Lingual Orthodontics – A Review
Part I

Dr. Anurag Gupta
PG Student

Dr. VS Kohli
Reader & Guide

Dr. (Mrs.) PV Hazarey
Proi. & HOD

Dept. Of Orthodontics
Sharad Pawar Dental College
Sawangi (M), Wardha
Maharashtra

Abstract

Esthetics has always been a catchword among patients. With more number of adult patients desiring orthodontic treatment, special esthetic demands of these patients pose a great challenge to the orthodontic community. These patients have professional and social commitments and cannot accept ‘visible braces’ even for a short time. Even a specialty like orthodontics which had traditionally given more importance to treatment objectives than anything else had to rethink its approach towards such patients. To be able to serve such patients, the orthodontic community came out with the ultimate esthetic solution – Lingual orthodontics (LO). Lingual orthodontics, apart from offering the esthetic benefit, also provides several mechanical advantages. Since its inception in 1970s great advances have been made in this modality. At present, the modality of Lingual orthodontics is a complete system in itself and encompasses accurate diagnosis, treatment protocol, clinical and laboratory procedures. This article reviews the development and present status of this interesting and exciting orthodontic approach.

Keywords

Lingual orthodontics, lingual brackets, lingual bracket placement, lingual bonding, patients’ responses

Adult patients present with a unique challenge, of wanting to look good (read ‘normal’) even during orthodontic treatment. They have demands of their work and broader social needs to consider. They think that braces are ‘normally meant for kids’. In an effort to provide solutions to these esthetic problems tooth colored brackets and wires were also introduced. But these brackets were invisible only from a distance. Some orthodontists thought of placing braces on the lingual side, leaving the labial surface untouched. Thus was born the methodology of Lingual Orthodontics.

Historical Perspective

The first reference to lingual mechanics dates back to 1889, when John Farrar introduced the ‘Lingual removable arch’.1,2 Time to time, clinicians have tried to use the mechanical advantage of lingual aspect of the teeth to bring about desired tooth movements. Mershon’s lingual removable arch with finger springs 1, Oliver’s Labioliciallingual appliance 3, The Crozat appliance 4, Conventional acrylic removable appliances etc. were some of the efforts in this direction. Nance buttons, TPAs, and lingual attachments have all been utilized for optimal results. But most of these appliances were supplements to the labial mechanics.

The development of Lingual Orthodontics as a complete system in itself began in 1970s with the pioneering works of Dr. Craven Kurz of USA 5,6 and Dr. Kinya Fujita of Japan 7,8.
Evolution of brackets and present status

Kurz worked as a part of a ‘Lingual Task Force’ at theOrmco Company and his brackets had a horizontal slot, whereas Fujita’s brackets had an occlusally facing slot. Both clinicians tried to adapt the labial edgewise mechanics to lingual side.

Development by Kurz and Co-workers

In 1976, 1st Generation of Lingual brackets were produced at Ormco. By 1990, Vllth generation had come out for clinical use. The 1st generation brackets or First Kurz Appliance was a .018" slot bracket with a built-in bite plane and were bonded according to reciprocal tip and torque values to Andrew’s published values (Fig 1) 1,6.

While these brackets had larger profile and crude prescription, the latest generation i.e. Vllth Generation Ormco brackets (Fig 3) which are still popular, are much refined, low profile, and patient friendly brackets. The prescription used is also vastly improved. The maxillary anterior bite plane is now heart shaped with smaller hooks. The premolar brackets have increased width to allow better angulation and rotation control. The molar now comes with either a hinge cap or a terminal sheath 6,9.

Fujita’s lingual bracket system

Fujita worked independently at Kanagawa University, Japan and introduced his version of lingual brackets. His purpose for lingual bracket system, apart from esthetics, was to prevent injury with labial brackets during sports 7,8.

- Fujita’s brackets had an occlusally facing slot. He found arch wire insertion, seating, and removal easier with an occlusal slot.
- The grooves for insertion of lockpins were set mesiodistally, (parallel to the wire)
- Auxiliary groove was set in the occlusogingival direction to facilitate correction of the mesiodistal tipping of the teeth.

