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Changing Criterion in Lingual Orthodontics

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Abstract

With orthodontic patient demographics expanding to involve more adults, the demand for esthetic appliances is greater and orthodontists are keen on offering their patients more discreet and even invisible options. Lingual orthodontics is a very viable field which offers all this, and it is noteworthy that more and more orthodontists in India are practicing the craft. With laboratory support being the backbone of this technique, it is gratifying that support is also within reach of the Indian Orthodontist with many of our own colleagues pioneering and contributing in this area. The purpose of this review is to investigate the current evidence and implications of lingual orthodontics.

Keyword: Orthodontic Patient, Lingual Orthodontics, CAD/CAM Technology

Introduction

With orthodontic patient demographics expanding to involve more adults, the demand for esthetic appliances is greater and orthodontists are keen on offering their patients more discreet and even invisible options. Lingual orthodontics is a very viable field which offers all this, and it is noteworthy that more and more orthodontists in India are practicing the craft. With laboratory support

being the backbone of this technique, it is gratifying that support is also within reach of the Indian Orthodontist with many of our own colleagues pioneering and contributing in this area.

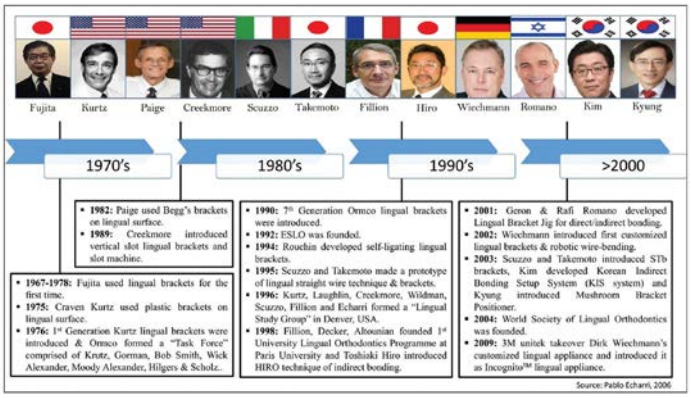
The growing interest in lingual orthodontics is perhaps a reflection of the social and esthetic issues of orthodontics being addressed as more adults seek treatment. The issue remains confounded by the clinical manipulation of the appliance, the patient comfort, and the predictability of outcomes. For any technique or system to succeed, it must address the above three issues directly.

The purpose of this review is to investigate the current evidence and implications of lingual orthodontics. The electronic database search was done on PubMed, EBSCO host, Web of Knowledge, and Google Scholar reporting on appliance design, bonding, and laboratory setup, biomechanics, survey studies, case reports, and treatment outcomes.

History of Lingual Orthodontics

Lingual orthodontics started in 1970's when Fujita in Japan and Kurtz in the USA used lingual brackets for the first time. It made a sensational debut as lingual brackets were invisible, and the number of initiated cases increased exponentially. A few years later, the number of lingual orthodontic cases decreased greatly. The reason was very clear; most doctors could not achieve satisfactory results with lingual orthodontics. Following this, initial development and expansion of lingual orthodontics in the 1990s, interest, particularly in the United States, decreased, probably due to the poor results of completed cases.[1]

Major developments in lingual orthodontics, which occurred around the world can be seen in the following timeline [Figure 1]



Trends From Past to Present

Indirect bonding and laboratory setup is a very important step in lingual orthodontics for accurate treatment results. There were only few publications available on indirect bonding and laboratory setup in 1980's and this remained constant in 1990's. Due to failure of treatment in initial years, there was a surge of publications in the last two decades accounting to large number of publications on bonding and laboratory setup.

As the biomechanics of lingual orthodontics is entirely different from that of labial orthodontics, there is an increasing trend of publications on biomechanics. In 1980's the focus was mainly on understanding the biomechanics of lingual therapy, in 1990's, there were publications on comparison of biomechanics in lingual and labial orthodontics.

