Evaluation of Angulation between Labial & Lingual Surfaces of Crown of Anterior teeth & 3D Mapping Lingual Surface for Development of Concept of New Preadjusted Lingual Bracket

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Abstract

Introduction: The present work focuses on digital analysis and evaluation of angulation between labial & lingual surfaces of the crown of each anterior tooth and lingual curvature for the development of a pre-adjusted lingual bracket system.

Material & Methods: The sample consisted of 100 dental casts (maxillary & mandible) and 100 CBCT scans made at Santosh Dental College, Ghaziabad which were selected on the basis of Angle's Class I molar relationship without any crowding, rotation, attrition, abrasion, erosion, abfraction & anomaly on any tooth with the patient age group between 16 years to 20 years. CBCT scans were taken by KODAK 9500 Cone Beam 3D System (Carestream Health, Inc. 150 Verona Street Rochester NY 14 608) at Institute of Lingual Orthodontics, Centre for Advanced Dental Care, Indirapuram. The samples were evaluated for 3D Surface Topography, Labio-lingual angle and Lingual Curvature.

Results: This study's confirmation of digital dental analysis enables for the assessment of tip and torque, which might be used to better comprehend the subtleties of various bracket prescriptions. A broad range of incisor and canine shapes, forms, and sizes were observed. There was a greater than 24-degree difference in incisor and a greater than 28-degree difference in canine CRA values. A total of eight different types of lingual curvatures were established that included four lingual curvatures for maxillary central incisor, two for maxillary lateral incisor and two for maxillary canine respectively.

Conclusion: In the present study by the use of digital analysis, we were able to establish eight distinct lingual curvatures namely four for maxillary centrals, two for maxillary laterals and two for the maxillary canine.

Keywords: Preadjusted Lingual Bracket, ligual curvature, Mapping Lingual Surface

Introduction

Lingual orthodontics grew slowly in North America in the 1980s as orthodontists grappled with the lingual technique, which needed distinct treatment planning and a different approach to biomechanics, as well as ergonomics and treatment efficacy difficulties.[1,2] The early excitement of lingual orthodontic treatment faded with the discovery of "tooth-colored" labial brackets manufactured from single-crystal sapphire and later from ceramics, and much of the improvement of lingual orthodontics occurred outside the United States. Removable orthodontic aligners, rather than lingual braces, have become the treatment option for patients seeking invisible orthodontics with the introduction of Invisalign in 2000.[3]

The advancement of numerous orthodontic procedures has resulted in the attainment of excellent orthodontic treatment standards. People's self-esteem rises when they have a pleasing aesthetic appearance. The fundamental purpose of orthodontic therapy is to establish facial balance by balancing aesthetic treatment, functional balance, and harmony. Lingual orthodontics is the most effective way to address these goals without sacrificing biomechanical efficiency.[4]

The future of lingual orthodontics is reliant on three major issues: (1) advancements in appliance design and laboratory protocols; (2) demographic changes in the population age group: an increase in the number of adult patients seeking orthodontic treatment, coupled with an increase in affluence and disposable income, will result in a patient-driven demand for more aesthetically acceptable appliances; and (3) orthodontists' attitudes.[5]

The prevalence of unfavourable effects connected with lingual and buccal fixed orthodontic procedures was studied. Lingual orthodontic equipment provides undeniable cosmetic benefits over buccal orthodontic appliances. Furthermore, it has been suggested that lingual appliances may minimize the incidence of caries, possibly due to the pooling of saliva on the lingual portion of the mandibular teeth in particular, but that they can cause greater issues with oral hygiene and discomfort.[6]

It is difficult to observe the lingual surfaces of all teeth in order to identify the exact Facial axis of the clinical crown (FACC point). So, no matter how precisely brackets are positioned on set-up models, if these placements are lost after intraoral bracket placement, it's pointless. The phrase "incorrect bracket positioning leads to treatment failure" is not an exaggeration. It would be difficult to visualize and correctly position lingual brackets if they were directly glued. The norm in the lingual optimal configuration for Lingual Bonding Orthodontics is hence indirect bonding.[7]

