STATUS OF LINGUAL ORTHODONTICS

The lingual appliance was developed simultaneously in 2 countries during the 1970s. Although not fully recognized by the orthodontic mainstream, lingual treatment has steadily expanded, with increased numbers of lingual orthodontists and patients. This article reviews the development, advantages and disadvantages, bonding techniques, biomechanics, and treatment procedures of the lingual appliance. Currently, there are few contraindications for treatment with the lingual appliance. Cephalometric measurements do not reveal statistically significant differences in treatment results between labial and lingual treatment; however, more clinical trial studies are needed to compare the efficiency and outcome of lingual appliances with those of labial appliances. World J Orthod 2006;7:361–368.

The labial fixed appliance is the standard in the history of fixed orthodontics. However, many types of lingual apparatus, such as buttons, cleats, eyelets, lingual retainers, transpalatal appliances, and quad-helix appliances, are also used.

The true lingual appliance system was developed in the 1970s in 2 countries. Kinya Fujita in Japan designed a lingual appliance system in 1975 and applied for a Japanese patent in 1976 and a US patent in 1977. He introduced this appliance in a Japanese dental journal in 1978 and, 1 year later, published the first English language article about lingual orthodontics in the American Journal of Orthodontics. The Fujita system included the bracket, lockpin, and mushroom archwire.

Around 1975, Craven Kurz in the US developed his lingual system by bonding plastic brackets to the lingual surface of anterior teeth and metal brackets to posterior teeth. Kurz applied for a US patent for his lingual system in 1981 (Kurz originally applied for a US patent on November 15, 1976, Ser. No. 741850, and later abandoned it). Supported by Ormco (Glendora, CA, USA), Kurz and other orthodontists (John Gorman, John Smith, Richard Alexander, Moody Alexander, Bob Scholz, etc) formed the Ormco Lingual Task Force to develop and promote the commercial lingual appliance. The first generation of Ormco-Kurz lingual brackets was produced in 1979, with the latest, the 7th generation, marketed in 1990. During the early developmental stage of this lingual appliance, the Ormco task force was the driving force for improved appliance design and treatment outcome. From 1982 to 1983, the task force published a series of papers, “Lingual orthodontics: A status report,” to systematically introduce the technique to practitioners. The task force simultaneously held seminars for dentists around the US, as well as in Europe and Asia. Public and commercial interest spread rapidly.

However, in the US, lingual treatment was publicized too early—just after the clinical tests were initiated. Seminars were held without a single finished case. Many manufacturers rushed to market the untested lingual appliances. Due to incomplete clinical trials and erroneous use, orthodontists lost interest in lingual treatment just as quickly as they had embraced it. By the mid-1980s, the number of patients treated with the lingual technique had plummeted dramatically in the US. In 1988, only 3 (Kurz, Gorman, and Smith) of the original mem-
bers remained on the Ormco task force. In contrast, lingual orthodontic treatment was gradually developing outside of the US, especially in Europe and Asia, accompanied by a steady increase in the number of lingual orthodontists and patients. By 2001, the number of patients treated with lingual systems in Europe, as well as those in Japan, was more than twice that of the US.

CHARACTERISTICS OF LINGUAL ORTHODONTICS

The fundamental advantage of the lingual appliance is undoubtedly the esthetics. Labial and buccal parts of the crown are not affected by bonding, debonding, adhesive removal, or decalcification. Labial and buccal gingival tissues are not affected by hypertrophy or inflammation. The position of teeth and facial soft tissues can be more precisely appraised by the doctor and patient without interference from the bracket and archwire. Clinicians have suggested that patients are more cooperative, and there is no premature removal of appliances and disruption of treatment with the lingual technique.

The lingual technique efficiently intrudes anterior teeth, which is helpful for a deep bite patient. In the Ormco-Kurz 7th generation bracket, in particular, a bite plane redirects the shear force from opposing teeth into a compressing force onto the bracket. Ronchin reported that the distal movement of the maxillary molars is faster and has fewer side effects; this is because the center of resistance in a maxillary molar is near the palatal root, which makes bodily movement easier to generate with a distalizing force from the lingual.

