

Lingual Orthodontics- A review

V. Sreelekha¹, C. Sunitha², T. Saritha³, P. Kiran kumar⁴, and R. Naveen⁵

¹PG student, ²Professor and Head, ^{3,4,5}Reader, Mamata Dental College, Telangana.

Abstract:

The growing awareness and demand for orthodontic treatment among all age groups, as well as the desire for inconspicuous tooth alignment with occlusion correction and esthetics, led to the development of lingual orthodontics. With the invention of lingual orthodontics, malocclusions can be corrected without the device being visible in the mouth. Lingual orthodontics is widely accepted all over the world. With these undetectable appliances, the patient's cooperation and confidence have increased. The lingual orthodontic treatment differs significantly from conventional labial approach in terms of anchorage control, bonding, and biomechanics. The concept of lingual orthodontics has been highlighted in this article.

Keywords: Lingual orthodontics, Conventional labial approach, Esthetics, Biomechanics

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I. Introduction

Orthodontic research has resulted in the development of new fixed appliance techniques that can treat wide range of malocclusions. An increase in demand for esthetics among adult and adolescent orthodontic patients led to the development of lingual orthodontic appliances.¹ The aesthetic aspect of orthodontic treatment is extremely important, and it is the most common reason for patients to seek orthodontic treatment. Many patients, if given the option, would choose an appliance that is both invisible and provides high-quality treatment, despite the fact that it is more expensive. Lingual orthodontics is the best option for meeting patient needs without the risk of damaging biomechanical efficiency.² Most malocclusions that can be treated with conventional labial techniques can also be treated with lingual orthodontic techniques; however, not all patients can be treated with lingual orthodontics, particularly those with low pain tolerance. Recent advancements in bracket design, new metal alloys for arch wires, and new mechanics have not only simplified the technical aspects of lingual orthodontics, but have also contributed to a significant reduction in patient discomfort and improved patient cooperation.³

II. Evolution Of Lingual Brackets

During the early days of lingual mechanotherapy, two researchers introduced two different bracket designs. Dr. Kurz created horizontal slot brackets and Dr. Fujita introduced occlusal slot brackets. Dr. Craven Kurz and his Ormco Company team initiated various designs and studies on a near-conventional edgewise approach to lingual mechanics in collaboration with Ormco engineers. The initial criteria were:

1. To provide the same degree of control as it is achievable with fixed appliances,
2. To make a smooth, low-profile appliance with minimum irritation to soft tissue, comfortable to the patients, and
3. To develop an appliance that had minimal deviation from the well-known and accepted labial edgewise principle, as well as the straight-wire principle, if possible.⁴

Seven generations of lingual brackets were developed by Dr. C. Kurz and his team at Ormco Company.⁵

Generation # 1 – 1976

This appliance had a flat maxillary bite plane from canine to canine. The lower incisor and premolar brackets were low profile and rounded margins without hooks. Large brackets facilitated bite opening anteriorly, and produced mesiodistal movements or expansion. It also caused extrusion of molars and intrusion of incisors.

Generation #2-1980

Addition of hooks on canine brackets

Generation #3-1981

There was addition of hooks to all anterior and premolar brackets. The bracket for the first molar had an internal hook. The second molar had a terminal sheath without a hook button and a terminal recess for elastic traction.

Generation # 4 - 1982-84

Brackets were low profile with anterior inclined plane on the central and lateral incisor brackets. There was option for hooks

Generation # 5 - 1985 – 86

The anterior bite plane became more pronounced. There was an increase in labial torque in the maxillary anteriors with accessory tubes for transpalatal arch. The canine bracket was bi-beveled which allowed 8 maxillary cusp intercuspation within the embrasure between the mandibular canine and first premolar. Hooks were optional.

Generation # 6 - 1987 – 90

The inclined plane on the maxillary anteriors was square in shape. Hooks on the anterior and premolar brackets were elongated. Elongation of hooks was done as an option for attachment of TPA. Hinge cap tube for second molar was added.

