Clear aligners: How has the technology evolved?

By Brendan Day, DTI

Though still a relatively new orthodontic treatment modality, clear aligners have quickly become an increasingly popular alternative to fixed appliances for tooth straightening, since they provide an aesthetically appealing and comfortable choice. However, the recent rapid advancements in aligner technology are yet to be recognised by many dentists, leading to a low adoption rate. This article will provide an introductory overview of aligner treatment and its development.

Traditionally, malalignment has been corrected using fixed orthodontic appliances. However, in 1999, Align Technology made its Invisalign system available for commercial purchase, altering the future path of orthodontics. A clear aligner, Invisalign offered an effective alternative in orthodontic treatment, as its correct use can minimise the plaque build-up, gingival recession and inflammation of soft tissue sometimes associated with fixed appliances. Additionally, its complete lack of metal parts presented an aesthetic advantage, and the ability to remove it at any time (especially relevant during eating) allowed Invisalign patients a level of comfort and hygiene care previously unmatched in orthodontic treatment.

Through its recently introduced Invisalign Go system—a treatment programme aimed at guiding general dental practitioners through the process of identifying, planning and treating suitable cases using the aesthetic tooth straightening solution—Align Technology has become entrenched as the global market leader in clear aligners. Other companies have since recognised the value of this therapy, though, and this increased focus has led to a rapid progression in the sophistication of aligner modelling and manufacturing. Dr Les Joffe, Secretary of the European Aligner Society (EAS), the only international organisation in Europe devoted to the promotion of education and research in aligner therapy, believes that these advancements have not yet been fully recognised by all dental practitioners. In an interview with Dental Tribune, Joffe said that dental professionals often pass judgment on the suitability of aligners based on outdated information and technology. “There is a misunderstanding by many clinicians that aligner treatments are limited,” said Joffe. “Many clinicians base their view on the early stages of aligner development, from around 2001 to 2003. More than 15 years later, the huge strides that have been made in aligner performance are not fully understood and therefore the modality is either not adopted or provided.

These major advancements in clear aligner technology include the integration of much more sophisticated 3-D modelling software, able to customise each aligner to an individual patient’s needs. “Clear aligners have deeply changed orthodontics,” Agnieszka Dziedzic, Clear Aligners Department Manager for NiminoDENTAL Orthodontic Solutions, told Dental Tribune. Established in 1993, NiminoDENTAL is one of the largest orthodontic laboratories in the UK, using four different aligner systems in its work with dental practices. “When we started making clear aligners 15 years ago, we were limited to creating movements by hand on a plaster model,” said Dziedzic. “Today, though, we use sophisticated software and the latest 3-D printers to create clear aligners that can correct the majority of malocclusions.”

The lack of awareness of clear aligners benefits among dental practitioners has sometimes been attributed to a lack of scientific studies on this treatment modality. As aligner therapy has developed and been more widely adopted, however, increasing research into its effectiveness and patient satisfaction rates has been conducted. For example, a 2015 study published in the BMC Oral Health journal compared oral health status and satisfaction levels among patients who had received fixed appliances and those treated with the Invisalign system. It found that Invisalign patients were more satisfied overall and enjoyed greater periodontal health, with slightly lower levels of dental plaque. According to another study, conducted in 2013 and published in The Angle Orthodontist journal, compared with those treated with conventional edgewise brackets, patients who had received aligner therapy had significantly fewer dental visits, shorter treatment duration, fewer emergency visits and less overall chair time.

Aligner therapy is one of the fastest-growing areas in orthodontics, driven significantly by patients who regard it as a more comfortable, convenient and discreet alternative to fixed appliances. Given that market research firm Technavio has projected this market to grow at a compound annual growth rate of 12.68 per cent globally from 2016 to 2020, the need for organisational bodies to increase education on the latest technologies used by clear aligners is essential. The German Association for Aligner Orthodontics was founded in 2007 and the Japan Academy of Aligner Orthodontics in 2012, with both organisations aiming to foster a space for increasing awareness of the applications and advantages of aligner therapy.

