

# **Corticotomy and Tissue Engineering for Orthodontists: A Critical History and Commentary**

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## ***Seminars in Orthodontics***

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## **I. Introduction**

Twenty-first century discoveries in cellular and molecular biology have explained how clinicians in medicine and dentistry can engineer tissue regeneration with more precision than ever before. This field can also include orthodontists if they are willing to define themselves as dentoalveolar orthopedists by coordinating minor alveolar surgery with orthodontic tooth movement (OTM) and deliver force vectors appropriate for specific alveolus forms. This can be achieved if the orthodontist can modulate physiologic internal strains -- similar to those of distraction osteogenesis in long bones -- which supplement the work of the scalpel, bone grafts and growth factors. Tissue regeneration alone only reestablishes original form (phenotype). As Wilcko et.al.<sup>1</sup> have amply demonstrated for over a decade, the orthodontist can use internal bone strain to engineer a completely different and more stable phenotype.

The aim of this treatise, using critical rationalism and analytical commentary, is to chronicle the historical techniques which have evolved into orthodontic tissue engineering (OTE) (Murphy, 2006).-The methods employ the redoubtable theories of emerging biology without changing traditional biomechanics. Specifically, this includes selective alveolar decortication (SAD), (periodontally) accelerated osteogenic orthodontics (PAOO/AOO)\*, stem cell therapy (SCT) and, recently, the promise of out-patient gene therapy (OGT) which will be discussed in a future treatise.

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\* For the sake of patient safety and intellectual integrity, both accelerated osteogenic orthodontic (AOO) and periodontally accelerated osteogenic orthodontics (PAOO) are trademarked by Wilckodontics, Inc. Erie, PA USA. The acronym PAOO is generally used when AOO candidates present periodontal issues.

Concepts implicit in this summary, are discussed elsewhere<sup>2-5</sup> and lie beyond the scope of this critical review. Nonetheless some brief discussion of “bone bending” is important to show how robust concepts can languish beyond the fashions of contemporary professional culture the re-emerge in an entirely new context.

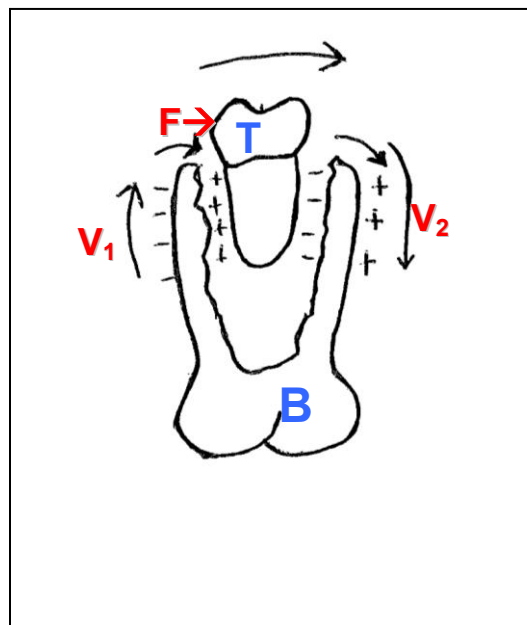
Considering the periodontal ligament, as a complex, anisotropic visco-elastic gel, it receives complex fields of tensional strain with OTM and does not always exhibit distinct “pressure” or “tension” sides of the classic periodontal ligament model of Oppenheim (1901).<sup>6</sup> The alveolus organ, seen as a whole bone, can be bent and the study of that perspective must go beyond the ligament. Interestingly, the concept of bending bone is not new. Dr. John Nutting Farrer (1839-1913), wrote

Teeth will move in any direction by force continuously maintained, as frequently repeated for a sufficient length of time. The first aim in any operation for the movement of a tooth is to cause slight looseness by more or less decalcification its socket tissues, a condition that results from pressure of the teeth upon these tissues. The softening of the socket breaks the fixedness or rigidity of the tooth leaving it comparatively easy to move, either by resorption of the tissues or by bending of the alveolar process or both (Farrer, 1888) (Emphasis added)

Technically, when bone is bent, the internal bone strain elicited by alveolar orthopedic forces during wound healing recapitulates regional ontogeny as stem cells receive signals to differentiate into osteoblasts and subperiosteal appositional bone growth follows the functional matrix of the teeth roots. What is new in OTE, is not the fact that bone is “bent” but rather the combination of bone bending conjoined simultaneously within the healing wound of a minor\* outpatient surgery.

