In order to convey how this approach differs from other treatments on offer, I compare it to the difference between an off-the-peg suit and going to a tailor in Savile Row. Many of the patients I treat at my practice are referred by leading London lingual orthodontics provider Dr Asif Chatoo describes his navigation of digital technology

By Dr Asif Chatoo, London

My professional journey has no end or destination. If I ever felt satisfied by one system and I applied it in the same way without acquiring new knowledge or discovering more advanced technologies and materials, I would consider myself ready for retirement, which I am certainly not. My voyage through digital technology, however, has just reached a natural conclusion. I realised recently that I had progressed through all aspects of digital technology as it relates to orthodontic treatment and I had completed a circle (Fig. 1).

My journey started with photography some years ago, but the process accelerated, and in recent years, everything has gone digital, including radiography, record-taking, treatment planning, and the manufacture of brackets and wires.

Over the course of my digital conversion, I have tried several different systems, all of which have delivered important benefits. The system I have used most as I completed the digital circle over the last two years is suresmile (OraMetrix). It is a treatment management system I have used most as I completed the digital circle over the last two years is suresmile (OraMetrix). It is a treatment management system and among its benefits is that it is immediate. Adult patients are particularly grateful not to have impressions taken, and the orthodontic nurses are delighted to avoid this most trying aspect of record taking. It was invariably messy. Being impression-free has brought more value to the team than going paperless.

It goes without saying that a key benefit of digital technology is the integration of the orthodontic processes and records. For instance, a scan of the patient’s teeth can be superimposed on to a photograph, which I can in turn integrate with a grid. I can relate the tooth positions to facial planes and check that the dental midline is centrally located. I can show the patient his or her teeth and bite and I can provide him or her with a visual simulation of the difference that treatment will make. The patient can then ask questions. My vision for the finished result may not be the patient’s vision and being able to manipulate the outcome on screen means one can be absolutely sure the patient understands the treatment planning. The patient can influence the treatment if he or she wishes, and if he or she changes his or her mind towards the end, the technology allows for last-minute reusing.

In order to convey how this approach differs from other treatments on offer, I compare it to the difference between an off-the-peg suit and going to a tailor in Savile Row. Many of the patients I treat at my practice are referred by leading dentists. Their expectations are high. Sometimes orthodontic treatment is just one part of an interdisciplinary treatment that in its entirety will cost in excess of £20,000. Patients expect perfection—in so far as it is possible in an ageing dentition—and they expect a high level of service. Suresmile allows me to deliver both. Rigorously for a West End practice, many of the benefits of suresmile relate to communication and the care of patients with high expectations, but there are also personal benefits for the clinician.

In my case, there is one that surpasses all others. Bending archwires at the end of treatment is almost always inevitable and it is an aspect I dread. Why am I so hung up on this? The reason is that, if one bends a wire on one tooth, one will affect all the other teeth. This will increase the chairside time. The solution is the robotic wire bending that is central to suresmile.

I aim to deliver several things to my patients: an aesthetic result, a functional occlusion and an occlusion that is comfortable at rest. More than anything, I want them to be wowed by their experience.

I believe suresmile delivers that wow factor. I have gone 360 degrees around my practice, and am now fully digital, but this is only the first navigation of new and evolving technology. My orthodontic journey continues and I suspect a few more digital revolutions await.

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A Practical Treatment Objective: Alveolar Bone Modeling with a Fixed, Continuous-Arch Appliance

By Thomas W. Barron & Frank Bogdan, USA

Bone is a dynamic tissue that is continuously adapting its structure via the processes of remodeling and modeling. Remodeling is the coupled sequence of resorption and formation involved in physiologic turnover. It is necessary to adjust internal architecture in response to mechanical needs, repair microdamages in the bone matrix, and to maintain plasma calcium homeostasis. Remodeling may be observed histologically or by chemical assay of biomarkers. Modeling is a change in the size and shape of bone that can be observed and measured radiographically. It is the net gross anatomic result of bone resorption and formation on a given bone surface in response to growth and development or mechanical load. These processes are well accepted phenomena in the field of physiology.

In the orthodontic literature, it is widely held that the alveolar bones of the maxilla and mandible are immutable—that once formed, their size and shape cannot be changed significantly with tooth-borne, continuous-arch orthodontic appliances. Attempts to do so have been associated with root and cortical plate resorption, loss of periodontal attachment and unstable tipping of teeth. Under this paradigm, orthodontic treatment must maintain the existing size and shape of the alveolar bone. In many cases, this can only be accomplished with surgery, tooth extraction, or separation of the midpalatal suture.