They agreed that one of the key goals of orthodontic treatment is aesthetics; lingual appliances are really aesthetic appliances since they are put on the lingual surface of the tooth and are completely invisible. The invisible braces have widened the horizons of society, reaching out to more people, particularly those who are concerned about the appliance's sight.[8] In comparison to labial appliances, lingual appliances have encountered challenges with sophisticated laboratory procedures, uneven lingual tooth morphology, high cost, and bonding trouble over time. With the current improvement of processes, additional materials and methods have been introduced, making in-office bonding possible with lingual appliances.

The goal of present work focuses on determining the anatomical measurements on maxillary anterior teeth using measurement of the angle formed between the labial and lingual surface of teeth and 3D mapping of the lingual surface for developing a Pre-Adjusted Lingual Bracket System independent of the irregularity of the lingual surface. It involves study on the labio-lingual angulation and curvature of lingual surfaces of maxillary anterior teeth, for the creation of an innovative concept of an Pre-adjustable lingual braces.Also, it would allow for a reduced laboratory dependency as it is working in collaboration with a digitalized CAD-CAM Technology.

Material & Methods

Hundred Dental Casts (16-20 years age group) were selected on the basis of Angle's Class I molar relationship without any crowding, rotation, attrition, abrasion, erosion, abfraction & anomaly on any tooth. The curvature of lingual surfaces of maxillary anterior teeth was studied, for the creation of an innovative concept of a Preadjustable lingual brace.

Diagnostic Casts / Impression were made at Santosh Dental College, Ghaziabad was immediately poured by Orthokal at normal room temperature nearly 30^{o} with the help of a vibrator for 30-40 seconds until large bubbles largely stop coming to the surface, approximately 1 hour was given to maximum strength of stone.

100 CBCT scans were taken by KODAK 9500 Cone Beam 3D System (Carestream Health, Inc. 150 Verona Street Rochester NY 14 608) with FOV of 18 cm height x 20.6 cm diameter at 0.3 mm slicing for orthodontic diagnostics purposes at The Institute of Lingual Orthodontics, Centre for Advanced Dental Care, Indirapuram.

3D Surface Topography - The images were reconstructed with 0.3-mm slice thickness and exported as digital imaging and communications in medicine (DICOM). CBCT images were opened using the Fusion tab found within On Demand 3D software. [Figure 1]

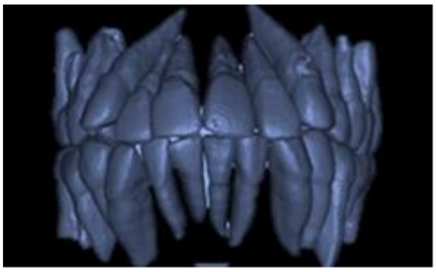


Figure 1. CBCT images for dentition

Labio – Lingual Angle - Measurement with CBCT measured by CS 3D Imaging Software 11.6. Angle is formed by drawing three axis –

First, a form tip of the coronal portion of the crown to the apex of the root.

Second, labial axis FACC touching at FA point.

Thirdly, the axis from the most prominent on the cingulum to the tip of the incisal edge intersects the FACC. [Figure 2]

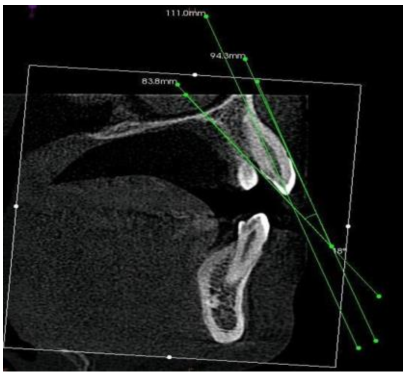


Figure 2. Measurement of labiolingual angle on CBCT IMAGES

Lingual Curvature – Cross section of each individual anterior teeth Central Incisor, Lateral Incisor, and Canine was extracted by CS 3D Imaging Software 11.6, cross-section of each tooth was taken at the middle along the long axis. [Figure 3]