There is also compelling evidence that the treatment protocols of Williams<sup>7</sup> and Damon<sup>8</sup> do the same thing non-surgically over a longer period of time. If this be true, then surgical alteration of alveolus bony form is simply an acceleration of a natural process.

Looking beyond the ligament at the labial and lingual alveolar cortices and endosteal surfaces (Figure 1), any applied orthodontic force (**F**) applied to a tooth (**T**) bends alveolar bone (eliciting resultant shear vectors, **V<sub>1</sub>** and **V<sub>2</sub>**) and creates *shear* tensional strain (-) and shear compression strain (+) respectively. This induced physical disequilibrium persists until the bone remodels (i.e. models) to a point of architectural and biochemical homeostasis, so-called “steady state” bone. The subperiosteal/endosteal convex and concave surfaces exhibit respectively (as they do in long bones) compensatory bone resorption (- sign) and osteogenesis (+ sign). This term “subperiosteal compensatory appositional osteogenesis\* is what periodontists commonly call “buttressing bone” from occlusal trauma. The PDL and cribriform plate therefore can be considered as a kind of specialized long bone (**B**) endosteal homologue.



Source: UniversityExperts.com

Figure 1

\*Professor James Burch,, NOVA Southeastern University, Fort Lauderdale, Florida, USA.

Figure 1 reconciles the ostensible intellectual conflict between medical orthopedic theory and traditional dental/orthodontic theory. The former preaches that “pressure induces osteogenesis” and the latter posits that pressure induces bone resorption. Both are correct in the reconciliation schematic of Figure 1 and dispenses with the traditional but myopic “pressure-tension hypothesis of Sandstedt (1901), a concept popularized by Oppenheim popularized in 1911 and perpetuated in dental literature for a century. This original model presupposes a isotropic mechanical *milieu* for the root when, in fact, the periodontal ligament is a anisotropic viscoelastic gel dissipating pressures and tensions in complex vector flux through time. SFOT simply allows this reconciled model of histophysiologies to manifest more rapidly with minor surgery\* selective alveolar decortication (SAD) and adds mass with PAOO/AOO.

## **II. Surgically Facilitated Orthodontic Therapy (SFOT)**

Surgically Facilitated Orthodontic Therapy (SFOT) is a 100 year-old idea first proposed by Cunningham<sup>9</sup> that has evoked a progression of surgical refinements designed to (a) accelerate orthodontic tooth movement, (b) limit the quantity and pathologic potential of the inevitable bacterial load, (c) enhance stability, and (d) reduce the morbidity of orthognathic alternatives. After intermittent studies, an influential resurrection of the technique published in 1991 by Suya<sup>10</sup> who used the unfortunately vague term, “corticotomy” instead of the more precise selective alveolar decortication (SAD). His techniques was ingeniously embellished by Professors Wilcko with grafting demineralized bone matrix (DBM)\*\* and was rigorously tested in both clinical and

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\* The depth of surgical intervention is rarely greater than 2-3 mm beyond the surface of the alveolus bone.

\*\* AKA demineralized freeze-dried bone allograft (DFDBA)

experimental studies reviewed below. Various theories to explain the biologic mechanisms were developed from existing ligamentous models, (Kokich<sup>11</sup> and novel syntheses of 21<sup>st</sup> century biology<sup>2,4</sup> medical orthopedics<sup>12-14</sup> and molecular biology.<sup>15, 16</sup> SFOT is a general term which includes a broad range of clinical strategies that use orthodontic force application on a healing wound. But this range does not include traditional segmental osteotomies that mobilize or luxate sections of bone and teeth; that is a very risky 19<sup>th</sup> and 20<sup>th</sup> century misinterpretation. Twenty-first century SFOT demands a synthesis of bone physiology and healing dynamics to earn the rubric “orthodontic tissue engineering” (OTE).

