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Influence of tooth morphology on torque expression with preadjusted edgewise appliance in anterior teeth in a mixed indian population: An in-vitro study

Ashish Kamboj[1],*, Atul Bali[1], Vineet Sharma[2], S S Chopra[2], Dinesh Chaudhary[1], Prateek Mathur[3]

[1]*Army Dental Corps, India*
[2]*Dept. of Dental Surgery, Armed Forces Medical College, Pune, Maharashtra, India*
[3]*Dept. of Orthodontics, Army Dental Centre (R&R), Delhi Cantt, Delhi, India*

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ABSTRACT

The effect of racial and ethnic variations of dental morphological traits on torque expression of preadjusted edgewise appliances has rarely been documented. This in vitro experiment was carried out with the aim to study the extent to which the anterior tooth morphology of a mixed Indian population affects torque expression of a preadjusted edgewise appliance. This study was conducted on extracted maxillary and mandibular anterior teeth of a mixed Indian population. These teeth were divided into two similar groups and were bonded with 0.018" Roth and MBT prescriptions. Full slot engagement was obtained using a 0.018" x 0.025" stainless steel wire to study how the variation in the tooth morphology affects the torque expression. Each tooth with the test wire engaged in the slot was radiographed using standardised procedures. The radiographs were photographed; images were transferred to a computer and enlarged 6 times. Printouts of the images were taken and the torque expression angle for each tooth of the two groups was measured. A wide range of torque expression was obtained reflecting the influence of tooth morphology on the expression of torque, suggestive of significant variations in the tooth morphology of the same tooth type. However, the mean torque expressions obtained in this study were comparable to the average values of torque prescribed for the two prescriptions.

1. Introduction

Orthodontic treatment aims at positioning anterior teeth to achieve optimum aesthetics, function and stability. The difficulties in obtaining satisfactory treatment results with the standard edgewise technique paved the way for the development of brackets with inbuilt torque in the 1960's. The foundation of the then nascent process of developing pretorqued and preangulated appliances was laid down by Lawrence F Andrews when he developed the 'Six Keys to Normal Occlusion' and the first fully programmed appliance was introduced.[1]

The rationale for the use of any standard preadjusted edgewise appliance prescription with inbuilt first, second and third order adjustments is based on the assumption that extensive similarities exist in the morphology of normal tooth types and their positions, when optimally occluded. Advocates of the straight wire appliance claimed, that very small and inconsequential differences exist in tooth morphology and these minor differences do not have a major effect on the treatment outcome. However, various studies[2–6] had shown the existence of differences in tooth morphology. Wheeler[3] had stated that the maxillary central incisors are the most consistent in their shape than any other tooth in the oral environment. However, studies had reported

* *Corresponding author.*
E-mail address: aashishkamboj@ymail.com (A. Kamboj).

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variations in the shape and size of maxillary central incisor. Morphological differences had also been reported between right and left central incisors in the same individual.[6] This variation in tooth morphology is at its extreme in the case of maxillary lateral incisors. This variability in tooth morphology negates the very concept of a typical tooth and can result in variable amount of torque expression for the same prescription.[7–10]

Race and ethnicity influence the form of human teeth in varying ways.[11–14] It has been documented that the labial surface curvature in Asians is less pronounced compared to Caucasians but the effective thickness of incisal edge is more in Asians compared to their Caucasians counterparts.[14] The differences in dental morphological traits such as tooth shape or size among different races and ethnic groups can be of great interest to dentists in general and orthodontists in particular. If these racial variations in tooth size and form are significant enough, then the very basis of the straight wire appliance, based on the average Caucasian norms, is challenged. Such an appliance when used for different races may result in significant clinical variations in the form of poor clinical outcome.

Very few studies have been reported in literature on the influence of tooth morphology and its effect on labiolingual inclination in Asian populations.[15,16] Most of these studies were either cast based or were based on ideal diagnostic setups. But, none of the studies had evaluated the influence of tooth morphology on torque expression using the preadjusted edgewise appliance. The present study was an endeavour to find an extent to which the anterior tooth morphology affects torque expression of a preadjusted edgewise appliance in a mixed Indian population.

The aim of the research work was to study the influence of morphology of anterior teeth of a mixed Indian population on torque expression of a preadjusted edgewise appliance.

The objectives of this in vitro study were:

1. To determine the degree of torque expression in anterior teeth of mixed Indian population with a preadjusted edgewise appliance.
2. To compare the torque values in anterior teeth using a preadjusted edgewise appliance in a mixed Indian and Caucasian populations.
3. To compare if any significant differences exist in the torque expression of the right and left anterior teeth when a preadjusted edgewise appliance was used.

