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Methods of measuring distal canine movement and rotation- A review

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Abstract

This article provides an overview of the various methods for measuring distal canine movement and rotation during retraction. Various databases, including PubMed Central, Science Direct, Wiley Online Library, the Cochrane Library, Textbooks, Google Scholar, and Research Gate, and a manual search up until September 2022, were used to search for various methods of measuring distal canine movement and rotation during retraction. After excluding the duplicate articles, the papers explaining these techniques were included. Four significant techniques were identified. The digital method with 3D superimposition is the safest, most accurate, and most accessible of the methods reviewed.

Keywords:

Canine distal movement, digital scanner, rotation

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Introduction

Approximately 50% of orthodontic cases require dental extraction, with the maxillary first bicuspids being the most often extracted teeth.[1]

After extraction of the premolars, the canines are distalized to the extraction region employing a wide variety of mechanisms. These were frictional (sliding) or nonfrictional (nonsliding) mechanisms.[2-4]

Frictional mechanics may have disadvantages such as canine tilting, archwire binding that inhibits movement, anchorage loss, and incisor extrusion.[5] However, orthodontists frequently like this mechanism because it is accessible in the application, requires less chairside time, and provides superior control of the entire dental arch with a single archwire.[6]

This review was conducted to explain different methods used to measure the amount of distal canine movement and rotation using different approaches.

Methods

Methods of measuring distal canine movement and rotation were searched in different databases, including PubMed Central, Science Direct, Wiley Online Library, the Cochrane Library, Textbooks, Google Scholar, and Research Gate, and a manual search up until September 2022. The unrelvant and deplicated articles were excluded; finally 53 articles were included in this narrative review.

Methods of Measuring Distal Canine Movement

There are numerous techniques for measuring the velocity and magnitude of distal canine movement.

Clinically (Intraorally)

Using a sliding caliper, Huffman and Way[7] and Ziegler and Ingervall[8] determined the distance between the distal surface of the canine bracket and the vertical wire put into the flat acrylic plate covering the maxillary dental arch [Figure 1].

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Sonis[9] used a Boley gauge to calculate the distance between the mesial surface of the mesial wing of the second premolar bracket and the distal surface of the distal wing of the canine bracket. Hasan *et al*.[10] measured precisely using digital vernier calipers.

Mehta and Sable[11] used a bespoke acrylic occlusal split with integrated hooks corresponding to the distal edges of the lateral incisor brackets and a digital caliper to measure the distance between the hook and the center of the canine brackets.

Using a digital caliper, Pavlin *et al*.[12] measured the distance from the canine cusp tip to the miniscrew parallel to the occlusal plane [Figure 2].

Khalid *et al*.[13] assessed the distance between the lateral incisor and canine on the maxillary arch at the mid-incisal, middle, and cervical thirds using vernier calipers.

Mezari and Ahmed[14] used a vernier caliper to measure the distance between the distal surface of the canine and the mesial surface of the second premolar on both sides prior to and after various intervals of canine retraction [Figure 3a].

Using an electronic digital vernier, Sivarajan *et al*.[15] assessed the distance between the cusp tip of the canine and the mesiobuccal groove of the first molar [Figure 3b].

Finally, using a digital caliper, Qamruddin *et al*.[16] measured the distance between the dental midline and the mesial surface of the canine [Figure 3c]. On the other hand, Shankar *et al*.[17] and Tawfik *et al*.[18] measured the rate of distal canine movement as the distance between the cusp tip of the canine and mesiobuccal cusp tip of the first molar.

Using study models

Lotzof *et al*.[19] used an acrylic palatal plug with wires extending toward the canine cusp points. They selected the central fossa of the first maxillary molar as the reference point, whereas Limpanichkul *et al*.[20] used the mesial contact point.

Dixon *et al*.[21] and Nightingale and Jones[22] determined the maximum distance between the cusp point of the canine and the buccal groove of the first permanent molar [Figure 3b].

Sukurica *et al*.[23] assessed the perpendicular distance between the canine cusp tips and a reference line tangent to the interdental contact points of the maxillary central incisors and intersecting the mid-palatal raphe vertically.