More recently, the EAS was established in 2013, with Dr Graham Gardner serving as its founding and current president. In order to promote education on the latest technologies used by clear aligners, the EAS will be hosting its first AlignerLab workshop on 18 February 2017 in Vienna in Austria. It follows on from the successful first EAS congress in February 2016 and will provide clinicians with an opportunity to engage in a variety of hands-on sessions covering 3-D intra-oral scanning, 3-D printing, virtual treatment planning techniques and tooth movement acceleration techniques.

Gardner believes the AlignerLab will highlight how far aligner therapy has come in such a short time. “With the explosion in the 3-D treatment planning and manufacturing processes now available, we at the EAS believe that not only do we need to update our knowledge on the various aligner systems available, we also need to understand the associated hardware scanners, computers, software, 3-D printing—that is necessary to optimise the aligner system and improve treatment results,” he told Dental Tribune. Gardner envisions the event ideally becoming a regular occurrence to allow dental professionals to trial and compare new systems and developments in aligner technology.
Obesity may influence response to orthodontic treatment in minors

By DTI

LONDON, UK: In Western countries like the UK, it is estimated that almost every third child is now overweight or obese. At the same time, an increasing number of children are receiving fixed braces to correct malocclusions at an early age. A new study conducted by researchers at King’s College London Dental Institute and published in the Journal of Dental Research has now indicated that the response to this particular type of treatment can significantly vary depending on a child’s body weight.

In the cohort study, the researchers followed a number of adolescent patients, who were classified as normal weight or obese based upon their body mass index, from the start of their treatment to the completion of tooth alignment. During the examinations, it was found that those patients who were obese had a significantly increased rate of initial tooth movement and required less time to achieve tooth alignment compared with normal-weight patients.

The researchers also noticed increased levels of inflammatory biomarkers in the gingival tissue of obese patients prior to orthodontic treatment.

The first of its kind to study the relation between obesity and orthodontic tooth movement, it demonstrates that the condition in adolescent patients influences the supporting tissue around the tooth, the researchers said, and this could have important implications for orthodontic treatment outcome in obese patients over both the short and long term.

Levels of obesity have increased significantly throughout all age groups in Western societies in the last two decades, and it has been linked to multiple chronic diseases, including periodontal inflammation. In a 2015/2016 evaluation, Public Health England found that 14 per cent of one million schoolchildren in the UK were classified as overweight and almost 20 per cent as obese.

The King’s study, titled “Impact of obesity on orthodontic tooth movement in adolescents: A prospective clinical cohort study”, was published online on 23 January in the Journal of Dental Research.
Aligner therapy continues to improve

An interview with the President of the European Aligner Society (EAS) Dr Graham Gardner

Since it was commercially introduced in 1999, aligner therapy has grown and developed substantially as an orthodontic treatment modality. Dr Graham Gardner from Wimbledon, who is President of the European Aligner Society (EAS), an organisation dedicated to increasing education and research in aligner therapy, The inaugural EAS AlignerLab workshop held in Vienna in Austria on 18 February aims to provide a hands-on learning experience for dental professionals interested in updating their knowledge of aligner treatment. Dental Tribune interviewed Gardner about the role of aligners in orthodontics and what the event organisers have in store.

Dental Tribune: What benefits do aligners offer over fixed orthodontic appliances, and how have these developments since aligners were first introduced?

Dr Graham Gardner: In my opinion, the advantages of aligner therapy for the patient are:

1) They are more comfortable than fixed appliances.
2) They are more aesthetic, and therefore less noticeable, compared with fixed appliances. This is especially important for someone seeking orthodontic treatment because he or she is already concerned and self-conscious about his or her teeth, as the last thing such a patient would then want is to draw attention to his or her teeth with fixed appliances.
3) Improved maintenance of oral hygiene and no dietary restrictions, as the aligners are removed for eating.
4) Improved treatment planning allows one to manage treatment before commencing.
5) Improved treatment software. Virtual treatment planning allows one to evaluate different treatment options that can be more clearly discussed with the patient owing to the virtual presentation process. In my opinion, this allows the patient to make a more informed decision on the treatment.
6) Broken brackets and emergencies are things of the past.

