Study on the angulation between the labial and lingual surfaces of anterior maxillary teeth for the creation of an innovative concept of an adjustable lingual brace

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Abstract---Introduction: The lingual appliance is genuinely an aesthetic device since it is positioned on the lingual surface of the tooth and thus is referred as ‘The invisible brace’. 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. The aim of this study was to develop a pre adjusted lingual bracket system that will be as efficient as labial orthodontics and can remove laboratory dependency. To accomplish it two parameters namely labiolingual
angulation and labiolingual width were studied with the help of cast analysis. Material & Methods: Sample consists of 100 Dental Cast (Maxillary & Mandible) of patients aged 16-20 years 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. Dental models / Impression were made at Santosh Dental College, Ghaziabad and were immediately poured by Orthokal at normal room temperature. Two important parameters were studied to develop the concept of New Pre Adjusted Lingual Bracket. It includes measurement and comparison of two parameters i.e. (1) Average angulation between Labial & Lingual surface of crown of each anterior tooth and (2) Labio-Lingual width of each anterior tooth crown at different heights to compensate for in-out discrepancy of the anterior teeth. These measurements were done on the dental models and compared with the help of appropriate statistical analysis.

Results: In the study with cast conventional method, the maximum mean labio-lingual angulation for central incisor, lateral incisor and canine was found to be 49.16±5.18º, 49.84±4.59º and 59.08±4.87º respectively. The mean labio-lingual width for all the three maxillary anterior teeth ranged from 2.2±0.5mm at 2mm height and 6.64±0.66mm at 7 mm height, mesially, centrally and distally in gradation with various dental heights. Conclusion: Lingual orthodontics is a subset of general orthodontics, and as such is bound by all of the same rules that govern proper patient selection and diagnosis. The future of orthodontics is changing at a breakneck pace. Lingual orthodontics’ future depends on technological advancements in appliance design and laboratory operations. The preadjusted lingual system aims to provide a consistent, rapid and economical way in the future, so many patients will choose Lingual orthodontics especially adult patients who don’t want to wear traditional visible appliances for social or professional reasons and want to maintain their appearance.

Keywords---angulation, labial surfaces, lingual surfaces, buccolingual width.

Introduction

Fixed lingual orthodontic appliances were first developed in the mid-1970s, owing to a surge in interest in adult orthodontics. These new “invisible braces” were created to provide a vital service to many patients who were hesitant to undergo labial appliance treatment due to aesthetic concerns. Various lingual bracket designs have been employed and often improved over the last ten years in an attempt to promote patient comfort, mechanical efficiency, and accurate tooth alignment.¹ The lingual appliance is genuinely an aesthetic device since it is positioned on the lingual surface of the tooth and is completely invisible. Aesthetics is one of the key aim of orthodontic treatment and the invisible braces have widened the horizons of society, reaching out to more people, particularly those who are concerned about the appliance’s sight.²,³ The most recent variants
of fixed lingual orthodontic appliances were mostly developed as a result of recent breakthroughs in bonding technology. The wide innovation in the bonding materials, mechanisms enhancing bond strength, use of orthodontic implants have made lingual orthodontics preferable in a large varieties of cases.

In labial orthodontics, the Angle’s edge wise appliance was ‘non programmed’ and had shortcomings few of them being bracket base perpendicular to bracket stem, bracket bases not contoured occluso gingivally and bracket stems of equal faciolingual thickness. These shortcomings were corrected in Preadjusted edgewise appliance by Lawrence F Andrews.\textsuperscript{4,5} The Andrew’s straight wire technique is still the choice of most orthodontists due to more consistent results, the ease in workability, reduced chair time, less patient discomfort and less laboratory dependency. The facial axis of clinical crown (FACC) and the facial axis point (FA point) formed the basis of the Andrews straight wire concept.\textsuperscript{4,5} 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 present improvement of processes, additional materials and methods have been introduced, making in-office bonding with lingual appliances a possibility.

Lingual orthodontics has been constantly growing, customization method being the most recent one. However this customization is limited to the bracket base and bonding material thickness. Very limited work has been done in past that could develop a ‘fully programmed’ lingual bracket. A lingual system with the ‘preadjusted’ concept similar to labial can be a great possibility if certain parameters favourable in lingual biomechanics are taken care off. These possibly include the FA point, FACC, labioliingual thickness, labioliingual angulation, labial and lingual surface curvatures and many more.

Recently, digital imaging is being used widely for the preorthodontic treatment assessment. Unlike labial treatment which had an advantage of easy access and visibility, lingual treatment faced a slower work to bypass this issue. With the advent of digital technology like rapid prototyping, stereolithography, cone beam computed technology (CBCT), accuracy, lower laboratory dependency and rapidity can be achieved easily. Latest digital softwares like Digital Imaging and Communication in Medicine (DICOM) is the latest standard for storing, handling, printing and transferring information.\textsuperscript{6} Use of such technologies permit us for developing a Pre Adjusted Lingual Bracket System which can remove laboratory dependency and make lingual orthodontics as easy, efficient with consistency and economical as is labial orthodontics.

