid to Ptv and palatal plane has reduced but the change is not statistically significant. The mean and standard deviation of various measurements in group II close loop) at T0 and T4 are shown in Table 2. The inclination of upper incisors was not significant from T0 to T4 in relation to SN plane and NA line. The nasolabial angle increased from T0 to T4. But the changes were not statistically significant. The incisal exposure in relation to upper lip also reduced but was found to be statistically insignificant. The horizontal and vertical distance of centroid to Ptv and palatal plane has reduced but the change is not statistically significant. The comparative changes between the means of group I and group II from T0 to T4 are given in Table 3. While comparing the change between open loop group and close loop group, no significant differences were seen except nasolabial angle and palatal plane to incisal edge. The amount of extraction space at T0 and T4 in group I open loop) and group II close loop) was measured from distal of lateral incisor to mesial of canines on the scanned models. The extraction space reduction from T0 to T4 in both the groups was highly significant Table 4. The total mean change seen in extraction space reduction from T0 to T4 was statistically insignificant. The inter-canine width change from T0 to T4 in open loop group and close loop group is given in Table 4. The inter-canine width reduced more in open loop group with 2.0 mm 0.73), as compared with close loop group in which 1.4 mm 0.65) of reduction was seen. These changes were statistically significant p = 0.041). The change of inter-molar width in both the groups was similar, with no statistically significant changes. The arch length significantly reduced more in open loop group as compared with close loop group. The degree of molar rotation was seen more in open loop group with 2.13 degrees of rotation 0.85), as compared with close loop group in which only 1.0 degree 0.21) of rotation was seen. These mean changes were statistically significant.

Table 1: Comparison of various cephalometric parameters in Group I open loop).

Measurements	T_0	T_4	Paired t test	P value, significance
	Mean S.D)	**Mean S.D)**		
Upper incisor to NA	23.41 4.44)	22.25 4.91)	0.610	0.548
Upper incisor to SN	106.9 6.57)	105.08 6.93)	0.665	0.513
Nasolabial angle	91.66 7.25)	98.58 8.80)	-2.1	0.047*
Incisor exposure in relation to upper lip	5.83 1.60)	4.45 1.05)	2.486	0.021*
Upper incisor to NA mm)	6.29 1.55)	5.29(1.33)	1.686	0.106
Centroid to Ptv horizontal –mm)	53.16 3.99)	50.89(3.98)	1.407	0.173
Centroid to palatal plane mm)	17.33 3.56)	15.83 3.58	1.027	0.316
Palatal plane to incisal edge	28.25 4.33)	28.25 2.59	0.00	1.00
Molar to Ptv mm)	18.25 4.09)	18.29 4.22)	-0.25	0.981

p> 0.05- not significant **p*< 0.05- significant ***p*< 0.001-highly significant

Table 2: Comparison of various cephalometric parameters in Group II closed loop).

Measurements	T_0	T_4	Paired t test	P value, significance
	Mean S.D)	**Mean S.D)**		
Upper incisor to NA	29.33 10.28)	28.08 8.26)	0.328	0.746
Upper incisor to SN	112.0 9.00)	111.4 8.30)	0.165	0.870
Nasolabial angle	90.33 10.92)	93.58 10.46)	-0.744	0.0465
Incisor exposure in relation to upper lip	4.45 2.06)	3.83 1.58)	0.833	0.414
Upper incisor to NA mm)	7.5 3.15)	6.5 2.47)	0.864	0.397
Centroid to Ptv horizontal –mm)	56.58 3.34)	54.08 3.44)	1.803	0.085
Centroid to palatal plane mm)	16.87 1.96)	15.87 2.33)	1.134	0.269
Palatal plane to incisal edge	28.91 3.52)	28.41 3.46)	0.350	0.729
Molar to Ptv mm)	21.08 3.05)	21.04 2.39)	0.037	0.971

p> 0.05- not significant **p*< 0.05- significant ***p*< 0.001-highly significant

Table3: Comparison of open loop group I) and close loop group II).