Generation # 7 - 1990 to present

The maxillary anterior inclined plane was heart shape with shorter hooks. The hooks on the lower anterior brackets are shorter and had a larger inclined plane. The hooks were shortened and widened mesiodistally for premolar brackets. These premolar brackets with a wider width allowed for better angulation and rotation control. The molar brackets come with either hinge cap or a terminal sheath.

ADVANTAGES:^{6,7}

1. Procedures such as bonding, debonding, and adhesive removal do not cause damage to the facial surfaces of teeth.
2. Facial gingival tissues are not adversely affected.
3. The contour and drape of the lips are not distorted by protruding labial appliances, allowing for a true visualization of facial contours.
4. Because of the smaller lingual arch radius, the inter bracket width is greatly reduced on most of the teeth when more resilient archwires are used, this becomes less of an issue.
5. Majority of adult and young patients would prefer "invisible" lingual appliances if the costs, treatment times, and results were comparable to labial appliance treatment for aesthetic reasons.
6. The bite plane like effect in brackets will allow intrusion of the incisors and a limited extrusion of molars.

DISADVANTAGES:^{6,7}

1. Tissue irritation and speech difficulties.
2. Gingival impingement.
3. Difficulty in rotation correction.
4. Difficulty in oral hygiene.
5. Non economic.
6. Technique sensitive

III. Patient Selection

Although lingual orthodontics can correct majority of malocclusions, some cases are more amenable to treatment than others.

Favorable Cases³

- Cases with anterior deep bite and mild incisor crowding
- Teeth with long and uniform lingual surfaces without fillings, crowns, or bridges
- Good gingival and periodontal health
- Keen, compliant patient
- Skeletal Class I pattern
- Mesocephalic or mild/moderate brachycephalic skeletal pattern
- Patients who are able to open their mouths and extend their neck adequately

Unfavorable Cases³

- Dolichocephalic skeletal pattern
- Cases where maximum anchorage is required, unless treated with micro implants
- Short, abraded, and irregular lingual tooth surfaces
- Presence of multiple bridges, crowns and large restorations
- Non – compliance patients.
- Patients with limited mouth opening (trismus)
- Patients with neck injuries or cervical ankylosis that prevent neck extension.

IV. Diagnostic Considerations For Lingual Orthodontics³

General considerations

These are the same considerations that apply to labial orthodontics, particularly to those concerning adult orthodontics. Patient selection should be given special consideration particularly for adult patients.

Esthetic Factors

Adult patients' aesthetic concerns are one of the most important considerations in their treatment. The majority of adult orthodontic patients seek treatment to improve their facial and dental aesthetics.

Lingual crown height

Lingual crown heights are usually 30% shorter than the labial surfaces. The most suitable teeth for lingual orthodontics are those with long and smooth surfaces with at least 7mm of lingual crown height of incisors and the incisors with lingual surfaces shorter than 7mm should be reconstructed.

Periodontal and Gingival Considerations

Before beginning of active orthodontic treatment, patients should have a healthy periodontium and be able to maintain a high level of oral hygiene. Gingival recession is most commonly seen on the labial tooth surface. Lingual technique is often recommended in patients who are prone to gingival recession. With lingual orthodontic treatment, gingival inflammation risk is transferred to the lingual aspect of the mouth, where bone resorption and gingival recession are less common. Gingival irritation, on the other hand, can be reduced by taking the precautions as listed below:

- Lingual bracket hooks should be bent while positioning them on the plaster cast, to avoid gingival impingement and reduce tongue irritation.
- Patient education to maintain good oral hygiene
- Prophylaxis, especially at each archwire change.
- Proper adjustment of the bracket transfer tray, use of liquid adhesives, and application of the appropriate amount of adhesive will reduce the amount of flash paste and subsequent inflammation. The double-tray system is specifically designed to remove any excess flash paste during the bonding process.
- During space closure, the effect of tooth movement on the gingival tissues should be controlled to minimize any possible inflammation.

Dental considerations

Patients at high risk for caries, with histogenetic or colour changes in the teeth, or with decalcifications, can be treated with lingual orthodontics, because the caries and decalcification hazard is transferred to the lingual surface, where the aesthetic and therapeutic solutions are always easier to manage, being the nonvisible surfaces of the teeth.