Additionally, a benefit shared by both patient and clinician is that adjustment appointments are often quicker and certainly more comfortable for the patient compared with fixed appliances.

We are excited about the first EAS AlignerLab. With the explosion in the 3 D treatment planning and manufacturing processes now available, we at the EAS believe that not only do we need to update our knowledge on the various aligner systems available, we also need to understand the associated hardware, such as scanners, computers and 3 D printers, and software that is necessary to optimise the aligner system and improve treatment outcomes. It is therefore our objective to bring these two areas together with one event with the AlignerLab.

This will allow attendees the opportunity to listen to world-famous clinicians on different systems, to compare these different aligner systems and to gain hands-on experience with the treatment equipment associated with these systems. We think it is a unique way to update our knowledge on aligner therapy, with a bonus opportunity to forge links with our colleagues across Europe.

Is the AlignerLab a one-off thing or is it intended to become a regular event?

We hope this will become a regular event because technological developments and advances will continue. Thus, an event at which practitioners can both make direct comparisons and trial new systems should become a popular and regular occurrence.

Thank you for the interview.
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Vibration therapy in orthodontics: Realising the benefits

Dr Amit Lala, USA

Introduction to vibration therapy—multiple potential benefits

Accelerated orthodontics and vibration therapy to fast track orthodontic tooth movement (OTM) have been hotly debated topics in the orthodontic industry in recent years. Periodontally Accelerated Osteogenic Orthodontics (PAOO) techniques such as osteotomy, open flap corticotomies, and piezocision have been shown to decrease treatment time. Unfortunately, these classical techniques have had limited patient acceptance because of their invasiveness and side effects. In the last several years, microosteoperforation, which takes advantage of the same biological regional acceleratory phenomenon as these classical techniques, has been gaining rapid clinical adoption because of the simplicity of its chairside microinvasive nature.

There is also growing evidence that the application of mechanical energy-based therapies such as vibration can stimulate and accelerate bone formation and possibly bone remodelling. Orthodontic tooth movement, caused by the application of light continuous forces that induce bone formation and remodelling, could logically be accelerated by the application of vibrational force, with the benefit of reducing the overall treatment time.

Orthodontist (OrthoAccel Technologies) has offered the AcceleDent device, offering the promise of accelerated orthodontic treatment based on delivering mechanical stimulation to the dentition. At this point, research on the efficacy of this device in accelerating OTM has been mixed, and clinicians debate its value.

The debate on vibration therapy as it applies to accelerated orthodontics in general and the effectiveness of the AcceleDent device specifically, should consider other factors in evaluating efficacy. First, there is a distinct possibility that frequency optimisation of the devices concerning bone formation/remodelling has not been established. AcceleDent operates in a low frequency range, however, research points towards the benefit of high frequency in bone modulation. Secondly, current research indicates that high frequency low magnitude (HFLM) vibration therapy as applied to orthodontic treatment may have multiple potential benefits, including, but not limited to, accelerated OTM.

This article will discuss these additional benefits, including faster and more efficient aligner therapy. When used as a nightly seating tool, relief of normal orthodontic discomfort from new tight fitting aligners and routine adjustments to fixed appliances, and enhancement of orthodontic retention. Additionally, it will touch upon evidence that HFLM vibration therapy is useful in increasing bone density and trabecular bone thickness, suggesting applications in implant dentistry and prosthodontics.

Current vibration devices used in orthodontic therapy

As mentioned previously, the most common, commercially available, vibration device for orthodontic treatment is AcceleDent manufactured by OrthoAccel Technologies. This device delivers a vibrational frequency of 30 Hz and requires 20 minutes per day user wear time.

Several early studies on the AcceleDent device seemed to demonstrate higher rates of OTM than the established norms.