	Open loop T_0 - T_4	Close loop T_0 -T_4	Unpaired t test	P value, significance
	Mean S.D)	**Mean S.D)**		
Upper incisor to NA	1.6 4.6)	3.08 3.75)	t= -1.117	p = 0.276
Upper incisor to SN	1.83 0.71)	1.91 1.88)	t= -0.143	p = 0.887
Nasolabial angle	8.58 5.08)	4.41 5.28)	t= 1.968	p = 0.042*
Incisor exposure in relation to upper lip	1.37 1.15)	1.04 0.8)	t = 0.820	p = 0.421
Upper incisor to NA mm)	1.0 0.76)	1.0 0.92)	t = 0.00	p = 1.000
Centroid to Ptv horizontal –mm)	2.29 1.17)	2.5 1.38)	t = -0.398	p = 0.695
Centroid to palatal plane mm)	2.08 2.81)	1.5 1.65)	t = 0.618	p = 0.543
Palatal plane to incisal edge	2.33 2.34)	1.08 0.76)	t =1.753	p = 0.049*
Molar to Ptv mm)	1.95 1.17)	1.12 1.53)	t =1.490	p = 0.150

p> 0.05- not **p*< 0.05- significant ***p*< 0.001-highly significant

Table 4: Comparison between both the groups.

T_0 - T_4	OPEN LOOP	Closed LOOP	Unpaired t test	P value, significance
Extraction space	2.5 0.41)	2.70(0.414)	-1.735	0.089
Inter-canine width	2.0 0.73)	1.4 0.65)	1.900	0.0041*
Inter-molar width	1.04 0.78)	1.04 0.98)	0.0	1.000
Arch length	2.83 0.53)	2.33 0.57)	2.198	0.039*
Molar rotation	2.13 0.85)	1.0 0.21)	1.903	0.039*

p> 0.05- not significant **p*<0.05- significant ***p*< 0.001-highly significant

Discussion

Space closure is one of the most important processes in orthodontics and requires a solid comprehension of biomechanics in order to avoid undesirable side effects. In spite of variety of appliance designs, space closure can be performed by means of friction or frictionless mechanics. Sliding mechanics or friction mechanics is attractive because of its simplicity; the space is closed by means of elastics or coil springs, and the brackets slide on the orthodontic archwire. On the other hand, frictionless mechanics uses loop bends to generate force to close the space site, allowing differential moments in the active and reactive units, leading to a less or more anchorage control, depending on the situation [1]. According to Staggers [3]. Both the mechanics have their own advantages and disadvantages depending on type of tooth movement needed. Loop mechanics involving the use of retraction loops in continuous arch wire or in segmental form offers more controlled tooth movement in comparison to friction mechanics. Another design factor relates to whether a loop is activated by opening or closing. All else being equal, a loop is more effective when it is closed rather than opened during its activation. [4]. On the other hand, a loop which is designed to be opened can be made so that when it completely closes, the vertical legs come in contact, effectively preventing further movement and producing the fail-safe effect. In contrast a loop activated by closing, must have its vertical legs overlapped. This creates a transverse step, and archwire does not develop the same rigidity when deactivated.