2. Material and Methods

This in vitro study was carried out at the Department of Orthodontics and Dentofacial Orthopaedics of a tertiary care teaching institution. Extracted anterior teeth were collected in the outpatient department of the institution from a mixed Indian population. One hundred eighty maxillary (180) and an equal number of mandibular anterior teeth were collected. They comprised 30 teeth each of central incisor, lateral incisor and canine of right and left sides. The teeth were cleaned with pumice slurry and rubber cup while taking care that they were not damaged in the cleaning exercise. The teeth of each type were equally divided into two groups X (Roth) and Y (MBT). Therefore, each group had 15 teeth of each type divided randomly to receive brackets of Roth and MBT prescriptions (Figure 1) respectively. Each tooth was given a specific number using a permanent marker for ease of identification and reference.

A test jig was fabricated which comprised of a plexiglass platform and a wire mesh with grid dimensions of 5mm (Figure 2). The mesh acted as a guide for orienting the teeth, the radiographic film and a reference to determine the image magnification. Two points were marked on labial surface of each tooth with a fine point pen.

1. Point I: Midpoint of the incisal edge or cusp tip of canine
2. Point C: Most apical point on the curvature of the cementoenamel junction

These points were connected to mark the long axis of the crown. The cervicoincisal height (from point I to point C) of each tooth was measured with the help of digital Vernier calliper calibrated to measure distance of 0.00mm. The anatomic height of the crown minus 1.8mm gives the height of the clinical crown. Once the clinical height of the tooth was determined the FA (Facial axis) point was marked.

The X (Roth) group of teeth were marked for bracket placement according to the Andrews' method.[1] The brackets were centred on the FA point and bracket wings were aligned parallel to the long axis of the clinical crown. The Y (MBT) group of teeth of each type were marked to receive brackets according to the method described for the MBT prescription.[17] In the present study bracket placement recommendations for an average adult were used for group Y (MBT)[17] and were as follows:

1. Maxillary central incisor: 5mm
2. Maxillary lateral incisor: 4.5mm
3. Maxillary canine: 5mm
4. Mandibular incisors: 4mm
5. Mandibular canine: 4.5mm

The marked teeth were bonded using Roth and MBT prescription brackets of 0.018" X 0.025" slot (Ortho Organizers, San Marcos., CA 92069, USA.) after etching with 37% phosphoric acid gel (Scotchbond, 3M) for 15 seconds with a light cure adhesive primer (Transbondxt) cured with a light cure unit (Confident India Ltd.) at a constant light source - tooth distance for 40 seconds. In the Roth group a straight probe was used to position the brackets at the FA point and to angulate them accurately to the long axis of the tooth. In the MBT group bracket placement

gauges were used to accurately position the brackets. Fifteen stainless steel rectangular wires (0.018"× 0.025") 5 cm in length were bent at right angle (L- shaped) using Tweed's Ribbon arch pliers. The angle of the wires was confirmed on a protractor (Figure 3). Care was taken to ensure that no torque was introduced into the wire. This was done by holding the wire between the beaks of the Ribbon arch pliers. This wire was inserted into the slot. The test wire was fully engaged in the slot with the help of 0.010" ligature wire and a snug fit was ensured. The tooth with the wire was mounted on the test jig using Cyano-acrylate adhesive material. A size 2, E speed radiographic film was oriented on the wire mesh with the help of adhesive tape. Care was taken to ensure that the long axis of the tooth to be radiographed and the radiographic film were parallel to each other and in case of the canines there was no rotation of the tooth around the cusp tip.

All the radiographs were photographed using a SLR camera (Canon 350) mounted on a tripod at a fixed object camera distance of 6 inches (Figures 4 and 5). The photographic images were inverted using Adobe Photoshop – 7, software and projected to a magnification of 6 times their original size. Printouts of the magnified images were taken on fine quality paper. On the magnified image a tangent was drawn to the bracket base point and another line was superimposed on the image of the long axis of the test wire. These two lines were extended to intersect at a point forming an angle θ. Using a protractor, the formed angle was measured. This angle gave the value of torque expression of the bracket for that tooth. This value was designated as T1. The torque expression angle was measured for all the teeth in both X and Y groups of each tooth type.

The torque expression values were designated as

1. Zero: If the two reference lines ran parallel to each other, then the torque expression angle was zero.
2. Positive: If they met incisally the torque expression angle value was positive
3. Negative: If they met gingivally the torque expression angle was negative

To assess the error of the method, two teeth of each type were selected from each group X (Roth) and Y (MBT). For these selected 24 teeth the brackets were debonded and any residual adhesive was carefully removed using a tungsten carbide bur. The standard procedure of bonding, slot engagement and measurement of torque expression was repeated using new brackets. The torque expression angle values measured were designated as T2. The difference between the T1 and T2 values was used to calculate the standard error of the method.

