Maxillary molar distalisation with aligners and cyclic forces

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Introduction

In the last decade, clear aligner therapy (CAT) has become a well-known treatment option in orthodontics, mainly owing to patients’ preferences for aesthetic appliances. With respect to conventional fixed appliances, aesthetics is not the only advantage of CAT. Several papers have concluded that aligners provide better comfort and, being metal-free, avoid irritation of the cheek and gingival tissue; facilitate better oral hygiene, allowing the patient to remove the aligner while eating and to brush and floss the teeth after eating; and results in less pain compared with conventional brackets. In clear aligner-based orthodontics, an intentional mismatch between the aligner and the teeth is programmed based on the desired tooth position. Through this process, a force system is transmitted to the teeth. However, CAT has shown some limitations regarding the generation of complex force systems for achieving extrusion, rotation, bodily tooth movements and root movement control. In order to overcome these limitations, auxiliaries such as power ridges and composite attachments were designed and engineered to improve CAT biomechanics, enabling the expression of more complex force systems. Even so, orthodontics is not only a matter of applied mechanics, since the biological response of the patient plays a determining role. Aligners are capable of producing the same biological response as fixed appliances do.1

Stimulation of the bone cells is mediated by several factors, such as a member of the tumour necrosis factor ligand and receptor superfamilies, including the receptor activator of nuclear factor kappa B ligand, the receptor activator of nuclear factor kappa B, and osteoprotegerin.2 Osteopontin is another protein that has been linked to bone resorption via promotion of osteoclast adhesion to the osseous matrix.3

Research has demonstrated that the use of cyclic forces increases the rate of bone remodeling compared with static forces.4 A force propagating through biological tissue, such as alveolar bone and the periodontal ligament, is transduced as a tissue-borne and cell-borne mechanical stress that in turn induces interstitial flow.5 Although liquid flow is a current focus of the mechanotransduction pathways, its anabolic and catabolic effects rely upon deformation of extracellular matrix molecules, transmembrane channels, the cytoskeleton and intranuclear structures.6 Cells are known to respond more readily to rapid oscillation in force magnitude (i.e. to cyclic forces) than to constant forces.7 However, randomised clinical trials testing the effect of a commercial device generating cyclic forces during orthodontic treatment produced contrasting results.8 Biases in both the cited studies prevented the drawing of a definite conclusion. In a real clinical setting, the same device has been reported to be reliable.9 The tested device is AcceleDent (OrthoAccel Technologies). The device has a mouthpiece similar to a sport mouthpiece, which the patient bites on to during use. The mouthpiece portion is connected to an activator that stays outside the mouth. The activator houses the components that generate the cyclic forces (vibration). The activator includes a battery, motor, rotating weights and microprocessor for storing usage data. The patient connects the mouthpiece to the activator and uses the device once daily for 20 min. The applied force from the device is 0.25 N (25 g). This low force is
intended to be barely noticeable and not uncomfortable. The device can be used with fixed appliances and aligners. A human skull study has shown that the vibration generated by the AcceleDent device can be well transmitted through the dentition and skull. Therefore, the device is able to reduce treatment time by inducing a more rapid response of bone cells to orthodontic forces.

**Case report**

A 25-year-old female patient requested an aesthetic orthodontic treatment that was not easy to manage because of her job as a make-up artist travelling across Europe. She presented with a Class II, Division 1 relationship: mild crowding in the lower arch and moderate crowding in the upper arch. The overjet was increased up to 10 mm. The profile analysis also revealed a protruded lip position (Figs. 1a–c). Considering the patient’s aesthetic request and her refusal of surgical intervention or extraction, the treatment plan was designed to obtain a final molar and canine Class I relationship through sequential distalisation of the maxillary teeth using Invisalign aligners (Align Technology), composite attachments on all of the distalising teeth and Class II elastics.
The patient was instructed to wear the aligners and the Class II elastics for at least 21 h per day. Furthermore, she used the AcceleDent device for 20 min per day for the duration of the orthodontic treatment. Aligners were changed every two weeks until the maxillary second molars were fully distalised, then every ten days until the first molars were in their final position and then every seven days until the end of treatment.