Though less publicized, continuous research is on, since last 25 years and presently available Fujita system has multiple slots 10.

- Brackets for anterior and premolars have three slots: occlusal, lingual, and vertical.
- Molar brackets have five slots; one occlusal, two lingual and two vertical.

Basic purpose behind incorporating multiple slots is to use Tandem wire mechanics. This entails use of multiple wires in different slots to bring about desired tooth movements without side effects.
Begg's lingual brackets

Dr. Stephen Paige found that Begg's technique suited best to lingual and introduced Lingual Light Wire technique in 1982. Initially he used the Begg's TP 256-500 labial brackets. Later he switched to the Unitek's Unipoint Combination Bracket that along with a vertical slot had a gingival wing to place elastic modules on continuous E chains. Brackets were bonded with vertical slot facing occlusally or incisally. Lingual Light Wire technique has also been improved by many clinicians over time.

Many more kinds of lingual bracket systems were introduced in following decades since the 1st Kurz appliance. For example, those by Vincent Kelly and Creekmore at Unitek, Forestadent etc. Newer lingual brackets are being continuously developed around the world. Straight Wire Lingual Brackets by Takemoto and Scuzzo are designed to eliminate offsets in the wire. Self Ligating Lingual Brackets solve the problem of ligation in lingual orthodontics and reduce chair time. With the latest CAD/CAM technology, Weichmann described an individualized lingual bracket system in which the processes of bracket production and positioning are combined.

Keys to success in Lingual orthodontics

Smith and coworkers reported 12 keys to success in LO. They were patient selection, bracket placement accuracy, indirect bonding, vertical and transverse control of buccal segments, double over-ties on anterior teeth, buccal and lingual molar attachments, rotation corrections, arch form and archwire sequence, archwire stiffness and torque control, en-mass retraction, light resilient wire for detailing Gnathological Positioner and retention.

Diagnosis and case selection

Proper diagnosis and treatment planning is essential before commencing any treatment. This step assumes more importance in lingual orthodontics because of the inherent complexities of this approach. Routine investigations are needed to be able to analyze and diagnose the case for LO.

Patient selection

Important factors involved in case selection are:
1. Patient's physical status
2. Personality of the patient
3. Time and cost factors

Physical status

There are some physical limitations to lingual orthodontic treatment and these are considered critically.

1. Patients with short clinical crowns.
   Maxillary incisor lingual crown heights of less than 6mm will not permit sufficient space for optimal lingual bonding.
   - The most critical crown heights in the majority of cases appear to be those of the maxillary incisors and mandibular bicuspids.
   - Brackets are placed at least 1 mm from the gingival margins for adequate hygiene maintenance.
   - Crown lengthening may be needed in some cases.

2. Dolicofacial patterns
3. Multiple prostheses that may be expensive Porcelain or Metal crowns: Resin temporaries may have to be made.
4. Compromised periodontal condition and/or questionable oral hygiene
5. Severe skeletal discrepancy cases: Orthognathic surgery may be needed.

Personality of the patient

Personality of the patient is one of the most important factors in case selection. This is primarily because of the initial effects of the lingual appliance like distorted speech, soreness, bite opening, and difficulty in mastication. Only an understanding patient will be able to adapt to such new situations. Emphasis is laid on good communication between doctor and patient. Starting treatment with only one arch helps in early adaptation.

Time and Cost Factors

1. There will be increase in time involved in terms of increased appointment time and total treatment time.
2. Orthodontist and staff time may increase by 30-50%.
3. Laboratory procedures for the indirect appliance setup will appreciably increase the fixed costs.
4. Given these factors, it is apparent that a treatment fee may be 30 - 50% more than the orthodontist’s usual fee.

Additionally to formulate a definitive treatment plan it is first necessary to consider the following factors:

- **Changes induced by lingual appliance**

The lingual appliance induces changes in all the 3 planes. Scuzzo and Takekoto analyzed the effects of different forces on both the lingual and labial brackets.