By combining the conventional dental cast examination as well as CBCT scans, a holistic and accurate pathway can be formulated in the journey of developing concept of new preadjusted lingual brace. In this context, the current study looked at cast analysis of two important parameters to develop the concept of new preadjusted lingual bracket. It includes measurement and comparison of (1) Average angulation between Labial & Lingual surface of crown of each maxillary anterior tooth and (2) Labio-Lingual width of each maxillary anterior tooth crown at different heights to compensate in-out discrepancy of the anterior teeth.
Material & Methods

Sample consists of 100 Dental Cast (Maxillary & Mandible) of patients with age group between 16 - 20 years were selected on the basis of Angle’s Class I molar relationship without any crowding, rotation, attrition, abrasion, erosion, abfraction & anomaly on any tooth. Dental Casts / Impression were made at Santosh Dental College, Ghaziabad and were immediately poured by Orthokal at normal room temperature with the help of vibrator for 30-40 seconds until large bubbles largely stopped coming to the surface. Approximately 1 hour was given to achieve maximum strength of stone.

Two important parameters were studied to develop the concept of New Pre Adjusted Lingual Bracket namely- (1) Average angulation between Labial & Lingual surface of crown of each maxillary anterior tooth and (2) Labio-Lingual width of each maxillary anterior tooth crown at different heights to compensate in-out discrepancy of the anterior teeth. These measurements were done on the dental models and compared with the help of appropriate statistical analysis.

Labio – Lingual Angle

Measurement on the Cast was done by using 0.019 x 0.025 mm Stainless Steel Wire, Labial axis followed facial axis of clinical crown (FACC) touching facial axis (FA) point contouring over the incisal edge to the most prominent part on lingual surface. [Figure 1]

![Figure 1](image)

Labio–Lingual Width

The vertical crown height was measured 2mm from the incisal edge to varying heights of labial bracket placement progressing towards the Cemento Enamel Junction (CEJ) with the help of Boons Gauge. The labio-lingual width of each maxillary anterior tooth was measured with the help of Boley’s gauge at every 2 mm along the long axis in the middle of the tooth from the coronal tip upto the CEJ. [Figure 2-4]
Inclusion criteria

Cast models from patients with full dentition except third molars; and all permanent teeth in occlusion according to Andrews’ keys of normal occlusion.

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, ratio, histograms, scatter plots. Different parametric and non-parametric measurement such as Pearson correlation test, independent-measures t-test, Anova tests and the Spearman correlation test were used to analyze the data.

Results

In the study with conventional method, the maximum mean labio-lingual angulation for central incisor, lateral incisor and canine was found to be 49.16±5.18°, 49.84±4.59° and 59.08±4.87° respectively. [Table 1] [Table 2] In our study, central incisor mean labiolingual width at 2mm height was 2.44±0.5mm and at 7 mm height was 6.64±0.66mm mesially, 2.24±0.62mm at 2mm and 6.50±0.64mm at 7 mm height centrally and 2.44±0.5mm at 2mm height and 6.53±0.66mm at 7mm height distally. [Table 3].

In our study, lateral incisor mean labiolingual width at 2mm height was 2.35±0.5mm and at 7 mm height was 6.51±0.66mm mesially, 2.33±0.62mm at 2mm and 6.52±0.64mm at 7 mm height centrally and 2.46±0.5mm at 2mm height and 6.55±0.66mm at 7mm height distally [Table 4]. In our study, canine mean labiolingual width at 2mm height was 2.38±0.5mm and at 7 mm height was 6.52±0.66mm mesially, 2.25±0.62mm at 2mm and 6.50±0.64mm at 7 mm height centrally and 2.39±0.5mm at 2mm height and 6.53±0.66mm at 7mm height distally [Table 5].
### Table 1: Labio-lingual angle conventional cast analysis mean

<table>
<thead>
<tr>
<th>Labio-lingual Angle</th>
<th>Central Incisor</th>
<th>Lateral Incisor</th>
<th>Canine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>49.16 °</td>
<td>49.84 °</td>
<td>59.08 °</td>
</tr>
<tr>
<td>SD</td>
<td>5.18</td>
<td>4.59</td>
<td>4.87</td>
</tr>
</tbody>
</table>

### Table 2: Labio-lingual angle conventional cast analysis mean and standard deviation

<table>
<thead>
<tr>
<th>Crown height</th>
<th>Labio-lingual Width for Central Incisor (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mesial</td>
</tr>
<tr>
<td>2mm</td>
<td>2.442</td>
</tr>
<tr>
<td>3mm</td>
<td>2.95</td>
</tr>
<tr>
<td>4mm</td>
<td>3.838</td>
</tr>
<tr>
<td>5mm</td>
<td>4.254</td>
</tr>
<tr>
<td>6mm</td>
<td>5.833</td>
</tr>
<tr>
<td>7mm</td>
<td>6.642</td>
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</tbody>
</table>