In the present study, while comparing the cephalometric changes in open loop and closed loop no significant differences were seen, except nasolabial angle p=0.042) and incisal intrusion p=0.049) which was seen to be more increased in the open loop group as compared with the close loop group fig.9). This could be because of the difference in force values between the two groups. Burstone [5]. Showed that if a higher moment-to-force ratio is required, it is necessary to use a greater vertical height. The amount of wire incorporated in the loop is very important factor. The length of the wire is inversely proportional with the magnitude of force [4]. The effect on spring characteristics changes by changing the wire size, the design of the loop, the interbracket span. Even though the loop length and diameter was standardized in both the groups, the amount of wire used for bending the closed vertical loop was more which helps in reducing the force value. In this investigation we measured extraction space at the start of the study period and total reduction of space at the end of the study period. At the end of the study period of four months, reduction in space was measured from distal surface of the lateral incisor to mesial surface of the canine. The space reduction in both the groups was almost same. The total space reduction during the study period was 2.5mm in open loop group and 2.7mm in closed loop group. Also, the arch length was measured on the mid palatal line and to the transverse line joining the mesial of the first molars on either side. The arch length reduced more in the open loop group with 2.83mm and in closed loop group, the arch length reduced by 2.33mm p=0.039). Even though random allocation was done in the sample between the two groups, the extraction space and the arch length was found to be more in the closed loop group at the start of the treatment which could also have affected the outcome of the results. The rate of incisal retraction per day was found to be greater with 0.023mm in open loop group and 0.0194mm in closed loop group. The literature provides information on the optimum magnitude of force required for incisor retraction. According to Rickets [6]. Force not more than 300 grams should be applied for the incisor retraction. The way the tooth moves is dependent on the nature of the forces i.e. the force system) imposed on it. The force system includes the applied force and moments at the bracket and the actual force distribution about the periodontium. This force system could also be affected by altering the interbracket distance, the position of the loop and the pre-activation bends in the wire. In this study the position of the loop was same in both the groups with same amount of gable bends. Ronay and Burstone [7]. Described a closing loop functioning as a V-bend because of the gable bends which is sensitive to its position. Only if it is in the center of the span does a V-bend produce equal forces and couple on the adjacent teeth. If it is one-third of the distance between adjacent brackets, the tooth which is closer to the loop will be extruded and will feel a considerable moment to bring the root towards the V-bend, while the tooth which is farther away will receive an intrusive force but no moment. If the loop or V-bend is closer to one bracket than one-third of the distance, the distant tooth will not be intruded but will receive a moment to move the root away from the V-bend which is almost never desirable). The changes in inter-molar width and the inter-canine width were compared between the two groups. The inter-molar width showed no significant change. Inter-canine width was seen to reduce in the open loop group unfavorably. The inter-canine width did not change in the closed loop group during the study, since the design of the closed loop has a transverse step between the vertical legs which helps in maintaining the inter-canine width. On the other hand there is no transverse step in the open loop design because of which there is reduction in inter-canine width during the retraction. This reduction in the inter-canine width in the open loop group can also affect the outcome of the treatment in correcting the sagittal relationship. The change in the molar rotation was measured by the angle formed by the line joining the distobuccal and mesiopalatal cusp to the mid palatal line. The molar rotation was seen more in the open loop group as compared to the closed loop group. As we have seen more incisor retraction as compared to closed loop, there is more mesial rotation of molars with open loop. Though there is no anchorage loss noted in both the groups, there is significant mesial molar rotation which is the first sign of anchorage loss in maxillary arch which is observed in open loop group. Interestingly, the narrow tolerance and high repeatability common to experiments in physics or mechanics were not found in the present clinical investigation. Rather, these results reveal a broader distribution of the measures observations. This clinical study bridges the gap between laboratory bench-top, where the investigator can maintain exceptional levels of control, and the clinical- biological realm, where variability is frequently the rule rather than the exception. Although all the loops were bent manually and the dimensions were standardized in both the groups, previous data shows that even with careful bending, a different force system may result. Burstone [8]. Reported that the spring is unforgiving of fabrication error and that the force system may suffer as a result. More likely, however, if the altered force systems were present, they were probably due to the two factors. First, some patients required intraoral adjustment of the loop to relieve impingement on the buccal gingiva. This was achieved by moving the loop away. Although care was taken to not alter the second-order preactivation gabling), distortion is quite possible. Second, the loops were subject to the demands of the oral environment, which may have caused any distortion and a change in the force system. Biologic variation may also be considered as substantial variability that could not be explained by the force system and thus implicate individual biologic factors, for example—cellular turnover rates, vascularity, or bone density and masticatory forces. Also cephalometric measurement is fraught with potential error because of problems with magnification, projection, landmark identification. Also any changes, in the head orientation during radiograph exposure at the two time points may have adversely affected the comparability of two head films and acted as a confounding error. This error could be a contributor to the variation found in the present study.

Conclusion

The pattern of space closure was different in both the groups. There was a more controlled retraction of incisors in the closed loop group with no incisor torque loss but slower rate of retraction Whereas, the open loop shows faster retraction but at the expense of molar rotation and reduction in inter-canine width.

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