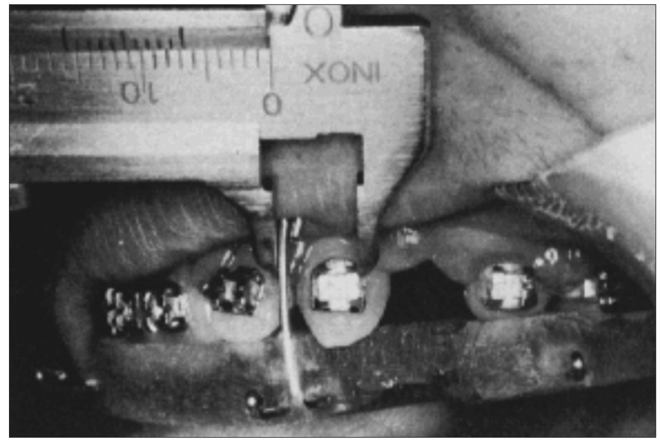

Figure 1: Measuring the distal canine movement by sliding caliper intra-orally[8]

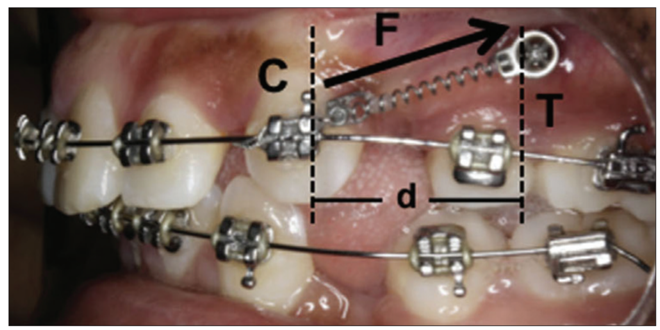

Figure 2: Measuring the distal canine movement (d) by digital caliper intra-orally[12]

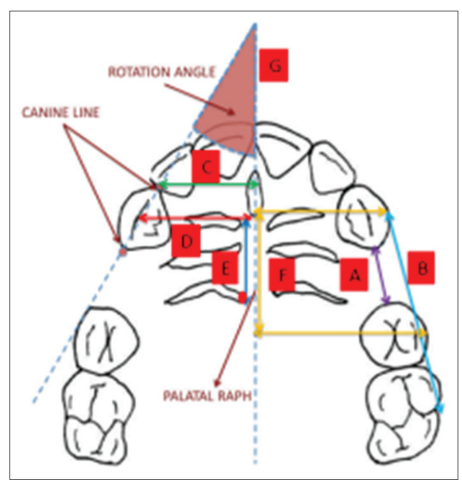

Figure 3: Different methods of measuring canine distal movement and rotation

Ravi *et al*.[24] drew a perpendicular line from the canine cusp tip to the median palatal raphe and then measured the difference between before and after retraction [Figure 3d].

Similar to Mezari and Ahmed, Mezomo *et al*.[25] evaluated the distance between the contact points on the distal surface of the canines and the mesial surface of the second premolars.[14]

Using either photographed or scanned dental models, Aboul-Ela*et al*.,[26] Kalra *et al*.,[27] Hassan *et al*.,[28] and Alfawal *et al*.[29] calculated the distance between the median point of the third palatal rugae and the perpendicular line from the canine's cusp tip to the mid-palatal raphe [Figure 3e].

Using a vernier caliper, Bhat *et al*.[30] measured the distance between the canine cusp tip and the second premolar fossa.

The distance between the distal edge of the canine bracket base and the mesial margin of the first molar band tube was determined by Abdul-Wahab *et al*.[31]

Finally, Alqadasi *et al*.[32] projected the buccal cusp tips of the second premolars and canines on the midpalatal raphe and measured the distance between the canine cusp tip and the line [Figure 3f].

Radiographically

Thiruvenkatachari *et al*.[33] assessed the rate of canine retraction using lateral cephalometric radiographs as a reference to a stable cranial landmark. The maxilla used the vertical pterygoid plane, whereas the mandible employed the sella vertical plane.

Martins *et al*.[34] used a series of normal 45° oblique cephalograms obtained from both sides and superimposed them to determine the rate of canine distal movement.

Oz *et al*.[35] put L-shaped, 0.021 × 0.025 inch stainless steel reference wires into the canine brackets and molar tubes and evaluated the horizontal distance between these reference wires on both sides using a lateral cephalometric radiograph.