3. Results

The results showed that in the maxillary arch the incisors had positive torque expression angle values (labial crown torque) in both the X (Roth) and the Y (MBT) groups. For the central incisor the mean torque expression angle value was significantly greater ($p<0.05$) in the Y group (14.72º ± 2.98) than in the X group (11.37º ± 4.10). For the maxillary lateral incisors, the torque expression angle values of the two groups were comparable {X (8.15º ± 5.03) and Y (7.08º ± 3.57)}. The maxillary canines had negative mean torque expression angle values in both the groups. The values were however significantly greater ($p<0.001$) in the X group (-4.33º ± 3.18) as compared to the Y group (-1.50º ± 0.38).

In the mandibular arch, the central incisors in the X (Roth) group were almost upright on the basal bone (0.30º ± 5.71), while in the Y (MBT) group they had significantly greater ($p<0.01$) negative mean torque expression angle values (-5.62º ± 5.65) i.e. they had lingual crown torque. The mandibular lateral incisors in both the groups had negative mean torque expression angle values {X group (-1.10º ± 5.30), Y group (-6.30º ± 5.42)}. However, the lateral incisors in the Y group showed significantly greater ($p <0.01$) mean negative torque expression angle values. The mandibular canines also had negative mean torque expression angle values in both the groups. The values were however, significantly greater ($p<0.05$) in the X group (-7.12º ± 5.16) as compared to the Y group (-3.00º ± 3.87).

A Comparison of the mean torque expression angle values of the right and left maxillary and mandibular anterior teeth in both the X (Roth) and the Y (MBT) groups showed no significant difference ($p>0.05$) in all the tooth types. The mean torque expression angle values of the mandibular central and lateral incisors in both the X (Roth) and Y (MBT) groups showed no significant differences ($p>0.05$) in both the groups. (Tables 1 and 2).

Fig. 1: 0.018" X0.025" slot Roth and MT preadjusted edgewise bracket (Ortho Organizer)

The results of the error analysis of the present study showed that when the T1 and T2 values were compared: the maximum standard error was 1 degree and the minimum was 0.25 degree. The low error values obtained in this study indicated the accuracy of the method used.

Table 1: Comparison of mean torque values obtained in the present study {X (Roth) group}, with the prescribed values for the Roth prescription.

Tooth type	Maxillary central incisor	Maxillary lateral incisor	Maxillary canine	Mandibular central incisor	Mandibular lateral incisor	Mandibular canine
Torque in degrees (Present study)	11.37 ± 4.10	8.15 ± 5.03	-4.33 ± 3.18	0.3 ± 5.71	-1.1 ± 5.3	-7.12 ± 5.16
Range (Present study)	3 – 19	-6 – 19	-12 – 0	-7 – 13	-8 – 12	-14 – 15
Prescribed values (Roth)	12	8	-2	-1	-1	-11

Table 2: Comparison of mean torque values obtained in the present study {Y (MBT) group}, with the prescribed values for the MBT prescription.

Tooth type	Maxillary central incisor	Maxillary lateral incisor	Maxillary canine	Mandibular central incisor	Mandibular lateral incisor	Mandibular canine
Torque in degrees (Present study)	14.72 ± 2.98	7.08 ± 3.57	-1.5 ± 0.38	-5.62 ± 5.65	-6.3 ± 5.42	-3 ± 3.87
Range	10 – 21	2 – 15	-8 – 7	-13 – 12	-16 – 3	-11 – 3

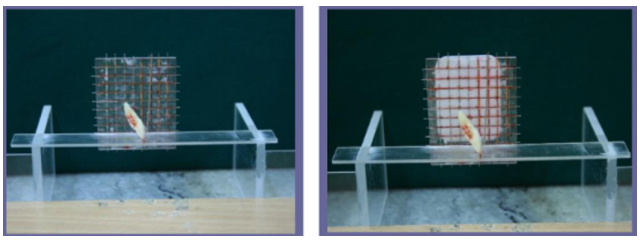

Fig. 2: Test Jig

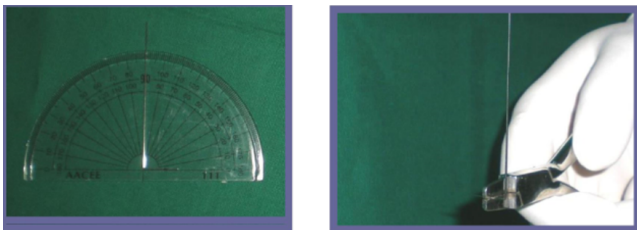

Fig. 3: A-test wire bent at ring angle

Fig. 4: X-ray machine

4. Discussion

Determination and quantification of the effects of tooth morphology on torque expression of labial/buccal surfaces of maxillary and mandibular teeth had been widely investigated. Most of these studies[7–10,18–24] were carried out on samples obtained from Caucasian populations. Few studies had been reported on the Asian population.[15,16] The present study was carried out on a mixed Indian population.