In recent years, there has been a growing body of clinical evidence bolstered by studies that challenge the immutability of the alveolar bone and the mandate to treat to the existing dentoskeletal arch form.

The purpose of this article is to present a review of the literature challenging alveolar bone immutability along with clinical cases treated with passive self-ligating orthodontic brackets and low-force low-load force protocols that demonstrate alveolar bone modeling.

Challenging Alveolar Bone Immutability

The alveolar process is defined as that part of the maxilla and mandible that forms and supports the sockets of the teeth. It includes the thin lamella of bone that surrounds the root of the tooth and gives attachment to the principal fibers of the periodontal ligament.

It also includes the supporting inner and outer cortical plates of compact bone along with the spongy bone between the cortical plates. Though anatomically, no distinct boundary exists between the body of the maxilla or the mandible and their respective alveolar processes, the bone surrounding the teeth from root apex to the crest of the socket is considered to be the alveolar bone.

By means of the teeth, alveolar bone can be loaded with biomechanical force. The cellular response of the PDL to orthodontic force has been well characterized on both the pressure and tension sides of the bone socket surrounding the root as the tooth and its periodontal ligament are translated through the trough of bone confined by the buccal and lingual cortical plates. Until recently, modeling—or changing the size and shape of the developed alveolus by removing the pressure of the buccal musculature and allowing the light continuous force of the tongue to dominate—according to Frankel, when the forces of the cheeks are eliminated, the teeth tip laterally in the direction of least resistance. The alveolar walls in the radicular area are likewise deformed in a buccal direction.

Furthermore, the acrylic shields extend into the vestibule exert a constant outward pull on the connective tissue fibers and muscle attachments that are transmuted to the alveolar bone by the fibers of the periosseum. Apposition of buccal bone aids in the lateral movement of the dentoalveolus. The ability of periodontal tissue to induce apposition of bone on the lateral alveolus has been demonstrated in the animal studies of Altmann and Harvold. In addition, a study by Bendsen, et al., utilizing metallic implants placed in the maxillae of patients treated with the Frankel appliance demonstrated that widening of the maxilla was due to deposition of new bone along the lateral border of the alveolar bone rather than increased growth at the midpalatal suture.

This phenomenon of alveolar modeling, specifically lateral translation of the alveolus, achieved by disrupting the equilibrium of the inner and outer oral musculature and periodontal tension is consistent with the Functional Matrix Theory of Moss. While granting the innate growth potential of cartilage and bone, his theory holds that growth of the face occurs as a response to functional needs and neuromuscular influences and is mediated by the soft tissue in which the jaws are embedded.

The theory, simply stated, is that bones do not grow but are grown, emphasizing the ontogenetic priority of function over form. The Frankel appliance achieves a change in form by changing the function of the matrix tissues of the infraorbital musculature.

Load-Induced Alveolar Bone Modeling

It is commonly observed in the field of dental medicine that the continuous load of a growing odontogenic cyst can significantly model the alveolar bone of the maxilla and mandible, causing remarkable dis-
placement of the cortical bone. This pathologic process is well established and has been extensively documented in case reports and textbooks. The interstitial pressure of various odontogenic cysts has been measured and found to exert an ultra-low force load on the alveolar bone. This phenomenon clearly demonstrates that the developed alveolus can be modeled via pathologic induction with light, continuous force. Another commonly observed example of bone modeling is the bulge of the cortical plate associated with a palatally impacted canine. The impacted tooth is typically associated with an enlarged follicle. When the canine is exposed and brought into the center of the alveolus a normal palatal contour returns.

Kokich and Kokich demonstrated localized modeling of the adult alveolus in response to tooth displacement. Light, continuous orthodontic force was employed to distillate a tooth into the atrophic alveolar ridge associated with a congenitally absent second premolar. The distalized tooth moved with its supporting bone, changing the size and shape of the atrophic alveolus (Fig. 3).

Fontenele reported alveolar bone modeling with a passive/active distraction appliance in non-growing patients. The appliance (Fig. 4) consisted of a passive, rigid cast lingual arch and active, low-modulus wires activated between the cast lingual arches. Disassociation of the passive and active components facilitates the application of low, constant force load with near constant moment-to-force ratios, resulting in bone modeling induced by dental displacement. Clinical cases were shown demonstrating lateral modeling of the alveolus as observed by Frankel and localized alveolar modeling with tooth displacement as observed by Kokich and Kokich.