The ClinCheck (Align Technology) software demonstrated the need for 63 aligners to obtain the desired results with the prescribed sequence of stages, attachments and Class II elastics. Thus, the estimated treatment time was approximately 30 months. However, because the patient had chosen to use AcceleDent, the case was finalised in 18 months of treatment without any additional aligners with respect to the initial prescribed 63 (Figs. 4a–c, 5a–c).

The clinical results were excellent and revealed a final molar and canine Class I relationship with functional overbite and overjet, and the profile of the lower third of the face was highly improved. The superimposition of the cephalometric tracings revealed a maxillary molar distalisation of about 6 mm without significant tipping and excellent control of the buccolingual
maxillary molar distalisation with aligners

case report

Fig. 4a
Fig. 4b
Fig. 4c

Fig. 5a
Fig. 5b
Fig. 5c

Fig. 6
maxillary molar distalisation with aligners

Fig. 7a Fig. 7b Fig. 7c

Fig. 8a Fig. 8b Fig. 8c

Fig. 9
inclusion of the incisors. The Class II elastics
were responsible for mandibular protraction of
about 1.5 mm. Retention was provided by Vivera
retainers (Align Technology) (Figs. 6, 7a–c, 8a–c).

Discussion and conclusion

In several studies conducted on Class II intraoral
non-compliance appliances, dentoskeletal effects
revealed anchorage loss at the reactive part, distal
tipping and extrusion of molars.12 Usually, the
anchorage loss occurred particularly in the incisal
area owing to the reciprocal force reacting to the
distalising force. Previous studies have confirmed
that the use of Class II elastics during maxillary
molar distalisation with aligners prevents the
uncontrolled proclination of the anterior teeth.13
Furthermore, the sequential distalisation proto-
col limits space opening between the distalising
teeth, which is more aesthetic, maintains maxi-
mum aligner contact with the teeth and reduces
the flexibility of the plastic material. That, in turn,
minimises uncontrolled incisal tipping, which is
expressed clinically as increased overbite with a
loss of palatal root torque.

Treatment duration is influenced by the mal-
occlusion complexity, the amount of tooth move-
ment required and the applied system of forces.
The distalisation of maxillary molars is frequently
required in Class II non-extraction patients. Re-
solving Class II molar relationships by distalising
maxillary molars may be indicated for patients
with minor skeletal discrepancies.14

Simon et al. reported a high accuracy (88%) of
the bodily movement of maxillary molars with CAT
when a mean distalisation movement of 2.7 mm
was prescribed.15 The authors reported the best
accuracy when the movement was supported by
the presence of an attachment on the tooth sur-
face. Furthermore, they underlined the importance
of staging in the treatment predictability. Ravera
et al. investigated the dentoskeletal effect of max-
illary molar distalisation with Invisalign aligners
in adult patients and found that clinicians can con-
sider the use of Invisalign aligners in treatment
planning for adult patients requiring 2–3 mm of
maxillary molar distalisation.16 In order to obtain
this amount of movement, maxillary third molars,
if present, should be extracted to have sufficient
room to move the second and first molars in Class II
malocclusions. It has been suggested that teeth
moved with aligners do not undergo the typical
stages of orthodontic tooth movement described
by Krishnan and Davidovitch,17 because of the in-
termittent forces applied by the aligners. However,
light continuous forces are able to produce orthodontic
tooth movement with less cell damage with respect
to light continuous forces.19

Cyclic forces applied by the AcceleDent device
are oscillatory in nature and change in magnitude
rapidly and repeatedly, affecting the cells with
each oscillation of force magnitude.20 The fre-
quency of cyclic forces is never zero. Force fre-
quency is a concept of critical importance, but
has rarely been considered in the field of ortho-
dontics and dentofacial orthopaedics until recent
years. Cells are known to respond more readily
to rapid oscillation in force magnitude (i.e. to cyclic
forces) than to constant forces.7 Therefore, Ac-
celeDent acts as a physical mediator of the bone
modelling and remodelling processes behind or-
thodontic tooth movement, thus facilitating the
action of the aligners. The result is excellent track-
ing of the aligners, because of the expression of
the biomechanics produced by the interaction
between aligner, attachments and tooth surface
(Fig. 9). The successful incorporation of Accele-
Dent into an orthodontic treatment can signifi-
cantly reduce treatment time, making it an at-
tractive adjunct for patients. In the presented
case, treatment duration was shortened by 45%
with an effective, user-friendly and safe

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