In the recent years, the focus has shifted to the torque control of the anterior teeth in lingual orthodontic treatment. It was found that more than half of the articles on biomechanics were published in the last 6 years. As the number of patients seeking lingual orthodontics is increasing, seven out of ten articles was on case reports were published in the last 6 years as compared to two articles in 1990's

Since last decade, researchers have started to focus on oral hygiene issues and adverse effects associated with lingual orthodontics. There is still a lack of research on treatment

outcome as very less number of articles published on this topic in the last four decades. Hence, there is a need to further research to analyze the treatment outcome of lingual orthodontics.

Current Evidence and Implications

The current research progress in lingual orthodontics is described as follows:

Appliance Design

Lingual bracket system has evolved from first-generation Ormco lingual brackets to computer-aided design/computer-aided manufacturing (CAD/CAM)-based completely customized lingual appliance. First-generation Ormco lingual brackets of 1970's were evolved to seventh generation in 1990's, the changes were made in the profile of the bracket, addition of hooks, incorporation of rhomboidal shape bite planes, and increased mesiodistal width of the premolar brackets for better rotational control.[1]

Mushroom archwires have been in use since Fujita started lingual orthodontics which typically requires vertical step bends and insets between canine and first premolar andcomplicated wire bends. Scuzzo and Takemoto in 1995 introduced lingual straight wire technique and STb brackets and demonstrated that lingual straight wires can be used if the brackets are repositioned gingivally since the difference in thickness of the canines and premolars decreases with the bonding height.[1]

Weichmann in 2002 revolutionized the concept of lingual orthodontics by introducing CAD/CAM-based customized lingual appliance and robotic wire bending. In 2009, 3M Unitek took over this customized appliance and introduced it as Incognito™ lingual appliance.[1] Fillion in 2010, also developed a customized straight-wire technique, using the Orapix digital system to fabricate lingual appliances from a virtual setup.[2]

There are many customized lingual systems available today: WIN (DW Lingual Systems GmbH), HARMONY (American Orthodontics), and Indian customized lingual systems: Lingual Matrix and iLingual 3D. Scuzzo *et al*. in 2011 introduced first self-ligating lingual brackets with square slot. According to their experiments, the square slot (0.018 inch × 0.018 inch) is superior to rectangular slot in rotational control with both round and square archwires.[3] Kairalla *et al*. in 2014 established four lingual arch sizes: S, M, L, and XL and shape of lingual arch forms was described similar to a parabola, slightly flattened on its anterior region. Park *et al*. in 2015 also provided a new classification of maxillary and mandibular lingual arch forms: Narrow, tapering and ovoid according to intercanine and intermolar widths and their best-fit curves on lingual surface of dentition.[4,5]

Indirect Bonding and Laboratory Setup

The morphological variations of lingual dental surfaces limit the direct bonding of brackets on lingual surface accurately and precisely. Hence, indirect bonding technique is pivotal for success in lingual orthodontics. There are different laboratory techniques which have been developed for indirect positioning and bonding of lingual brackets. Laboratory setup for indirect bonding of lingual appliance can be divided into two categories, one is manual setup which uses patient's dental models and includes various methods (BEST, CLASS, and HIRO, etc.), the second is completely customized digital lingual setup (Orapix, WIN, HARMONY, Incognito™ and Lingual Matrix, and iLingual III D,) individualized for each patient, made by using patients scanned model or three-dimensional (3D) image and brackets are designed and manufactured by CAD/CAM technology.

Biomechanics

The biggest challenge in lingual orthodontics is to control inclination of anterior teeth during retraction phase. In the last decade, there are many studies on torque control of anterior teeth while treating with lingual appliance. Biomechanical design constituting palatal mini-screws and

lever arms make the point of application of retraction force at the level of center of resistance of the upper anterior teeth were seen to provide good torque control of anterior teeth during en-masse retraction as shown in a study conducted by Kim *et al*. in 2011.[6]

Kim *et al*. in 2011 also tested different lengths of the lever arm (from 0 to 20 mm) in their finite element analysis study for en-masse retraction of maxillary anterior teeth with lingual technique. The results of this study showed that when the length of lever arm was 20 mm in the anterior segment and a retraction hook which was placed at the level of root apex of maxillary molar with help of trans-palatal arch, it resulted in translation of upper incisors, buccal displacement of canines, no extrusion of upper anterior teeth, and slight distal displacement of molars.[7]