Williams and Murphy described alveolar bone modeling with evidence of apposition of bone on the maxillary buccal alveolus with permanent dentition patients (Fig. 5a-c). This was induced by a light, continuous load applied bilaterally to the maxillary alveolus with the Max 2000® alveolar development appliance (Fig. 5a). Their appliance consists of two nickel-titanium springs embedded in and connecting separate acrylic panels in a framework retained by bands on the first bicuspid and first molars. The transpalatal springs delivered 150 grams of force each in a lateral direction. Biopsies were performed on two patients upon completion of lateral alveolar development. The specimens were harvested via full-thickness flaps from the labial alveolar crest between the maxillary right first bicuspid and canine (Fig. 5b). An internal control specimen was taken from interseptal bone between the ipsilateral mandibular first bicuspid and canine (Fig. 5c). Standard hematoxylin and eosin stained sections were examined with and without polarized light and a histology specimen was subjected to fractional analysis.

The maxillary treatment sections demonstrated the absence of the lamellar pattern characteristic of mature bone and polarized light demonstrated a woven bone pattern characteristic of immature or new bone (Fig. 6). In addition, fractional analysis of the polarized light specimens demonstrated fractal patterns suggestive of woven bone modeling.

**Alveolar Bone Modeling with a Fixed, Continuous-Arch Appliance**

In recent years, fixed, passive self-ligating (PSL) appliances have been developed along with low-friction/low-force, continuous-arch protocols for orthodontic treatment. Dr. Hesham Badawi has reported evidence with his OSM apparatus supporting the ability of passive self-ligating brackets to deliver lower magnitude forces compared with elastomeric ligated appliances applied to the same malocclusion in an in vitro model (Fig. 7). Evidence has also been reported supporting the ability of passive self-ligating brackets to achieve a reduction in the frictional resistance to sliding at the bracket/wire interface. The resultant load applied to the teeth and transmitted to the alveolar bone lessens decreases as the frictional resistance to sliding and the force required to overcome it decreases. Clinical evidence has been reported demonstrating significant widening of the dental arches following treatment with the low friction/low-force Damon System. An increase in the transverse dimension of the alveolar bone has also been reported in response to the low, biomechanical load delivered by this treatment regimen.

The following case reports provide examples of the alveolar bone modeling the authors have observed over a combined 28 years of experience utilizing the Damon passive self-ligating fixed appliance and treatment protocols advocated by Dr. Dwight Damon.

**Discussion**

The case reports presented demonstrate examples of the change
in the size and shape of the maxillary and mandibular alveolar bone observed in adolescent, adult and children treated with a passive self-ligating, continuous arch appliance and Damon low friction/low-force treatment protocols. Specifically, the increase in the transverse dimension of the alveolus appears to be the result of lateral translation of the buccal and lingual cortical plates induced by the biomechanical load applied to the teeth and transmitted to the alveolar bone. These cases provide additional clinical evidence for the ability of the alveolar bone to undergo biomechanical load-induced modeling.

As Frankel had done previously with his Function Regulator appliance, Damon has proposed a mechanism of action for the dentoalveolar response to his treatment regimen based on clinical observations and analysis of photographs, plaster study model measurements and medical CT surveys of treated cases, he suggests that the light, continuous force delivered by his treatment approach disrupts the equilibrium of the tooth positions maintained by the inner and outer oral musculature acting on the vermiform alveolus. When the anterior component of the force acting along the continuous archwire is kept low, it is mitigated by the resting pressure of the lips in patients with adequate circumoral muscle tone. The posterior component of force is likewise resisted by multirotted molars along with the ascending rami in the mandible and the tuberosity in the maxilla. A resultant lateral component of force is expressed and transmitted from the teeth to the alveolar bone, inducing bone modeling or posterior arch adaptation as he describes it.

The CBCT findings of Radawi support Damon’s proposed mechanism of action, specifically the assertion of a lower anterior vector of force delivered with a passive self-ligating appliance compared with an stainless-steel ligated appliance applied to the same simulated malocclusion. In addition, there is a cellular mechanism of action that supports alveolar bone modeling induced by tooth displacement. Figure 8 from Graber describes bone modeling occurring in the periodontal ligament and on the peripheral surface resulting from net apposition of bone in the direction of the line of applied force and net resorption of bone away from the direction of force. Furthermore, this ability to move bone with a light, continuous load applied to the teeth has been corroborated in the sagittal dimension by Melvin’s Functional Matrix Theory and the case reports above.

In addition, future CBCT analysis should consider the voxel size and resolution of the machines used in making alveolar bone determinations as well as the time period in which the post-treatment assessments are undertaken to allow adequate time for completion of secondary mineralization. This article presents case reports demonstrating a change in the size and shape of the alveolar bone in child, adolescent and adult patients treated by a continuous arch, self-ligating appliance. These cases, along with a growing body of evidence, challenge the immutability of the alveolar bone and the axiom of treatment response to low-friction, low-force treatment approaches. Rigorous investigation should incorporate case selection criteria that include subjects with adequate circumoral muscle tone as well as close adherence to the established treatment protocols as described in the case reports above.