Each group of tooth cross-section is outlined in CorelDraw x6 (Corel Corporation, Carling Avenue, Ottawa, Canada) and superimposed the same software taking a tip of the crown to the apex of the root vertical landmark and Bucco-lingual CEJ as a horizontal landmark. [Figure 4, 5]

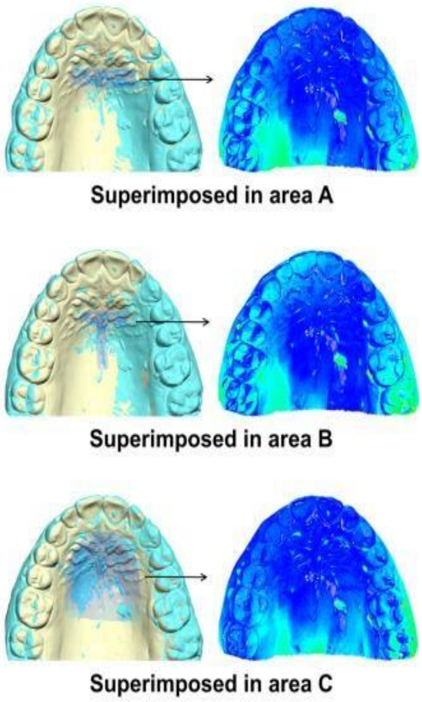


Figure 3. cross-section of the Central Incisor, Lateral Incisor, and Canine was taken at the middle along the long axis

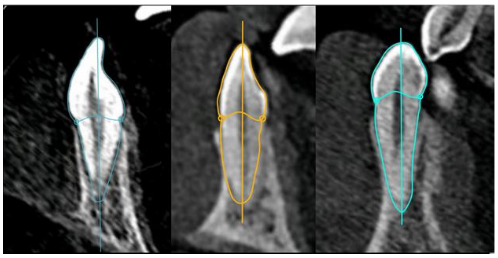


Figure 4. Superimposition of tooth cross-section outline in CorelDraw on CBCT images

Inclusion criteria

Cast models and CBCT scans from patients with full dentition except for third molars; and all permanent teeth in occlusion according to Andrews' keys of normal occlusion with the absence of odontogenic anomalies.

Exclusion criteria

Odontogenic anomalies, partial dental eruption, and the presence of erupted third molars were used as sample exclusion criteria.

Statistical analysis

The collected data was analyzed by using IBS-SPSS. The appropriate statistical method was used to make cross-tabulation, frequencies, ratios, histograms, and scatter plots. Different parametric and non-parametric measurement such as Pearson correlation test, independent-measures t-test, Anova tests and the Spearman correlation test wre used to analyze the data.

Figure 5. Superimposition in area A, B and C.

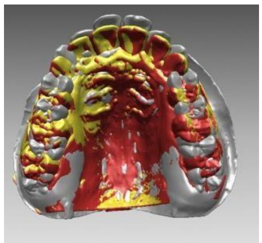
Results

In the study, the mean labiolingual angulation on CBCT scans was found to be 20.25º±3.47,20.55º±4.88 and 25.96º± 5.36 for maxillary central incisor, maxillary lateral incisor, and maxillary canine respectively. [Table 1]

Cross-sectional images were obtained for each individual anterior teeth Central Incisor, Lateral Incisor, and Canine extracted by CS 3D Imaging Software 11.6, cross-section of each tooth was taken at the middle along the long axis. [Figure 6]

On cross-sectional digital imaging, lingual curvature exhibited multiple variations in the study sample. Out of these, it showed four distinct lingual curvatures for the maxillary central incisor, two for the maxillary lateral incisor and maxillary canine respectively. [Figure 6]