Restorative considerations

Adult patients are more likely to require extensive restorative and prosthetic work. Many adult cases presenting for lingual orthodontics have mutilated malocclusions, which necessitates special treatment planning, especially when using the lingual technique. Crowns, bridges, and large restorations have negative impact on adhesion and hence they require special bonding techniques for plastic, metallic, or porcelain surfaces.

Surgical cases

To reduce postsurgical orthodontic treatment time, the best possible presurgical tooth position should be achieved in these cases. The patient should be informed about the possibility of bonding labial brackets just before surgery to help with postoperative fixation.

Pre prosthetic cases

Lingual orthodontic treatment is often indicated in patients requiring pre prosthetic tooth movement

DIFFICULTIES ENCOUNTERED DURING THE DEVELOPMENT OF LINGUAL THERAPY⁸

1. Tissue irritation and speech difficulties
2. Gingival impingement
3. Occlusal interferences
4. Appliance control
5. Base pad adaptation
6. Appliance placement and bonding

7. Appliance prescription
8. Wire placement
9. Ligation
10. Attachments

V. Laboratory Procedures In Lingual Orthodontics

Over the last few years, the indirect bonding technique has progressed and gained acceptance among orthodontists. The high degree of accuracy that can be achieved with bracket positioning is a major advantage of indirect bonding. Another benefit is the reduced amount of time spent in the chair during the initial bonding appointment.⁹

Custom Lingual Appliance Setup Service (CLASS System)¹⁰

The CLASS system procedure starts with duplicating the malocclusion model to create a set-up model with the teeth cut, repositioned, and aligned correctly. This method of lingual bracket placement considers anatomical differences in the lingual surfaces of the teeth. The ideal set-up or template is used as a physical guide to properly align the lingual brackets. The brackets are attached to the diagnostic set-up using composite adhesive, which acts as a spacer between the metal mesh pad and the individual dental surfaces. Following that, the brackets are returned to the original malocclusion cast. Transfer trays are made at this point so that the brackets can be delivered clinically via indirect bonding. The CLASS system has several advantages, including the ability to visualize the final occlusion on the articulated set-up model, which shows any premature contacts and residual spaces that may occur following space closure, particularly in extraction cases. The disadvantage of this system is that it requires number of steps before delivering the finished product.

Torque Angulation Reference Guide (TARG) System¹¹

The Ormco Society introduced the TARG machine in 1984 as an important aid to laboratory technique. It enables accurate bracket placement at a precise distance from the incisal and occlusal surfaces of the teeth, as well as the ability to prescribe torque and angulation for each tooth individually. Altounian¹² described the TARG system in detail in 1985. As the TARG machine does not account for the different thicknesses of the teeth, many second order arch wire bends must be made on a regular basis during treatment.

Bonding with Equal Specific Thickness (BEST) System

Fillion¹¹ introduced a novel system in 1986. He upgraded the original TARG machine with the Electronic TARG, as well as DALI (dessin de l'arch linguale informatise), a computer-generated arch wire tracing. The new laboratory technique was named as the BEST system. It eliminates the need for second and third order bends and the requirement for a set-up model. The benefit of this system is that clinical coordination of upper and lower arch wire is no longer required because the computer does it.

Slot Machine

Thomas Creekmore developed the slot machine to allow both conventional and lingual brackets to be placed directly on the malocclusion model. The machine aligns the bracket slot with Andrews labial arch wire plane (LA plane), taking torque and angulation into consideration. The inability to manage the slot machine is considered as disadvantage.¹³

Lingual Bracket Jig (LBJ)

The Lingual Bracket Jig introduced by Geron¹⁴ is the only system that allows for both direct and indirect bracket positioning. It includes a set of six anterior maxillary teeth jigs, one universal posterior teeth jig, and a special ruler. Andrews labial bracket prescription is transferred to the lingual surface using the jigs. The main disadvantage is the limited number of prescription jigs available.