Furthermore, alveolar bone modeling is a practical treatment objective.
that can decrease the need for more invasive approaches in appropriately selected and appropriately treated patients.

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Virtual reality and orthodontics: A new patient experience

By Yasmine Harichane, Canada

Imagine the following scenario: your patient arrives, both relaxed and calm, at your practice. Although the patient is visiting the practice for the first time, he is familiar with it and knows its interior well. Without fur-
ther introduction, the patient takes a seat in the dental chair, and the orthodontic procedure is performed quickly and comfortably with pa-
tient compliance. There are no compli-
cations or tension, and the treat-
ment is easily achieved. Imagine such a soothing and comfortable en-
vironment in which to treat patients.

Now imagine this very same scenar-
io through the eyes of the patient. One can see that it could actually be a comfortable experience.

This is not some hypothetical futur-
istic utopia, this is actually happen-
ing now, and the aforementioned points are some of the many benefits of virtual reality (VR). VR is a process that entails immersing the viewer in a 360° environment. The spectator could be immersed in the Caribbean Sea surrounded by corals or in a Ca-
nadian forest (Fig. 1). The operation is simple: the participant wears a light-
weight and comfortable headset in which a smartphone is inserted (Fig. 2). Owing to the gyrosopic sen-
sors, the smartphone will project a matching image corresponding to the movements. If the patient raises his head, he will see the sky or the ceiling, and if he lowers his head he

Figure 8. Orthodontic bone modeling, or sitespecific formation and resorption, oc-
curs along the periodontal ligament and periosteal surfaces.

Illustration from Orthodontic Current Principles and Techniques, Graber, Va-

Editorial note: The full reference list is available from the publisher.

Featured Article from Clinical Impres-

Orthodontics, for his assistance with

more information

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ORTHOTRIBUNE

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Convincing the patient to undertake an orthodontic treatment is one thing, convincing him to follow the relevant recommendations is another. Obtaining patient compliance is not easy, especially in the case of younger patients. Furthermore, dentists have an unfortunate notorious association with pain and suffering, which might induce anxiety in a patient. Again, VR can be applied here to divert the attention of the most dynamic patients. Another aspect worthwhile of mention regarding the benefits is the intellectual retention of instructions on hygiene procedures, for example, which might be dependent on support. It is plausible to assume that verbal instructions on hygiene may be forgotten once the patient has left the clinic. Most orthodontic procedures provide only leaflets, but few patients retain these or follow their recommendations. A VR video featuring the practitioner or team members might have a much greater impact on follow-up care at home. The message could be pre-recorded and viewed on demand by the patient. The aims of this format is that it can provide different intellectual integration between information, which is connected to a stream of visual and auditory stimuli. The clinician might wish to promote the patient retaining the provided information in an easier way to achieve greater clinical success. For example, youngsters might remember their favourite movie line by heart, as opposed to information provided by their dentist. This is because it demands less of youngsters to remember words that are connected with pictures.

For the health practitioner, VR may yield an unexpected, but welcome, advantage in terms of professional education (Fig. 6). Many of us have not been able to attend a conference on the other side of the world for logistical reasons. In the near future, it will be possible to attend an orthodontic congress and listen to international speakers while sitting comfortably at home. Similarly, the demonstration of a new therapeutic technique will be easier with a VR video rather than plunging into a detailed explanation in an article without any illustration. The trainer can record his or her procedures with a 360° camera to allow the student to learn through immersion the technical movements and ergonomics of the technique being taught.

It would be an understatement to claim that VR provides an alternative to conventional styles of learning. Although it is far from perfect, it allows a wider spread of knowledge and a totally immersive pedagogy. VR is changing the way we work, learn, and treat our patients. We have seen over time an evolution of orthodontic care by improving patient comfort. We are not just dealing with a set of teeth fixed into a bone mass appended to a skull, but with a person whose positive experience will inevitably lead to clinical success. Similarly, orthodontic education has evolved over time, since the transmission of knowledge is no longer done with a Kodak Carousel slide projector, but with sophisticated presentation software, incorporating photographs and clinical videos. VR is paving the way to a higher degree of evolution regarding how to understand our environment, whether it is an environment of care or work. As with tourism or cinema, VR offers many opportunities in the field of health. Orthodontics is entering into a 360° revolution focused on the patient experience.

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