1. **Vertical**

The most immediate and readily apparent appliance-induced change is the bite opening resulting from the lower incisors occluding on the maxillary incisor bracket bite planes.

Though there are numerous benefits of bite opening such as in brachyfacial cases, TMJ cases and rapid tooth movements due to posterior disclusion, lingual appliance are harmful in dolicofacial and mesofacial cases where bite opening is not needed.

For normally inclined and proclined upper incisors, intrusive forces in lingual are closer to the center of resistance than in the labial. Hence the moment is lesser and hence lesser labial tipping. For retroclinated upper incisors, labial intrusive forces produce counterclockwise moment but lingual intrusive forces produce clockwise moment, thereby increasing retroclination.

Effect of extrusive forces have also been studied by other authors and it has been found that in lingual mechanics with extrusion, labial root movement occurred only when incisors were proclined more than 20 degree to the occlusal plane. In all other tooth inclinations, lingual root movements occurred. In contrast, in labial mechanics labial root movements occurred in nearly all tooth inclinations.

2. **Anteroposterior**

- Because of the vertical opening and the immediate rotation of the mandible (down and back), the lingual appliance also induces a Class II tendency.

- With bite opening, AP molar correction is easier.

- Second molars are banded routinely. This increases AP molar control and reduces the vertical vector of posteriorly extended Class II elastics.

When the same amount of force is applied to anterior teeth, so that the intrusion force equals the retraction force, the net force vector points directly towards the center of resistance with the labial system, but lingual to the centre of resistance with the lingual system. This produces a lingual tipping force and vertical bowing effect (Fig 4). Therefore, during en masse retraction in lingual orthodontics, the retraction force should be minimized and more intrusion and palatal root torque should be applied.

![Fig 4.1 - Labial mechanics](image1)
![Fig 4.2 - Lingual mechanics](image2)

**Fig 4: Comparison between the anterior retraction in labial and lingual mechanics.**

3. **Transverse**

The lingual appliance has an expansive nature. This is coupled by the posterior disclusion.

- There is tendancy to cause mesiobuccal molar rotation during space closure. Hence addition of transpalatal arches is important.
Retraction is always done on stiffer wires to prevent "bowing effect", both in transverse and vertical plane (Fig 5.1 & 5.2).

Indications for lingual orthodontic treatment

Ideal cases for lingual orthodontic treatment are low angle deep bite cases, diastema, Class I minor crowding, and upper premolar extractions for Class II cases. The difficult cases for lingual orthodontic treatment are those with four premolar extractions, posterior crossbites, high angle cases, anterior open bite, and surgical cases.

Contraindications for lingual orthodontic treatment

The contraindicated cases are short clinical crowns, poor oral hygiene or unresolved periodontal involvement, unadaptable or demanding personality types, mutilated posterior occlusions, high angle/dolicho-facial patterns, severe Class II discrepancies and acute TMJ dysfunction.

Bracket placement and bonding techniques

Considering the difficulty of access, irregularity and variability of lingual tooth morphology, lingual orthodontics could only develop with indirect bonding technique, which allowed control of bracket placement in the laboratory. Even on the plaster cast, however, the morphology of the lingual tooth surfaces is so varied that it is difficult to locate exact bracket positions. Michael Diamond pointed out that profound change in torque values occurred with discrepancies in vertical positioning, varied lingual slopes, labiolingual thicknesses and use of different reference gauges.

The most important aspect of bracket placement in lingual orthodontics is that the required tip, torque, incline and rotational corrections are included in the bonded brackets through the resin beneath the bracket bases. If the brackets are properly placed as per the prescription, the amount of wire bending required in an already restricted area will be reduced.

For the above-mentioned reasons, a number of inventions and innovations have taken place to optimize this phase of treatment. They are as follows:

1. Torque angulation reference guide (TARG)
2. Fillion’s lingual indirect bonding system
3. The customized lingual appliance setup service (CLASS) system
4. The slot machine
5. Hiro system
6. The Ray set system

Appearance of spaces during retraction

1. In lingual, retraction of the entire maxillary anterior segment as a unit (en mass retraction) is preferred.
2. To prevent the opening of a “large black hole” (first bicuspid extraction) a riding pontic, or a composite resin build up, may be placed in the extraction site.

