My complete conversion - 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 I had progressed through all aspects of digital technology as it relates to orthodontic treatment and I had completed a circle (Fig. 1).

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Fig. 1

The Scope of Digital Technology in Orthodontics

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. Some, like 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.

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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.

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By Thomas W. Baron & 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 can only be observed histologically or by chemical assay of biomarkers. Modeling is a change in the size and shape of a 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 the existing dentoalveolar 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. It is necessary to redefine 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 socket of the teeth (Fig. 1). 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 biomechanically. The cellular response of the PDL to orthodontic force has been well characterized on both the pressure and tension sides of the bony socket surrounding the root as the tooth and its periodontal ligament. Alveolar bone remodeling is translated through the thickness of bone confined by the buccal and lingual cortical plates. Until recently, modeling—or changing the size and shape of the developed alveolus by translating the cortical plate—was not deemed possible with fixed orthodontic appliances, and consequently, has not undergone rigorous study. The critical questions that must be answered to challenge alveolar bone immutability and foster an acceptance of treatment modalities that are not confined to the existing size and shape of the alveolus are:

1. Is the alveolus, confined by the buccal and lingual cortical plates, immovable or is there evidence that it can undergo remodeling?
2. If it can undergo remodeling, under what conditions can it occur?
3. Can fixed, continuous-arch orthodontic appliances induce alveolar bone modeling?
4. Is there a cellular mechanism of action that can explain orthodontically induced alveolar bone modeling?

**Myno-PerioStelic Induction of Alveolar Bone Modeling**

Dr. Rolf Frankel described the transverse alveolar modeling observed in patients treated with his Functional Regulator appliance (Fig. 2). He reported that the increase in the transverse dimension observed in these patients is achieved primarily through the action of the bucal shears on the appliance. The alveolar shields disrupt the equilibrium of forces acting on the dentoskeletal axis by the pressure of the buccal muscularis 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 extending into the vestibule exert a constant outward pull on the connective tissue fibers and muscle attachments that is transmitted to the alveolar bone by the fibers of the periosteum. Apposition of buccal bone aids in the lateral movement of the dentoskeletal axis. The ability of periodontal tissue to induce apposition of bone on the lateral alveolus has been demonstrated in the animal studies of Altman and Harvold in addition, a study by Breiden, 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 alveolus 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.

**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 disruptions of the maxillary sinus.

**Figure 3.** The typical transverse alveolar modeling observed in response to treatment with the Frankel Function Regulator. Pretreatment study model shown on the left and posttreatment on the right, size-corrected and marked for transverse development.
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 have 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 pathologically 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 distalize 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).

Fontenelle reported alveolar bone modeling with a passive/active disassociation 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, constantforce 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 in permanent dentition 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. 5a). An internal control specimen was taken from interspacing the ipsilateral mandibular first bicuspid and canine (Fig. 5b). Standard hematoxylin and eosin-stained sections were examined with and without polarized light and a histometric specimen was subjected to fractional analysis. The histometric 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 specimen 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. Hisham Badawi has reported evidence with his OSM aparatrustic support demonstrating the ability of passive self-ligating brackets to deliver lower magnitude forces compared with elastomeric ligated appliances applied to the same maxillary arch (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 essentially 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, continuousarch 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 dentiosealular 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 alveolar bone and dentition. When the anterior component of the force acting along the continuous archwire is kept low, it is mitigated by the restoring pressure of the lingual in patients with adequate circumoral muscle tone. The posterior component of force is likewise resisted by multi-rooted 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 OSQ 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 elastomeric-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 peritensal surfaces resulting from net apposition of bone in the direction of the line of 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 Melsen and Allais. Despite the evidence presented in this article, there remains considerable debate regarding the immutability of the alveolar bone and the treatment response to low-friction/low-force passive self-ligating appliances. Rigorous investigation should be undertaken to validate and understand these clinical observations.

Future clinical investigations 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.

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 posttreatment assessments are undertaken to allow adequate time for completion of secondary mineralization.

CASE STUDY 2
PERIODONTOSE ALVEOLAR MODELING:
Pre-Posttreatment Comparison Demonstrates Alveolar Modeling

Pretreatment

Diagnosis

An 11.5-year-old female patient presented with a Class I jaw relationship and severe tooth size/arch length discrepancies with 9 mm of crowding in the maxillary arch and 15 mm of crowding in the mandibular arch. Her mandibular incisors were upright at 89° to the mandibular plane and exhibited normal circumoral muscle tone and competent lips. Her parents wanted to attempt a nonextraction treatment plan. Informed consent was obtained and a therapeutic diagnosis was initiated with a measurement planned for approximately 6 to 9 months to determine if the nonextraction attempt could continue or if extraction would be required.