To assess the effect of variations in tooth morphology on torque expression studies were carried out on plaster models[7,9,15,16,19,21,23,24] scanned images of labial surface contour of teeth[22] and contact radiographs of extracted teeth.[8,10,18,20] The present study was based on radiographs of extracted teeth with full slot engagement of the 0.018" Roth and MBT brackets.

Andrews[1] had stated that the human eye is quite accurate at bisecting and locating the center of a visible object. However, in a clinical situation direct visualisation of the center of the clinical crown is more difficult and this difficulty was attributed to the presence of partially erupted teeth, gingival inflammation and teeth with palatally and facially displaced roots. In a clinical situation, especially with the direct bonding technique bracket placement errors

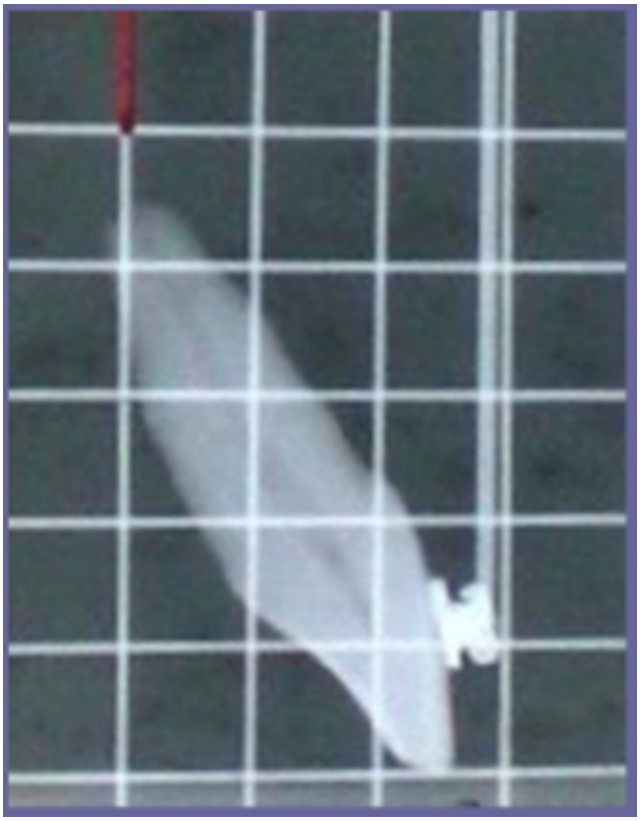

Fig. 5: Image of the radiograph

are inevitable. The advantage of using extracted teeth is that bracket placement errors due to the above mentioned factors can be minimised. This allows proper visualisation of the teeth and location of the centre of the clinical crown. This advantage was made use of in this study as extracted teeth were used as a study sample.

5. Limitations

1. A variation of torque expression is inevitable with different manufacturers due to a range of fabrication processes and materials used.
2. Effect of intra oral factors such as friction, influence of saliva and variation in bracket positioning can only be quantified in an in-vivo study.

6. Future Prospects

1. Torque expression analysis of the entire arch will help us assess the accuracy of a bracket system and help improvise the same.
2. An evaluation of the self-ligating brackets and lingual bracket system with variable anterior torque values is an interesting area to be evaluated.

7. Conclusions

The wide range of torque expression obtained, reflected the influence of tooth morphology on the torque expression in a mixed Indian population. This revealed the presence of significant variations in the tooth morphology of the same tooth type.

Considering the inter-tooth variations, it would be appropriate to use brackets designed individually for each tooth.

There were no significant differences in the mean torque expression of anterior tooth types on the right and left sides in the maxillary and mandibular arches.

There was no significant difference between the mean torque expression of the mandibular central and lateral incisors. This justified the use of similar brackets of any given prescription for the mandibular incisors of the same quadrant.

The mean torque expressions obtained in this study were comparable to the average values of torque prescribed for the two prescriptions. Thus, this study could not quantify any significant variation in the torque expression in a mixed Indian and Caucasian population.

Roth and MBT (0.018") pre-adjusted edgewise prescriptions can be used alike in Indian and Caucasian populations.

8. Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

9. Source of Funding

None.

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Author biography

Ashish Kamboj, Classified Specialist Orthodontics

Atul Bali, Classified Specialist Orthodontics

Vineet Sharma, Professor

S S Chopra, Professor

Dinesh Chaudhary, Classified Specialist Orthodontics

Prateek Mathur, Resident Officer

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