The adverse effects of the lingual appliance include irritation to the tongue caused by abrasion against the lingual brackets, difficulty pronouncing certain words, and mastication problems. Although there can be discomfort during the ensuing lingual treatment, most studies suggest that the majority of patients (80%) tend to adapt to the appliance within 1 month from the start of treatment. Procedures have been developed to minimize the discomfort caused by lingual appliances. These procedures include protective paste, silicone paste, or orthodontic wax to cover the irritating brackets or archwire; plastic protective tubing over the long-span archwire; and plastic bumper sleeves to alleviate the sharp surface near the tongue.

In general, oral discomfort will decrease with smaller brackets, thinner bonding material, and few bends or loops in the archwire. However, nearly all the relevant studies have emphasized that patients should be warned of every potential adverse effect prior to the start of lingual treatment.

Artun found that oral hygiene can be a problem with lingual brackets. In his study, visible plaque was observed at every visit in 7 of 10 lingual patients, and 4 patients were diagnosed with gingival inflammation after 3 months of treatment. Sinclair found that Plaque Index levels had significantly increased from pretreatment levels at 48 hours and 1 month after starting lingual appliance wear. However, no severe oral hygiene problems have been reported. This is probably because most patients undergoing lingual treatment are highly motivated adults, who are more attentive to oral hygiene than the adolescent patient.

A high prevalence of root resorption has been hypothesized, because the decreased distance between the lingual brackets could result in uncontrolled forces and moments on teeth. However, a comparison of pre- and post-therapeutic radiographs of 456 maxillary and mandibular anterior teeth in 40 patients showed that lingual orthodontic therapy resulted in only minor root resorption, similar to that observed in those treated with the labial technique.

POSITIONING AND BONDING TECHNIQUES

The major component of a lingual appliance is the bracket. Traditional labial brackets cannot be used in lingual treatment because of irregular lingual surfaces and the much shorter occlusogingival distance of the lingual surface as
compared with the labial surface. Lingual brackets have to be specially designed, and there are currently several brackets on the market (Table 1). The Ormco-Kurz lingual bracket is the most widely used bracket; this 7th-generation bracket is preadjusted. When brackets are correctly positioned on the teeth, only a first-order bend is needed to compensate for the different faciolingual thickness of the teeth. Recently, truly customized brackets were developed with computer-aided design/computer-aided manufacturing (CAD/CAM) technology. The customized virtual bracket is generated on a digital setup model, which is acquired by scanning the cast of the initial malocclusion (Fig 1a). The final low-profile bracket is cast using a gold alloy. The very thin base (0.4 mm thick) is large and provides a form that locks with the tooth (Fig 1b).

Bonding lingual brackets is more difficult and technique-intensive than bonding labial brackets. Indirect bonding is usually necessary, because the irregular lingual tooth surface and difficulty of direct visualization by the practitioner make it almost impossible to position brackets accurately using direct bonding. Improper bracket positioning on the complex lingual surface will cause more consequent vertical or torque changes than with labial brackets. Slight variance of lingual bracket position will also have a greater effect on the labial surface. Correction of improper bracket placement by archwire bending is difficult because of the reduced interbracket distance.

In vitro studies have suggested that there are no statistically significant differences in shear bond strength or tensile bond strength between labial and lingual brackets. In vivo data suggest that

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**Table 1** Lingual brackets currently on the market

<table>
<thead>
<tr>
<th>Bracket type</th>
<th>Designer; manufacturer</th>
<th>Development</th>
<th>Slot opening (size)</th>
<th>Prefabricated or customized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ormco-Kurz</td>
<td>Lingual Task Force; Ormco</td>
<td>1979–1990; latest is 7th generation</td>
<td>Lingual (0.018 or 0.022)</td>
<td>Prefabricated</td>
</tr>
<tr>
<td>Fujita</td>
<td>Fujita</td>
<td>1979; updated 1999</td>
<td>Occlusal</td>
<td>Prefabricated</td>
</tr>
<tr>
<td>Lingual straight-wire</td>
<td>Takemoto and Scuzzo; Ormco/&quot;A&quot;</td>
<td>From 2001</td>
<td>Labial and buccal</td>
<td>Prefabricated</td>
</tr>
<tr>
<td>Magic lingual system</td>
<td>Dentaurrem</td>
<td>From 2005</td>
<td>Occlusal</td>
<td>Prefabricated</td>
</tr>
<tr>
<td>Customized</td>
<td>Wiechmann; LingualCare</td>
<td>From 2002</td>
<td>Occlusal (0.018 x 0.025)</td>
<td>Customized</td>
</tr>
</tbody>
</table>