When labial and lingual curvatures were evaluated for the maxillary anterior teeth, eight different types of curvatures were observed (four for Centrals, two for laterals and two for canine). The difference was clearer when the crown-root axis was taken as the reference guide as in [Figure 7]. The difference in the depth of curvature for maxillary anterior teeth holds significance as the conventional bracket design offers a standard flat base and a variable slot for an additional tip and torque values.[Figure 7-9]



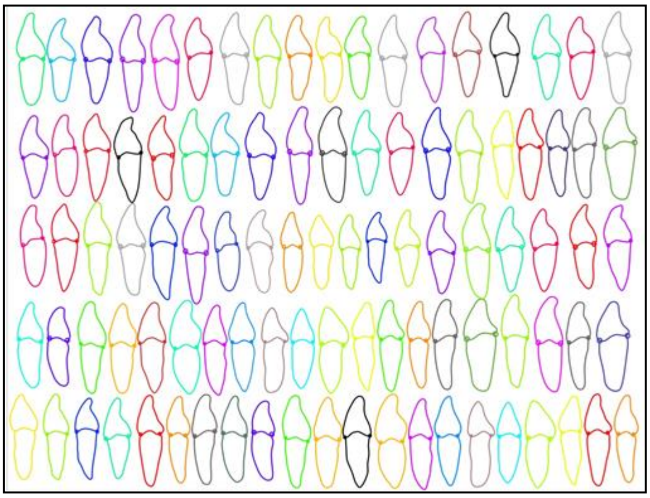
Thus, the study on lingual curvature on the maxillary teeth explains clearly the need for additional changes to be incorporated in the lingual bracket design. The probable options include adding the quantified amount of bonding adhesive to achieve a uniform straight standard base for all maxillary anterior teeth [Figure 9] or customizing the design of the bracket base by following the contour of individual lingual tooth contours. [Figure 8,9]

The former method seems clinically applicable in the initial stages of growth of lingual orthodontics thus giving it rapid popularity. However, speedy digitalization enables the incorporation of the altered lingual contour during the fabrication of a preadjusted lingual bracket system serving several advantages.

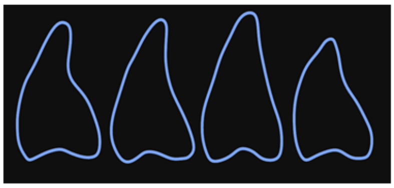
Table 1: Mean and standard deviation of Labio-lingual angle of central Incisor, Lateral Incisor and Canine on CBCT images

Labio-lingual Angle	Central Incisor	Lateral Incisor	Canine
Mean	20.25 º	20.55 º	25.96 º
SD	3.47	4.88	5.36

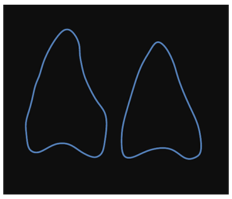
Figure 6: Cross-sectional images obtained for each individual anterior teeth Central Incisor, Lateral Incisor and Canine extracted by CS 3D Imaging Software 11.6.