Lossdörfer *et al*. in 2014 and Daratsianos *et al*. in 2016, in their *in vitro* studies, analyzed and compared torque control capacity of completely customized lingual appliance and other lingual brackets and archwire combinations. These studies have shown that because of the high precision of the bracket slot-archwire combination in completely customized lingual appliance, an effective torque control was achieved with this appliance.[8,9]

Speech

Objective auditive analysis and subjective questionnaire-based analysis have shown that patients with fixed lingual brackets have higher degrees of speech impairment. Speech difficulties were statistically more common with lingual than with buccal systems. Patients with lingual appliances were more likely to report a perception of articulation change and avoidance of some types of conversation even after 3 months compared with patients with labial appliances. The patho-mechanism of speech impairment during lingual appliance therapy results from the contact area of the tongue being shifted further palatally as a result of the presence of lingual brackets.[10-13]

PAIN

There are no significant differences in pain experienced during treatment between those treated with labial or lingual appliances. The only difference of pain experience in both techniques is that the patients with lingual appliance experienced more pain in tongue, whereas those treated with labial appliance experienced more pain in lip and cheek. Patients treated with lingual appliance reported experiencing pain earlier than those treated with labial appliance.[14]

Eating Difficulties

Ata-Ali *et al*. in 2016, in their systematic review, concluded that eating difficulties were not found to be statistically more common with lingual than with buccal appliances.[10]

Oral Hygiene and Periodontal Status

Ata-Ali *et al*. in their meta-analysis, found a greater compromise in oral hygiene levels with lingual appliance. After analyzing, the clinical (bleeding on probing, plaque index, and probe depth) and microbiological findings (detection of *Aggregatibacter actinomycetemcomitans* and *Porphyromonas gingivalis* in crevicular fluid) concluded that lingual orthodontics significantly worsen these parameters.[10]

Long *et al*. in their systemic review also revealed that the prevalence of oral hygiene problems was similar within the first 3 months between lingual and labial fixed appliance.[12]

One split-mouth study tested clinical periodontal and microbial indices before and 4 weeks after bonding of Incognito™ lingual appliances. Plaque index and bleeding on probing significantly increased in this period in the bonded sites while no significant difference was detected for pocket depth and periodonto-pathogenic bacteria.[15]

Conclusion

The current evidence on lingual orthodontics shows that any case that can be treated with labial orthodontic appliance can also be treated effectively with lingual orthodontic appliance. As the number of adult patients seeking orthodontic treatment is increasing, the demand for esthetic orthodontic appliance is also increasing. Lingual orthodontics is the only orthodontic appliance which has an advantage of complete invisibility and 3D control of orthodontic tooth movement. This review article has come to the following conclusions:

The limitations of manual setups such as tedious laboratory procedures, inaccuracy in bracket positioning, frequent debonding of brackets, problem in rebonding of brackets, difficult and time-consuming manipulation of the appliance, inability to express and control the torque in anterior segment effectively and poor standard of treatment outcome, now can be easily addressed with the advent of completely customized lingual appliance

The only issue with the completely customized lingual appliance today, is the cost of the appliance which can be overcome with the availability of advanced technology like “metal” 3D printers which directly can make the metal brackets without making the wax patterns as in the current method

Biomechanical principles of lingual orthodontics have been completely understood and established today. The issue of torque control of anterior teeth can be addressed with the use of palatal mini-screws and lever arms which make the point of application of retraction force at the level of center of resistance of upper anterior teeth during en-masse retraction.

Patients with lingual appliances are more likely to report a perception of articulation change and avoidance of some types of conversation. The patient usually complaints of speech problems related to the lingual appliance that may persist until 1 month after onset of the lingual

treatment or even after 3 months in some patients. There is no significant difference in pain experienced during treatment between those treated with labial or lingual appliances. Ata-Ali *et al*., in their meta-analysis, found a greater compromise in oral hygiene levels with lingual appliance.

It is advantageous that lingual fixed appliances are associated with reduced incidence of WSLs as compared to labial fixed appliance as reported by various studies including RCT and systematic reviews

A systematic review has shown encouraging results of the clinical outcome associated with the lingual orthodontic treatment, especially in regard to the achievement of individualized treatment goals with the completely customized lingual appliance.

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