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**Fig 1** Customized bracket: Therapeutic setup is scanned into computer. A customized virtual base (yellow color) is generated with design software (a). The final bracket with low profile bracket body is made from high gold alloy (b). (Provided by LingualCare; used with permission).
the failure rates of lingual bonded brackets are low (<3%),6,25,30 compared with more than 10% failure rate for indirect labial brackets.37

During indirect bonding, brackets are first positioned on a plaster cast and then placed intraorally. Various positioning devices are available to orient the brackets. Among these bracket positioning and bonding techniques,31,38-42 (Table 2), TARG (torque angulation reference guide), and CLASS (customized lingual appliance set-up service system) (Fig 2) are the most widely used. Due to the reduced interbracket span, archwire bending is difficult, and now almost all the bracket positioning methods avoid second- and third-order bends in the finishing stage; TARG and CLASS even compensate for the varying thickness of teeth to eliminate the first-order bend, with the exception of the insets between canine and premolar, and premolar and molar.

### BIOMECHANICS AND TREATMENT PROCEDURE

When the maxillary and mandibular incisors are normally inclined, the distance from lingual bracket to the center of resistance of the tooth is shorter than that seen with the labial bracket. Therefore, when the same intrusion or extrusion force is applied to the lingual bracket and the labial bracket, the rotational moment is much less from a lingual bracket than the moment from a labial

<table>
<thead>
<tr>
<th>Positioning/bonding techniques</th>
<th>Mechanism</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>TARG (torque angulation reference guide)</td>
<td>TARG instrumentation transfers the lingual bracket position from the labial surface of tooth. TARG does not consider the difference of faciolingual thickness of different teeth.</td>
<td>Lingual brackets are placed on the casts, then transferred and bonded to teeth of patients.</td>
</tr>
<tr>
<td>CLASS (customized lingual appliance set-up service system)</td>
<td>Brackets are placed on the idealized model set-up of patient malocclusion. The brackets are seated into an ideal anterior arch (anterior brackets) and straight line (posterior brackets) with template blade, with all the slots parallel to the occlusion plane. First-, second-, and third-order bends are not needed, except insets between the canines and premolars, and the premolars and molars.</td>
<td>Individual transfer tray is made for each tooth. Brackets are transferred to the teeth of the patient directly, or transferred to the casts and then to the patient, using a full arch transfer tray.</td>
</tr>
<tr>
<td>TOP (transfer optimized positioning system)</td>
<td>The position of brackets is defined on patient cast of TARG. Ideal set-up model is used as a 3-dimensional reference for optimized bracket placement. Each bracket has at least 1 contact point with the tooth, giving patients more oral comfort.</td>
<td>Same as TARG</td>
</tr>
<tr>
<td>Lingual bracket jig</td>
<td>The jig consists of a labial arm and a lingual arm. The labial arm holding the lingual bracket slot transfers the Andrews straight-wire appliance labial bracket prescription to the lingual surface.</td>
<td>Brackets can be mounted directly on the tooth surfaces of the patient or on the casts.</td>
</tr>
<tr>
<td>Slot machine</td>
<td>Slot machine defines the orientation of the slot of bracket by the labial surface. After adjustment for torque, tip, rotation, height, and faciolingual thickness, the adhesive will fill the space between bracket and tooth.</td>
<td>Same as TARG</td>
</tr>
</tbody>
</table>
bracket; more intrusion or extrusion movement are expected in a lingual case.\textsuperscript{5} Bite opening is the most significant effect of lingual orthodontics.\textsuperscript{43} There is significant intrusion of the mandibular incisors, especially in the extraction cases, but not of the maxillary incisors.\textsuperscript{43} In general, anchorage control is easier in lingual treatment than in labial treatment. When the posterior teeth are maintained by the intrusive forces, buccal root torque is created. The distal rotation and buccal root torque of posterior teeth produce cortical bone anchorage, which provides stronger anchorage in lingual orthodontics.\textsuperscript{9} When absolute anchorage is required, a transpalatal arch, J hook, and headgear can be added, as routinely used in labial treatment. As with labial treatment, implants can be used for anchorage in lingual treatment.\textsuperscript{45,46} Although lingual appliances have some biomechanical advantages, practitioners should not think that treatment is easier with lingual technique. Unexpected or inefficient tooth movement may also ensue from improper use of force.\textsuperscript{9}