However, there are other more recent studies that have failed to establish the advantages of the same therapy. A study by Woodhouse et al. (2013) assessed the AcceleDent device to demonstrate its effect on OTM in extraction cases. They found that the supplemental vibrational force did not significantly increase rates of orthodontic alignment with a fixed appliance. Another comprehensive review on vibration therapy by investigators Yada et al. (2015) concluded that low frequency mechanical vibration using AcceleDent had no significant effect in accelerating tooth movement.

The recent studies regarding the apparent ineffectiveness of AcceleDent may be explained by the relatively low vibrational frequency of the device. For purposes of this discussion low and high frequency are defined as:

- Low frequency—less than or equal to 43 Hz
- High frequency—greater than or equal to 90 Hz

In a 2010 study by Juxed and Rubin, ovariecotomised rats were subjected to either low or high frequency vibration therapy. Bone formation rates for subjects treated with high frequency were 199 per cent greater when compared to controls, whereas bone formation for low frequency rat subjects were not significantly different than controls. Trabecular bone volume and thickness were also significantly higher for subjects treated with high frequency.

Similarly Akikani et al. found a statistically higher rate of alveolar bone formation (190 per cent) at higher frequencies, with a five-minute per day application. In short, the most pronounced osteogenic effects of vibration seem to occur well above the AcceleDent's low vibrational frequency.

Practically speaking, five minutes of daily wear time may be beneficial, as it will reduce the dependency on significant patient compliance. In order to realise the maximum benefits of vibration therapy, shorter wear times would logically increase compliance and improve results. Given all other factors being equal, the studies suggest that a higher frequency device would deliver equivalent amounts of HFA Energy to the dentition in a significantly reduced timeframe.

The future of vibration therapy: Expanded application, multiple benefits

The apparent limitations of current commercially available vibration devices should not diminish the potential importance of vibration therapy. Setting aside applications such as implant dentistry and prosthodontics suggested by the osteogenic properties associated with vibration therapy, there are at least four important clinically beneficial orthodontic applications that can be anticipated. These potential applications are: 1) as a nightly clear aligner seating device; 2) analgesia, relief from normal discomfort associated with orthodontic treatment; 3) accelerated orthodontic tooth movement; and 4) enhancement of orthodontic relapse. What follows is a brief examination of each of the four applications of HFLM vibration as an orthodontic therapy.

Improved aligner seating

The importance of properly seated aligners, to efficient tooth movement in aligner therapy is clearly understood. Improperly seated aligners can slow treatment, forcing patients to backtrack to previous trays, and create unintended collateract tooth movements, with a consequence being time consuming and costly refinements. Seating recommendations range from using ‘chewies’, to biting on hard objects. Some clinicians advise seating only when trays are new (immediately post change), while others recommend daily seating. With the current seating modalities, it is unlikely that patients consistently seat aligners fully. A seating protocol, that takes only five minutes nightly, delivering a range of other patient benefits, would ensure that aligners are fully seated throughout treatment. Consistent proper aligner seating would likely result in more efficient, faster aligner treatment, even absent biomechanical instability caused by vibration itself.

Non-pharmacological analgesia

Discomfort or pain is a common side effect of orthodontic treatment. The forces applied to the dentioalveolar complex are required to move teeth, compress the periodontal ligament (PDL) causing inflammation. Pain is most notable when seating a new aligner, or immediately after wire changes and adjustments, when pressure on the PDL is at its greatest, and diminishes as the aligner material expands, and or the dentition composes. In a study accepted in September 2015 by the Angle Orthodontist for future publication, Lobre et al found in a randomised clinical trial that vibration therapy resulted in significantly lower perceived pain and less OTC medication use. One theory regarding the vibration restores normal circulation to the PDL, which is otherwise restricted by compressive forces. Increased blood flow interrupts the ischaemic response and limits inflammation.

Accelerated OTM

It is well established that bone undergoes formation and resorption in response to external loading such as gravitational forces, as well as to internal loading such as muscular activity. Recent research with both animal and human models have demonstrated anabolic responses such as bone growth and changes in bone mineral density in response to vibration. Since OTM is fundamentally based on bone modulating (formation and resorption) there is little doubt that HFLM vibration has the potential to favourably impact OTM.