Treatment Summary

Damon protocols were employed with initial 0.045” Copper-Ni-Ti wires and NiTi open-coil springs activated one-half of a bracket width to begin to create space for the unbracketed blocked-out teeth. Eyedl attachment were placed on the lingually blocked-out teeth and lightly ligated to the coil springs with enough force to minimally deflect the archwire. Since the alignment at the 10-week appointment was deemed insufficient to engage a larger wire and comfortably close the bracket slot, the initial wires were inspected for deformation and replaced. The springs were then reactivated, the blocked-out teeth religated, and the patient remounted for 8 weeks.

Although in significantly crowded cases the transitional wire is typically a 0.045” Copper-Ni-Ti wire engaged in preparation for a 0.045” x 0.025” Copper-Ni-Ti wire, at the eighth week bracket alignment was again deemed insufficient for rectangular wire engagement so a 0.045” Copper-Ni-Ti wire was placed, the springs were reactivated and the blocked-out teeth religated. At subsequent appointments as space was created, initially blocked-out teeth were bracketed and engaged with 0.045” Copper-Ni-Ti wires. At 8.5 months, the decision was made to continue with the nonextraction treatment plan. This severely crowded case did not progress beyond the 0.045” Copper-Ni-Ti wires until 12 months into treatment.

Results

The final result was obtained after 23 months of treatment. Retention included bonded lingual wire retainers and clear, vacuum-formed Essix-style removable retainers to be worn while sleeping. Sizecorrected lower occlusal photographs taken at initial bonding and debonding illustrate the change in the size and shape of the mandibular alveolus induced by passive self-ligation treatment. By the three-year posttreatment follow up appointment, teeth #8 and #9 had been crowned and the bonded maxillary lingual wire had been removed. The patient reported infrequent removable retainer wear and the alveolar modeling obtained had remained remarkably stable.

Conclusions

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 axioms of treatment to the existing arch form. It is the authors’ considered opinion that Mehunussoss’s Functional Matrix Theory is correct and the change in alveolar form induced by this low-friction, low-force treatment approach provides an opportunity to recapture the full genetic potential of the patient’s alveolus.

Furthermore, alveolar bone modeling is a practical treatment objective.

PERIODONTOSE ALVEOLAR MODELING:
Pre-/Posttreatment Comparison Demonstrates Alveolar Modeling

PRETREATMENT

POSTTREATMENT

3 YEARS POSTTREATMENT

ORHTO TRIBUNE

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Virtual reality and orthodontics: A New patient experience

Imagining 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 further introduction, the patient takes a seat in the dental chair, and the orthodontic procedure is performed quickly and comfortably with patient compliance. There are no complications or tension, and the treatment is easily achieved. Imagine such a soothing and comfortable environment in which to treat patients. Now imagine this very same scenario through the eyes of the patient. One can see that it could actually be a comfortable experience.

This is not some hypothetical futuristic utopia, this is actually happening 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. By turning his head left, right, up, or down, the patient can visualise the real or an artificial environment. The spectator could be immersed in the Caribbean Sea surrounded by corals or in a Canadian forest (Fig. 1). The operation is simple: the participant wears a lightweight and comfortable headset in which a smartphone is inserted (Fig. 2). Owing to the gyroscopic sensors, 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 will see his feet. This technique is made possible by a 360° shot using a dedicated camera (Fig. 3) and simple editing software (Fig. 4). The result is simply astonishing as we find ourselves projected into a place that may vary from virtual tourist sites to virtual scenarios as in video games. The applications in orthodontics are numerous and at present we are exploiting only a tiny part of its potential functions. The possibilities might be endless. Hence, it might become possible for the patient to visit the dental office from his horse, where he can visualise the front desk, admire the treatment rooms or view the cleanliness of the sterilisation area (Fig. 5). The aim is to offer a virtual visit of the practice to allow the patient to choose a quality clinic, as well as familiarise himself with the space before his first appointment. Once physically seated in the chair, the patient can wear the VR headset during the treatment and visualise a restful environment of his choosing. From here on, it is solely a matter of preference as the patient might enjoy the beach, a VR video of Honolulu, or maybe even climbing a mountain. Any VR video is acceptable, as long as it achieves its purpose: calming the patient during a treatment session. Thus, everything becomes less tense, and the patient is relaxed. This might also be convenient for the dentist, as he can then execute whatever treatment is necessary as quickly and efficiently as possible.

Figure 8. Orthodontic bone modeling, or specific formation and reposition, occurs along the periodental ligament and periosteal surfaces.
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 worthy 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 practices 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 a favorite 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 plugging 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 the past few years 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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Dr Yassine Harichane
Graduated from Paris Descartes University in France and completed his MSc and PhD on dental pulp stem cells. He maintains a private practice in Canada and can be contacted at yassine.harichane@gmail.com