### Table 3: Mean Labio-lingual Width for Central Incisor
<table>
<thead>
<tr>
<th>Crown height</th>
<th>Labio-lingual Width for Lateral Incisor (mm)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mesial</td>
<td>Central</td>
</tr>
<tr>
<td>2mm</td>
<td>2.345</td>
<td>2.333</td>
</tr>
<tr>
<td>3mm</td>
<td>2.913</td>
<td>2.908</td>
</tr>
<tr>
<td>4mm</td>
<td>3.749</td>
<td>3.825</td>
</tr>
<tr>
<td>5mm</td>
<td>4.3</td>
<td>4.308</td>
</tr>
<tr>
<td>6mm</td>
<td>5.792</td>
<td>5.746</td>
</tr>
<tr>
<td>7mm</td>
<td>6.513</td>
<td>6.525</td>
</tr>
</tbody>
</table>

Table 4: Mean Labio-lingual Width for Lateral Incisor

<table>
<thead>
<tr>
<th>Crown height</th>
<th>Labio-lingual Width for Canine (mm)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mesial</td>
<td>Central</td>
</tr>
<tr>
<td>2mm</td>
<td>2.379</td>
<td>2.246</td>
</tr>
<tr>
<td>3mm</td>
<td>2.946</td>
<td>2.854</td>
</tr>
<tr>
<td>4mm</td>
<td>3.792</td>
<td>3.792</td>
</tr>
<tr>
<td>5mm</td>
<td>4.333</td>
<td>4.258</td>
</tr>
<tr>
<td>6mm</td>
<td>5.671</td>
<td>5.746</td>
</tr>
<tr>
<td>7mm</td>
<td>6.521</td>
<td>6.504</td>
</tr>
</tbody>
</table>

Table 5: Mean Labio-lingual Width for Canine

**Discussion**

Most orthodontic problems that can be addressed by standard labial method, such as tooth malposition, anteroposterior discrepancies, and pre-prosthetic surgical situations, may be corrected using lingual orthodontics. This technique contains of brackets that are specifically intended to be inserted on the lingual surface of the tooth. In comparison to younger patients, adult patients are more hesitant to commit to orthodontic treatment. Because of the growing number of adult patients in orthodontic offices, lingual orthodontic therapy has become a preferred treatment option for most people.

Kinja Fujita was the first to design lingual orthodontic brackets in 1967. Craven Kurz and Jim tried plastic brackets on the lingual surface of the tooth in the 1970s because they were easier to modify, but they ran into a lot of issues with patient comfort and bonding failures. From the first to the seventh generations (1976-1996), the Kurz lingual bracket grew and evolved. Lingual orthodontics was first popular in Japan in 1970, and as an aesthetic alternative in America. In 1976, the first patient was treated with a lingual appliance in the United States. The issue addressing related with lingual orthodontics has improved through time, and it has enhanced and extended all across the globe.

Lingual orthodontics is a good option for comprehensive treatment of most malocclusions because the lingual surfaces of the teeth appear to be less prone to caries than the buccal surfaces due to differences in surface morphology, plaque retention, salivary flow, and mechanical cleaning of surfaces by the tongue, and it is the best option for adolescent and adult patients because aesthetic concerns are a big factor for these patients. As there are drawbacks to traditional
orthodontic treatment, such as non-esthetic look, there are drawbacks to inserting brackets on the lingual surface, including patient pain, speech issues, and tongue irritation, which may lead to ulcers on the tongue’s edge.\textsuperscript{19}

On the other hand, owing to anatomical variances in the lingual surface and extensive chair time for patients and orthodontists\textsuperscript{20}, the practitioner has challenges in the insertion and management of these appliances\textsuperscript{21} as well as the precision of bracket placement. Furthermore, brackets may induce changes in tooth shape over time.\textsuperscript{22} 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 (transverse dimensions, arch depth, and arch perimeter).

The labiolingual angulation and labiolingual width help in providing specific tip and torque values intended for the specific lingual tooth anatomy of specific teeth. The values change with change in tooth angulation, height and thickness and surface regularity [Figure 5]. Possible designs can be proposed based on the study as shown in Figure 6. The preadjusted lingual bracket will make lingual orthodontics as efficient as labial orthodontics. As there will be no dependency of the laboratory system, treatment can start faster. 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.

\begin{figure}
\centering
\includegraphics[width=0.8\textwidth]{figure5.png}
\caption{Figure 5}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=0.8\textwidth]{figure6.png}
\caption{Design One - Figure 6}
\end{figure}
Conclusion

The future of orthodontics is changing at a breakneck pace. The need for aesthetics is increasing, and lingual orthodontics is becoming well known. Lingual orthodontics’ future depends on technological advancements in appliance design and laboratory operations. The preadjusted lingual system aims to provide a consistent, rapid and economical way, and so it’s a greatest option for adult patients who don’t want to wear traditional visible appliances for social or professional reasons and want to maintain their appearance. By combining cast as well as digital analysis, the holistic approach regarding this concept of preadjusted lingual system can be developed in near future.

References

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