In a recent split-mouth randomised trial involving bilateral maxillary canine distraction after first premolar extraction on 15 human subjects, Leethanakul et al. (2015) investigated the impact of vibration on accelerated tooth movement...
ment, as well as on cytokine activ-
ity related to osteoblast and osteo-
clast differentiation (specifically IL-1β levels in GCF). The patients ap-
plicated vibration to the experimental
canine using a commercially avail-
able electric toothbrush operating
at high frequency (125 Hz). This
study found significantly increased
tooth movement (+46 per cent) ac-
companied by a threefold increase in
average IL-1β levels.8

It can be hypothesised that vibration, amplifies the familiar osteoblast–osteoclast cellular re-
sponse causing bone formation and resorption, when the teeth are
under force (i.e. from fixed appli-
ances and aligners). In the absence
of force, vibration causes new bone
apposition only, which has potent-
tial implications for the retention
phase (see below). Note that the
frequency of the device creating the
accelerated tooth movement in the Leethanakul study was in
that high frequency range shown
to have superior effects on alveo-
lar bone formation by Jukes and
Rubin, and Alikhani et al.13,14

Enhanced retention
Vibration therapy warrants the
attention of the scientific commu-
nity to further explore its effect
during the orthodontic retention phase. Scientific literature docu-
ments that the primary reason for
orthodontic relapse is the inability
of collagen fibres (Transseptal fi-
bres and PDL) to reorganise quickly
after the completion of orthodont-
tic treatment and the delay in new
bone apposition.6 Studies suggest
that vibration can have potentially
favourable impacts on both bone
formation and reorganisation of
the PDL fibres.

A study from Rubin et al. (re-
ferred above) states that vibration
therapy by itself has always been
anaesthetic, which means it led to
bone apposition and a decrease in
ebone resorption. Reports have
documented an increase in bone
density, bone formation, Type-1
collagen and non-collagenous ma-
trix expression in response to
the therapy.6

Recent studies by Yadav et al.
(2015) and Alikhani (2012) (both re-
ferred above), have demonstrated
that vibration therapy improved
not only bone density, but also re-
stored the integrity and thickness
of the collagen fibres. With evi-
dence suggesting that vibration
therapy positively impacts both
bone morphology and the PDL fi-
bres, vibration during the retention
phase may play a significant role in
preventing orthodontic relapse.

Conclusions
The current debate over vibra-
tion therapy and its impact on ac-
celerated orthodontic tooth move-
ment, should consider other poten-
tial benefits of this therapy includ-
ing applications for aligner seating,
relief of normal orthodontic pain,
enhanced retention and applica-
tions to implant dentistry and
prosthodontics.

It can be hypothesised that a
vibration device operating in the
high frequency range would likely
be most effective in creating OTM
as well as offering shorter wear
times impacting compliance. The
most commonly available commer-
cial device operates at a frequency
that is below thresholds having
statistical significance in creating
orthodontic tooth movement as
documented in several recent stud-
ies, and requires a relatively long,
20-30 minutes daily wear time.

The strong supporting data
concerning the positive effects of
vibration therapy on bone forma-
tion, bone density and collagen
fibre reorganisation leads us to be-
lieve that this modality of treat-
ment may revolutionise the con-
cept of orthodontic retention.

The effects of high frequency
vibration therapy may be useful
in modifying the bone density to
the clinician’s advantage in im-
plant placement or to maintain
the thickness of bone trabeculae
in edentulous patients undergoing
prosthodontic treatment.

Editorial note: A complete list of refer-
ences is available from the publisher.

Dr Amit Lala
DDS, PhD, earned
his Master’s De-
gree in Oral Bi-
ology from the
University of Cal-
ifornia in Los
Angeles. He then
earned his DDS and PhD in Oral Bi-
ology from SUNY Buffalo, NY. He also
completed his postgraduate resid-
cency in Orthodontics at SUNY, Buffalo,
NY. Dr Lala is affiliated with Harvard
School of Dental Medicine as a lec-
turer in the fields of Orthodontics and
Oral Biology.
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