Monini *et al*.[36,37] employed a vertical reference line perpendicular to the occlusal plane on both sides of oblique lateral cephalometric radiographs. The canine movement was indicated by the horizontal distance between the vertical reference line and the canine cusp point.

Finally, Abu-Shahba and Alassiry[38] used CBCT to determine the horizontal distance between the canine's tip and apex and a built line linking the points of maximal concavity of the posterior border of the palatine bone.

3D Assessment

El-Timamy *et al*.[39] scanned the research models and evaluated the canine movement over a period of four months using the superimposition technique and 3-shape analyzer software. The rate of distal canine movement was computed based on the change in canine position between successive models by measuring the perpendicular distance between the cusp tip of the canine and the median palatal raphe.

Ali and Chawshli,[40] using a CEREC Omnicam scanner and Laboratory CAM 15.0 software, evaluated the distance between the distal connecter of the canine and the mesial connecter of the second premolar on both sides before and after canine retraction [Figure 3a].

Barsoum *et al*.[41] scanned the plaster models using an R500 3-shape laser scanner to turn them into digital models. The preretraction models were oriented and superimposed on the third rugae's medial points with the aid of three planes (sagittal, horizontal, and frontal). Using 3-shape Analyzer software, the total canine retraction was assessed as the perpendicular distance from the cusp tip of the canine to the frontal plane before and after six months of retraction.

Akın and Camcı[42] determined the monthly amount of canine retraction by superimposing digital models using the distal point of the canines as a reference point for subsequent assessments. The region between the lateral tips of the first and third rugae is used as a reference area for superimpositions [Figure 4].

El Gazzar *et al*.[43] scanned the stone models with a 3-shape scanner and superimposed the models with 3-shape analyzer software based on three locations on the third rugae. After locating the cusp tip in each digital model, the distance between the frontal plane and the canine cusp tip was measured and the amount of canine distal movement per month was determined based on the difference in position between subsequent models.

Albelasy and Abdelnaby[44] assessed the amount of canine distal movement after five months of retraction at the level of cusp tip by superimposing digital models using the software Ortho Analyzer.

Türedi and Yazıcıoğlu[45] determined the rate of canine distal movement at the level of the cusp tip of the maxillary canine and the tip of the mesiobuccal cusp of the maxillary second molar by superimposing digital models using the medial and lateral points of the third palatal rugae and the medial point of the first palatal rugae as references for superimposition.

Angel *et al*.[46] used the inferior tip of the incisive papilla and the medial end of the first rugae bilaterally close to the median raphe as reference points to superimpose the

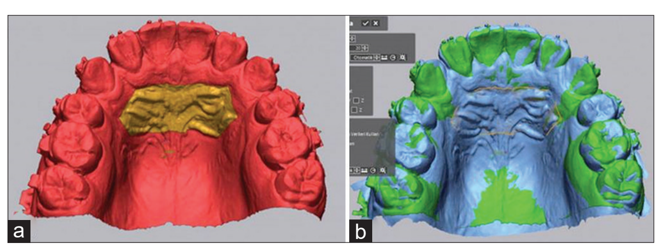

Figure 4: Measuring canine distal movement by local best-fit superimposition on the digital model[42] (a) Local best area, (b) Superimposed digital models

digital models and measured the rate of canine retraction at the cusp tip level at various time intervals using a 3D ruler of Dolphin 3D software.

Methods of Assessing Canine Rotation during Retraction

Ziegler and Ingervall[8] measured the angle produced between the medial palatal suture and a line passing between the mesial and distal contact points of the canines to assess the rotation of canines during retraction [Figure 3g].

Agha and Al–Saleem[47] developed a new method for assessing canine rotation using a vernier with 0.1 mm accuracy to measure the linear distances (directly on the study model) from the mesial and distal contact points of the canine to the mid-palatal raphe before and after retraction, with the net result representing the amount of rotation.

The third approach combined the second and the method of Ziegler and Ingervall.[8] Here, the second method's measurements were converted to paper with the addition of the indicated angle[8] and discrepancies between pretreatment and post-treatment were measured. A protractor measured the angle with an accuracy of 0.5 mm degrees.

Discussion

This article outlined several techniques for measuring the distal canine's movement and rotation. Each has both benefits and drawbacks. The clinical or intra-oral approach may be imprecise if the access to the area of measurement affects the angle of holding the vernier or if it does not rely on fixed and dependable locations in some instances.