TMJ Considerations

Many clinicians have reported relief of joint symptoms following lingual appliance placement. This apparently occurs because of the disarticulating effect of anterior brackets. In those cases where the health of the temporomandibular joint complex is in question, splint therapy and conservative treatment approaches are recommended.
The Slot machine

7. The lingual bracket jig
8. The mushroom bracket positioner

Torque angulation reference guide (TARG)\(^6\)\(^,28\)

This technique of bracket placement was developed by Ormco in 1984. This technique permits us to bond brackets in the laboratory, at an accurate distance from the occlusal edge of each tooth with respect to a horizontal reference plane. A labial reference gauge is used to orient individual tooth (Fig 6). Using only one unique angulation model, the TARG permits achieving a virtual set up with out the need to cut the teeth and mount them on wax. This orientation allows one to preprogram tip and torque before the start of the treatment.

Fig 6: Labial reference gauge for placing brackets (TARG)

Advantages are
1. It is an accurate and quantified two-dimensional system.
2. Allows accurate placement of the brackets on the cast with out having to cut the tooth and place in the wax.

Disadvantages are
1. The system does not take into account the labiobuccal thickness of the teeth. Hence correct alignment can only be obtained by adding a great number of first order bends.
2. The distance of the bracket base and the labial surface varies according to the level of bonding.

The Slot machine\(^{16}\)

Introduced in the year 1986, by Dr. TD Creekmore, the Slot Machine was meant to be used with the Conceal bracket system. It also used a labial reference to position the lingual brackets like the TARG machine.

Fillion’s lingual indirect bonding system\(^6\)

This system developed by Dr. Didier Fillion of France in 1987. It was developed to over come the drawbacks of the TARG system that was essentially the neglect of the labiobuccal thickness of individual tooth. This method is also called Bonding with Equalized Specific Thickness (BEST)\(^{29}\). A caliper is added as the thickness measurement system. Advantages are that it relates the labiobuccal thickness to the bracket position and allows working directly on the malocclusion model.

The Customized Lingual Appliance Setup Service (CLASS) system\(^6,28\)

The CLASS technique as described by Scott Huge, offers an integrated method of lingual bracket placement and indirect bonding. In this system, an ideal setup is made form the original malocclusion cast and brackets are placed on this setup. These are later transferred to the original cast by individual transfer trays. Finally, an indirect bonding tray is fabricated. A photocopy of the ideal setup helps in forming an ideal arch template for the arch wires. Advantage is that it takes into account the anatomical discrepancies in the lingual surfaces of the teeth.

Hiro System\(^9\)

It is a modified CLASS technique invented by Hiro and improved by Takemoto and Scuzzo. The technician shapes an ideal arch on the setup with a full size rectangular arch wire. The lingual brackets are transferred onto this wire and secured with elastic ligatures. Single rigid transfer trays are fabricated for each tooth. The archwire is then removed and custom bases for brackets are made. This method has several advantages over the CLASS and TARG techniques. No electronic equipment is needed, no need to transfer brackets from the setup model to the original malocclusion model, accuracy is improved due to individual transfer trays, bonding of one tooth not affected by position of other teeth and rebonding is easier.

The Ray Set system\(^9\)

The Ray Set System utilizes a 3-dimensional goniometer for analysis of the first-, second- and third order values of each individual tooth. Both pre- and post- set-up
values of individual teeth are evaluated and the amount of orthodontic tooth movement for each tooth on the set-up model is calculated.

The lingual bracket jig

Dr. Silvia Geron in year 1999 introduced a yet another lingual bracket placement system that was different from the others in being a CHAIRSIDE DIRECT BONDING system. This system is called the Lingual Bracket Jig (LBJ) and is used with horizontal slot bracket. The jig transfers the Andrews Straight-Wire Appliance labial bracket prescription to the lingual surface. Advantages are that it allows the orthodontist to perform direct as well as indirect bonding as in-office procedures, requires no special training and torque control can be modified with ease.