Transfer Optimized Positioning (TOP)

The TOP system follows the same set-up procedure as the BEST system, allowing the brackets to be placed directly on the malocclusion model. In addition to the horizontal and vertical measuring systems which was first described by Fillion,¹¹ this technique uses the TARG Professional, which includes a bracket holder for twin brackets and tubes. The target setup is used to determine the brackets' optimal height. The brackets are placed directly on the malocclusion model, as close to the lingual surface of the teeth as possible, without in-out compensation for labiolingual thickness differences.^{15,16}

Korean Indirect Bonding Set-up (KIS) System

The Korean Society of Lingual Orthodontics developed the KIS system, which uses a bracket-positioning machine capable of positioning all brackets at once. Once again it is necessary to create a set-up model; however, the set-up is created with the help of a special set-up model gauge for increased precision.¹⁷

Hiro System

The Hiro system and the Convertible Resin Core system are two laboratory techniques that do not require any special equipment. Toshiaki Hiro invented the Hiro system, which was later improved by Kyoto Takemoto and Giuseppe Scuzzo.¹⁸ It still requires the creation of a set-up model in which the teeth are sectioned and properly aligned. A full-sized rigid rectangular archwire is used to position and place the brackets on the set-up model.

Convertible Resin Core System

The individual transfer trays in this system are prepared with hard resin, and the tray and bracket are held together with an elastomeric ligature. This allowed accurate repositioning of the bracket within the resin core and the trays can be reused in cases of bracket failure. The use of unitary trays makes the initial bonding session longer and the technique still relies on a set-up model to position the brackets.¹⁹

Hybrid Core System

This system is a bracket-transfer system rather than a bracket-positioning system. Matsuno's²⁰ Hybrid Core system combines the advantageous properties of silicone and composite resin in the construction of its indirect transfer tray. Silicone covers the bracket, which is then covered by composite resin. This combination allows for stable positioning of the transfer tray within the mouth, followed by simple removal of the silicone component from the bonded bracket.

Simplified Technique

The Simplified Technique is correlated with the development of the new STb brackets. The brackets are positioned directly on the malocclusion model by using a bracket placement plier or simple tweezers.²

Orapix System

The Orapix system, which is still in its final stages of refinement, is the newest lingual orthodontic laboratory technique. A scanner will scan the model of a patient and create a three-dimensional (3D) data file. The patient's 3D data file and a 3-Txer software package will be sent to the orthodontist via the Internet. The orthodontist will be able to visualize a 3D model and create his own virtual set-up for that particular patient using the 3-Txer software.²¹

Simplified manual setup and customization by resin core indirect bonding technique

It's a modified resin core indirect bonding technique. The Hiro system (also known as the resin core indirect bonding system) does not require the use of any specialized devices and instead relies on the fabrication of a full-length lingual arch wire. The manual setup is created by separating teeth from the malocclusion model. Based on a modification of the Hiro technique, this is a simplified laboratory procedure for making the manual setup.²²

Incognito System

This bracket system is fundamentally different from existing appliance design and manufacturing methods. Using CAD/CAM technology, the two separate processes of bracket production and bracket positioning are combined into a single unit. A two-phase standard silicone impression is the first step in the manufacturing process. The impression's casts are used to create a customised desired setup. A high-resolution optical 3D scanner (GOM, Braun schweig, Germany) is used to scan the therapeutic setup without making contact.²³

The Ray set

The RAY SET is a step forward in indirect bonding technology which was proposed by Takemoto and Scuzzo¹⁸. It treats each tooth as a separate unit, virtually isolates it from the arch, and then places it at the centre of a three-dimensional control system that determines first, second, and third order values. The device is a three-dimensional goniometer control system that includes a cast holder base with RTT (rotation tip and torque) and a PRC (Plane rotational control) template for preliminary analysis of first-order tooth positions.

VI. Anchorage Consideration In Lingual Orthodontics²⁴

The primary changes induced by the lingual appliance can best be classified as dynamic effects on the vertical, anteroposterior, and transverse planes.

Anteroposterior

The factors that contribute to better anchorage control in lingual mechanics than in labial mechanics are as follows:

- The lingual tipping moment created on the anterior tooth is transmitted to the posterior teeth as a distal tipping moment, causing the molars to upright distally.
- In horizontal plane, molars have a tendency to rotate mesial-out and distal-in when a retraction force is applied.
- Cortical anchorage is established in occlusion following the placement of lingual brackets in molar teeth; usually, the lingual cusp of the lower molars touches the bracket on the upper molar. As the occlusal forces are transmitted lingual to CR, it results in lingual crown tip and buccal root tipping and establishment of cortical anchorage
- The rigidity of the lingual wire is increased by a smaller arch perimeter on the lingual side.