CENTRAL INCISOR

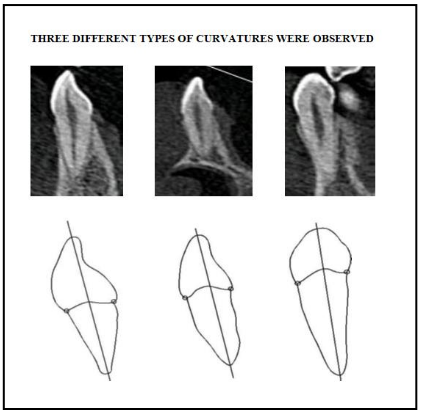


LATERAL INCISOR



CANINE

Figure 7. Three types of lingual curvature on the maxillary anterior teeth



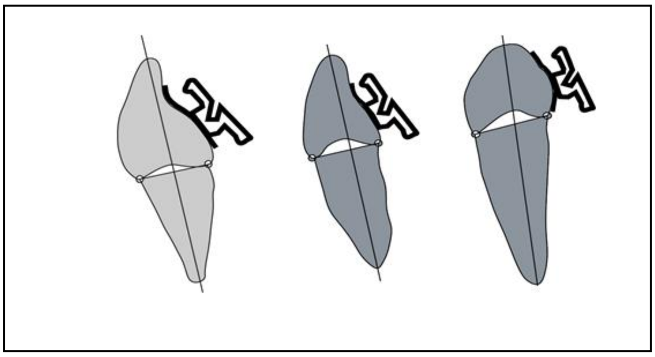
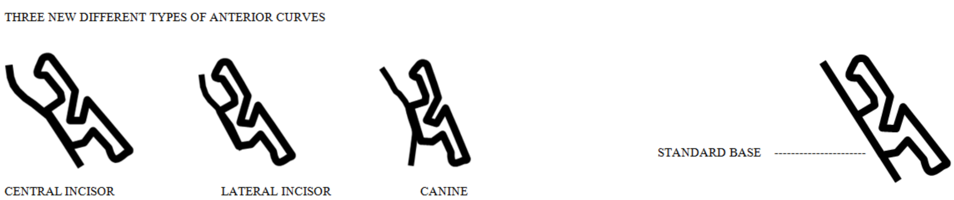


Figure 8. Variation in the adhesive on bracket base

Figure 9. Customizing the design of the bracket base by following the contour of individual lingual tooth contours



Discussion

This study's confirmation of digital dental analysis enables for the assessment of tip and torque, which might be used to better comprehend the subtleties of various bracket prescriptions. When comparing dental casts at two distinct time periods, this new technology may be valuable to both clinicians and researchers since it allows a better understanding of the changes that occur due to growth or therapy. Three-dimensional virtual dental cast analysis, which gives more information and accurate intra arch measurements than standard stone cast analysis, may be recommended.[9]

A broad range of incisor and canine shapes, forms, and sizes were observed. There was a greater than 24-degree difference in incisor and a greater than 28-degree difference in canine CRA values. Compared to previous research, this range is greater, although others have reported similar results.[10] When it comes to orthodontic treatment, the CRA is crucial to achieving a desired tooth position. Because a root that has been pushed against the cortical plate is more susceptible to root resorption, extreme caution should be used when using a large CRA to twist a tooth.[11]

The curvature of the facial surface varied significantly between 2 and 6 mm from the incisal edge of the central maxillary incisors. When a physician plans to attach a preangulated bracket to the labial or buccal surface, it should be glued at least 4 mm from the incisal edge to express the preadjusted bracket's most dependable and constant built-in torque (smallest SD).[12] A bracket location farther than 4.5 mm from the incisal edge, on the other hand, results in a less uniform manifestation of the torque incorporated into the bracket, since the curvature of the crown's labial surface is more likely to vary in this region.[13]

Because the SD of the buccal surface angle is significantly bigger than that of incisors, the location of a bracket on a maxillary canine is more vulnerable to individual variation. For all canines in this investigation, the SD of curvatures assessed between 2 and 4.5 mm from the incisal edge was found to be reasonably stable.[14]

Using one kind of bracket system and placing a bracket between 2 and 4.5 mm from the incisal edge for both incisors and canines, average torque expression may result in an average difference of 10 degrees at the conclusion of treatment in the same patient. More gingivally positioned brackets will result in a greater torque differential. The average values for the labial surface curvatures were used to arrive at these conclusions. The real variances between the lowest and maximum curvatures were significant, resulting in a torque variation that was considerably more dramatic.[15]