The mushroom bracket positioner

Developed by Kyung et al, in 2002, Mushroom Bracket Positioner is a machine for accurate bracket placement on an ideal setup. Since 2002, continuous research is underway to improve the Mushroom Bracket Positioner. Efforts have been to place the brackets on the teeth so as to eliminate offsets needed in wires. At present 5th Generation of MBP is available which places brackets to accept a straight wire.

Transfer optimized positioning system

This system utilizes CAD/CAM technology. Introduced by Wiechmann et al it scans lingual surfaces of the teeth on the ideal diagnostic setup via 3D optical scanner. The data obtained from the scanning is utilized to fabricate fully customized bracket with adapting base pads and built-in prescription.

Bonding techniques

All types of devices and methods have been tried to make the attachment of orthodontic appliances easier and more foolproof. Michael Diamond used direct bonding techniques and devised a Peri/Reflector for simplified direct bonding in the upper arch. While the choice of indirect bonding of labial brackets is elective, for bonding of lingual brackets it is the preferred, if not the mandatory, mode of placement. Research on lingual indirect bonding started with the works of Lingual Task Force and later on many new techniques were developed. They used indirect bonding with Two-Component Mix Systems like ENDUR, Concise and No-Mix Systems like SYSTEM 1, Insta-Bond. Although the above indirect bonding techniques have proven to be reliable and practical, many innovative modifications to the indirect bonding technique have been introduced.

Newer modifications are:

1. Bonding in CLASS system 6
2. HIRO’s method (Resin Core Indirect Bonding System) 9,35
3. Individual indirect bonding technique (LI BT) 29
4. Customized Indirect Bonding Method 35
5. Convertible resin core system (CRCS) 36
6. New Customized Indirect Bonding Method 37

Whereas in the CLASS system 5,28 a silicone or Biostar tray is formed, subsequent innovations in bonding techniques, emphasized on constructing individual transfer trays. This approach does away with the need for expensive machines for transferring the brackets back to malocclusion model before bonding in patient’s mouths. Resin core was used by Hiro 9,35 and Kyung, 31, stainless steel wires were incorporated in to transfer trays by Hong et al 35,36 and elastomeric ligatures were used by Kim et al in CRCS method.

Rebonding can be done in two ways:

- By again using the initial trays. Individual tooth can be sectioned and repositioned 6,34.
- By redoing an individual bonding tray using the same protocol 9.

Investigations of lingual bonding

Varied views on lingual bonding have been expressed 24,27,30,38,39,40,41. Many clinicians believe that lingual bonding is similar to labial bonding. Some believe that increased etching time and roughened lingual surfaces are needed to achieve satisfactory bond strengths 15. It was also found in both lingual and labial cases, that if the initial period of 3 – 5 months is passed, then the attachments will stay successfully. Maxillary molars showed greatest bond failures in both labial and lingual bonding. This was presumed to be due to occlusal stresses. Aguirre et al found that lingual, indirect-bonded brackets showed a smaller percentage of bond failures than direct-bonded brackets 39. Chumak et al compared the labial and lingual bonding extensively and found higher shear bond strengths of adapted lingual attachments over labial.
Communications

Dr. Anurag Gupta
Dept. Of Orthodontics
Sharad Pawar Dental College
Sawangi (M), Wardha-442001
Maharashtra

References

15. JCO Interviews Dr. Vincent M. Kelly on Lingual Orthodontics: July 1982;16(7):461-476.
53. Silvia Geron, Stella Chausiu: Lingual Extraction Treatment of Anterior Open Bite in an Adult. JCO 2002;36(8): 441-446.
59. Yuji Yoshizawa, Katsushi Tanaka: Lingual Segmented Treatment in the Maxillary Arch. JCO 2000;36(9):547-555.
70. Shouichi Miyawaki, Mika Yasuhara, Yasuhiro Koh: Discomfort caused by bonded lingual orthodontic appliances in adult patients as examined by retrospective questionnaire. AJODO, 1999;115:83-8.