Vertical

The bite opening caused by the lower incisors occluding on the maxillary incisor bracket bite planes is the most obvious appliance-induced change. The effects of this bite opening are both positive and negative. The bite opening is usually desired in low angle brachyfacial patterns. Many deep bite cases benefit from posterior extrusion due to low mandibular plane angles. The posterior disclusion caused by the anterior bite plane opening allows the molars and bicuspid to erupt rapidly with posterior occlusion re-establishing in approximately 3–4 months. Orthodontic mini-implants should be used in conjunction with bite opening in mesiofacial and dolichofacial types, where bite opening may be undesirable. The posterior disclusion eliminates two important anchorage factors: inclined plane occlusion and musculature.

Transverse

With the initial posterior disclusion, the expansive nature of the lingual appliance and tendency to cause mesiobuccal molar rotation during space closure, controlling intermolar dimension becomes more important. Therefore, transverse considerations gain additional importance. Retraction on resilient archwires will have number of adverse consequences, especially in the transverse planes. Inter-arch retraction forces while using more flexible wire can cause a "bowing" effect, results in the bicuspid to shift buccally and the molars to rotate to the mesiobuccal position. When the maxillary first molars rotate mesiobuccally, functional interference between the molars occurs, resulting in additional vertical opening and aggravating the anteroposterior discrepancy. Fortunately, most of these difficulties can be avoided with proper treatment planning and archwire sequencing, as well as some patience in allowing the more resilient archwires to exert their influence before progressing on to the next wire. Retraction and space closure with lingual mechanics must also adhere to well-established principles, requiring anchorage preparation and a transition to archwires of sufficient stiffness.

VII. Labial Versus Lingual²⁵

As the biomechanics differ when the appliance is bonded to the lingual surface, this difference must be evaluated in the sagittal, vertical, and horizontal planes of space.

Sagittal plane

When an equal amount of force is applied to both systems, the intrusion force equals the retraction force, different results are observed. The net force vector is pointed directly towards Ceres using the labial system. The net force vector, on the other hand, produces lingual tipping force and vertical bowing effect in lingual orthodontics. To counteract the above effects, we should reduce the retractive force during en masse retraction and increase intrusion and torque force in the anterior.

Vertical plane

As the point of application of the force is closer to the long axis of the incisors centre of resistance, the maxillary incisors are best intruded along their long axis into the broadest area of the alveolar process by using lingual mechanics. The intrusion should be controlled if the root tips are forward and the crowns are lingually inclined (as in Class II div 2 malocclusion), because the point of application of force is distal to the axis passing through the CR of incisors, increasing the lingual inclination of the crowns. As a result, correcting inclinations should come first, followed by intrusion.

Horizontal plane

In the occlusal plane, the teeth are arranged in geometrically elliptical arches (parallel to the horizontal plane). Lingual orthodontic appliance had smaller inter-bracket distance than labial one. This causes increase in arch wire stiffness than on labial side. Furthermore, in lingual mechanics, the point of force application is closer to the tooth axis. These anatomical factors require important biomechanical considerations. During rotational movement, it is more difficult to achieve an efficient coupling of forces on the lingual side. On the lingual side, the rotational moment is smaller than on the labial side. We must use more resilient wire in the lingual brackets because engaging the arch wire in the lingual brackets is more difficult than in the labial brackets in cases of crowding.

VIII. Conclusion

Lingual orthodontics is a component of general orthodontics, and as such, it is governed by all of the same principles that govern proper patient selection and diagnosis. Understanding of lingual biomechanics is essential for success with lingual appliance. There are significant differences in technique and clinical demands on both the patient and the orthodontist when compared to labial techniques. In this overview different laboratory procedures used in conjunction with lingual orthodontics, their advantages, disadvantages, anchorage considerations were discussed.

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