The bracket height in relation to all other brackets, rather than the actual height on the tooth, is significant, according to Creekmore and Kunik (1993)[16]. They also claimed that changing the bracket height would have no effect on the ultimate torque. The current study's findings, on the other hand, reveal that the curvature of the labial surface influences the amount of force applied. When various kinds of brackets are compared, a wider ultimate torque impact might be predicted. When the bracket is set at the precise height specified, the necessary torque will be indicated. Due to the curve of the labial surface, placing a bracket closer to the incisal edge or more gingivally will result in a varied inclination of the bracket. Every design's built-in torque was tweaked to fit all conceivable bracket heights.[17]

As a consequence of an average change in the labial surface angle at various heights, an increase or reduction in torque will be noted by adjusting the bracket height from that provided. According to the average inclination of the labial surface angles determined in this research beginning from the built-in torque supplied, mean values of torque at clinically acceptable heights between 3.5 and 5.5 mm from the incisal edge for the incisors and between 4.0 and 5.5 mm for the canines Even when the brackets are set at a clinically appropriate height, torque for the upper central incisors might range between 5.1 and 24.0 degrees depending on the procedure and bracket height. Torque ranges between –9.8 and 9.3 degrees for the canines.

On the other hand, owing to anatomical variances in the lingual surface and extensive chair time for patients and orthodontists[4,5], the practitioner has challenges in the insertion and management of these appliances[5] as well as the precision of bracket placement. Furthermore, brackets may induce changes in tooth shape over time.[18] Keeping the above facts in mind the present study was undertaken to fabricate preadjusted lingual brackets with the help of 3D mapping technology to enhance patient comfort and reduce the challenges that the practitioner come across while inserting and managing the appliance.

The reliability of a custom dental analysis conducted on virtual three-dimensional study models was presented and evaluated in this work. In addition to the conventional linear measurements, the transition from a normal "calliper and protractor" analysis to a virtual three-dimensional analysis permits the introduction of additional instruments and metrics.

Development of *New Lingual Pre Adjustment* will bring a great boom to the Lingual Orthodontics. This bracket will make lingual orthodontics as efficient as labial orthodontics. As there will be no dependency of the laboratory system, treatment can start faster which will decrease the treatment duration, at the same moment making new set up will a be few steps or few minutes work.

Debonding and lost brackets has been a great issue and some time for which again laboratory dependency increases. With this new bracket system, debonded or lost brackets will not be any issue. With all this, ease to work with lingual appliance will increase and costing will reduce which will be more economical for patient. With all the advantages of the New Bracket system Lingual Orthodontics will be able to serve the mass and all the myths and misconception will be eliminated.

Lingual orthodontics future depends on technological advancements in appliance design and laboratory operations. Most orthodontic patients may benefit from lingual appliance therapy and it is the greatest option for adult patients who don't want to wear traditional visible appliances for social or professional reasons and want to enhance their experience.

Accurate bracket positioning in lingual bracket therapy is very crucial to achieve better results. It not only glides the biomechanics smoothly but also enhances completion within the stipulated duration of treatment. The digital assistance through CBCT and DICOM software allow precise detailing thereby reducing the laboratory expenses and yielding a reliable preadjusted lingual bracket system.

Variations in individual tooth morphology like the labiolingual angulations, buccolingual thickness, labial and lingual curvature play a pivotal role in determining the optimum tip and torque values for the lingual bracket system. By the use of digital analysis, the present study greatly emphasizes on the different lingual curvatures obtained namely four for maxillary centrals, two for maxillary laterals and two for maxillary canine. Also, it explains the role of the labiolingual angulation helping in reducing the laboratory workload and expenses. However, the owing to the invitro study design, the findings are to be interpreted with caution.[19]

Conclusion

On combining this with other relevant parameters like labiolingual angle, labiolingual width, the lingual curvature offers a convincing and feasible method to produce an anatomical template that represents the customized lingual base for the creation of preadjusted lingual bracket system. This Pre-adjusted Lingual Bracket System with so many more advantages will be best suited for a greater mass and will provide the field of Orthodontics with an expanding horizon.

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