The same drawback of relying on unreliable reference points is also present in the study model approach and the method's dimensional change of the acrylic plug relies on this weakness. Changes in the dimensions of the impression materials and some tearing following removal are a further concern.

The radiographic method may have ethical and safety problems with the exposure to radiation and superimposition of teeth, particularly with lateral cephalometric X-ray, whereas the study model is safe, simple, and accurate.[25] The clinical procedures are less precise and error-prone than the models used in research.[15]

The superimposition of digital dental models is one of the most innovative instruments for calculating individual dental changes between two time points.[48] 3D assessment by the superimposition of the digital models from intra-oral scanner or scanned stone models is considered the superior method because the method of superimposition and digital measurements decreased the possibility of errors that could have occurred with other methods, in addition to the patient's comfort.[49] However, the technology for superimposing digital models has not been as thoroughly standardized as other common orthodontic procedures.[50]

Superimposition must be performed on stable reference points. The rugae area in the maxillary arch is the most correct portion for superimposition, notably the medial portion, as the lateral portion of the rugae may be impacted by headgear treatment,[51] extraction of the maxillary premolar,[52] and significant maxillary expansion.[53]

As per the majority of research, the growth changes in the vertical and sagittal planes surrounding the third rugae region are practically minimal.[54]

Thiruvenkatachari *et al*.[55] used stable spots on the palatal rugae and a stable region in the center of the hard palate in an effort to compare the accuracy of the 3D scanner to the measurements acquired from cephalometric radiography. They juxtaposed scans of models before and after therapy.

Cha *et al*.,[56] who evaluated the tooth movement measured by the superimposition of 3D images on the palatal rugae using the best-fit method on three implants that were considered stationary landmarks, determined that the medial point of the third rugae was the most stable point, confirming the findings of Frans van der Linden,[57] as it is the furthest away from the retracted anterior teeth. Jang *et al*.[58] concluded that the abovementioned landmarks might be relied upon as stable measuring points for tooth movement based on the stability of the posterior region of the palatal vault.

The same conclusion was obtained from a recent study performed by Garib *et al*.,[59] who used nine palatal landmarks [Figure 5], namely, the posterior limit of the incisive papilla, the medial edges of the second rugae, the medial and lateral edges of the third rugae, and two landmarks 10 mm distal to the medial edge of the third rugae landmarks to superimpose the maxillary arch at different intervals. In addition, they leveraged these landmarks to create an area of interest. The authors hypothesized that registration based on landmarks might be the preferred method for evaluating patients undergoing fixed orthodontic therapy. Furthermore, neither the enlargement of arches nor the closure of extraction gaps affected the location of these landmarks.

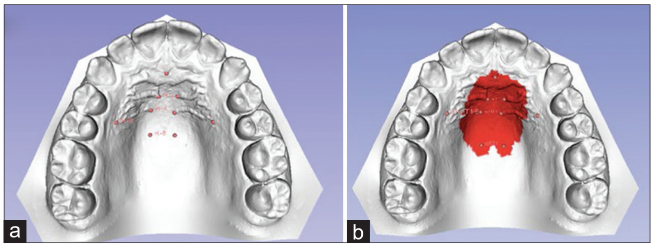

Figure 5: (a) Nine landmarks that used for registration on the palatal rugae. (b) Region of interest around the nine landmarks used for registration[59]

Assuming that superimposition is performed on the most stable palatal landmarks, additional research is required to compare alternative methods for assessing distal canine movement as there is no study that compares the accuracy of different digital scanners and softwares in evaluating the amount of distal canine movement and rotation. On the other hand, no study used the digital photographs in evaluating the same prupose, so further studies are needed to verify these two methods. Merging Digital imaging and communication in medicine and stereolithography might be a promising method for measuring distal canine movement just like the direct method.

Conclusions

Direct measuring inside the patient's mouth is the simplest method; however, it lacks accuracy. Changes in dimensions and tearing of the impression materials may influence the dental model analysis measurements. Exposure to X-rays is deemed dangerous and is not recommended from an ethical standpoint. It is the preferred way to use an intra-oral scanner and digital superimposition on stable palatal landmarks because it is safe, simple, rapid, accurate, and does not disturb the patients.

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Conflicts of interest
There are no conflicts of interest.

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