Table 3  Categorization of lingual cases according to Ormco lingual task force into 3 levels of difficulty\textsuperscript{50}

<table>
<thead>
<tr>
<th>Ideal</th>
<th>More difficult</th>
<th>Contraindicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonextraction</td>
<td>Surgical cases</td>
<td>Acute temporomandibular joint dysfunction</td>
</tr>
<tr>
<td>Deep bite, mild Class II or Class I</td>
<td>Class II, 4 first premolar extractions</td>
<td>Mutilated posterior occlusions</td>
</tr>
<tr>
<td>with mild crowding or spacing, with good facial pattern</td>
<td>Class III tendencies</td>
<td>High angle/dolichofacial patterns</td>
</tr>
<tr>
<td>Class II Division 2 with retruded mandible</td>
<td>Mesiofacial patterns and/or moderate mandibular plane angles</td>
<td>Extensive anterior prosthetics</td>
</tr>
<tr>
<td>Cases requiring expansion</td>
<td>Cases with multiple restorative work</td>
<td>Short clinical crowns</td>
</tr>
<tr>
<td>Diastema cases</td>
<td></td>
<td>Critical anchorage cases</td>
</tr>
<tr>
<td>Extraction</td>
<td></td>
<td>Severe Class II discrepancies</td>
</tr>
<tr>
<td>Class II, maxillary first premolar and mandibular second premolar extractions</td>
<td></td>
<td>Poor oral hygiene or unresolved periodontal involvement</td>
</tr>
<tr>
<td>Maxillary first molar extractions</td>
<td></td>
<td>Unadaptable or demanding personality types</td>
</tr>
<tr>
<td>Mild double protrusions with 4 first premolar extractions, with low or medium anchorage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
According to the Ormco lingual task force, lingual cases are divided into 3 categories, based on level of difficulty: ideal, more difficult, and contraindicated (Table 3). However, the continued development of the lingual technique has minimized difficulty. Many cases that were formerly contraindicated have been treated and published. Clinicians report surgical and lingual combined treatment, enhanced anchorage with implants and screws, adult periodontitis patients, and open bite cases, all treated with the lingual technique. In fact, it appears that the lingual technique is suitable for any patient.

Lingual treatment, like labial treatment, is divided into stages, including aligning, leveling, rotation control, bite opening, torque control, consolidation and retraction, and detailing and finishing. The first stage in lingual treatment is to align and level the arch, eliminate rotations, and obtain initial torque control. Alignment of the incisors and canines, en masse retraction of the anterior teeth is performed. Two-stage retraction (retracting canines first and then the 4 incisors), which is often used in labial treatment, is not optimal in lingual treatment because there will be an unesthetic space distal to the lateral incisors. In addition, in 2-stage retraction, the inset distal to the canines must be constantly adjusted. Therefore, en masse retraction is preferred in lingual treatment. There are 2 methods for en masse retraction: closing loop mechanics and sliding mechanics, each with its own advantages and disadvantages. The choice of closing loop or sliding mechanics depends on the anchorage needs, patient preference, and the clinician.

During detailing and finishing, the final adjustments are better accomplished with light and resilient round wire; heavy, rectangular archwire can result in undesirable torque and height discrepancies. In general, the finishing in lingual orthodontics is challenging because of the considerable variability in the lingual anatomy of teeth, the difficulty in distinguishing between third-order torque problems and second-order vertical problems, the difficulty of precise archwire bending with short interbracket distances, and the more demanding patient.

CONCLUSION

During the past 2 decades, dramatic progress has been made in the development of lingual orthodontic treatment. Although cephalometric measurements have not revealed statistically significant differences in treatment results between labial and lingual appliances, more evidence-based studies are needed to compare and appraise the final results between lingual and labial treatment. However, lingual treatment is suitable for most orthodontic patients, and is the optimal choice for adult patients who reject the unesthetic visible appliance for professional or social reasons.

REFERENCES