Many clinicians have published modifications of the refined techniques popularized by Professors Wilckos, seminal work in 2001. But if these modifications do not maintain this central essence, *viz.* intentionally engineering a specific wound phenotype, then these new styles are not SFOT in the modern sense. They merely define minor variations of a basic surgical theme, i.e. surgically “rearranging parts”, like orthognathic surgery or architectural renovation. Thus, the challenge for the individual practitioner is to select that comfortable place where he or she can clearly distinguish between a traditional manipulation of parts and modulation of genetic expression in wound healing physiology. The former is “OldThink”; the latter is “NewThink”.

Changing ones perceptions and modernizing identity is not always pleasant or easy (see: Kuhn, T. in Selected Readings); OTE demands disciplined scholarship in postmodern biology. It is important however because, collectively, the choice to change will define a new face for both patients and the specialty. That will be evident when, through a method of critical rationalism, analytical commentary on the classical historical

(Hegelian) dialectic. This takes us from the mechanical arts of the 1900's to the very edge of genetic engineering for the 21<sup>st</sup> Century Orthodontist.

### **III. Salient Modern Literature (1894-1959)**

Ironically, the original presentations of SFOT in America at the end of the 19<sup>th</sup> century<sup>9</sup> languished in journals and were not widely discussed for over half a century. However, in Europe the concepts blossomed. In 1921, Cohn-Stock<sup>17</sup> citing "Angle's method," removed the palatal bone near the maxillary teeth to facilitate retrusion of single or multiple teeth. Just before World War II, Bichlmayr<sup>18</sup> described a corticotomy for patients older than 16 years, to accelerate tooth movement and reduce relapse for maxillary protrusion. This was employed with canine retraction after first bicuspid extraction, by excising the buccal and lingual cortical plates at the extraction site.

While this procedure seemed bold to many American orthodontists, it became popular in the German scientific community. Skogborg<sup>19</sup> divided the interdental bone, with a procedure he called "septotomy," and later Ascher<sup>20</sup> published a similar procedure, claiming that it reduced treatment duration by 20-25%. These procedures were combined with Bichlmayr's procedure by Neuman<sup>21</sup> He divided the inter-radicular bone and ablated a wedge of bone palatal to the incisors meant to be retracted.

The seminal American work, published by Köle<sup>22</sup> summarized a decortication of the dentoalveolar process to facilitate OTM. With some notable refinements, this is the basic technique that is employed today by those who promote the integration of orthodontic therapy and periodontal surgery. The Kole surgery was limited to the cortex of the dental alveolus, but subapical decortication was embellished by extending buccal and lingual cortical plate incisions until they communicated through the subapical spongiosa. Bucco-

lingual communication is now considered unnecessarily morbid and eschewed by SAD and PAOO/AOO protocols.

#### **IV. The Post Modern Perspectives (1959-2000)**

As we will see, the literature in the latter half of the 20<sup>th</sup> century seems to miss the central purpose of SFOT, SAD and PAOO/AOO *viz.* to engineer alternative healing physiology, genetic expression and ultimately a novel alveolus phenotype. This bias and the lack of postmodern biological standards is the reason why the literature of this period is merely anecdotal, dismissive and often incorrect. Yet, ironically, this body of data is still used to justify criticisms of 21 century dentoalveolar surgery. Kretz<sup>23</sup> described a procedure similar to Cunningham's, creating, in effect, a therapeutic fracture of the anterior alveolus. His aggressive manipulation of bone contrasts sharply with modern SAD, a more conservative decortication designed for a proportionate response and a method which proscribes against any aggressive bone manipulation that might compromise vasculature. The reader of these articles is struck by the preoccupation with mechanical concepts (a kind of "Newtonian bias" that eclipses any appreciation of how physiologic alterations may be modulated.

The naiveté of the surgeons is evident in Reichenbach's contributions<sup>24</sup> and especially his admonition about the risk of periodontal pocket formation or alveolar necrosis with this peri-orthodontic surgery. The former is doubtful to those who understand the pathogenesis of periodontitis; the latter is a wise admonition indeed, where overly aggressive osteotomies are combined with alveolar decortication and injudicious flap reflection. The techniques which Reichenbach employed were closer to



luxated osteotomies than discrete SAD and the rationales should not be conflated under the rubric of OTE.

Unfortunately, without an empirical basis of prior controlled clinical studies, laboratory data, or conceptual sophistication (epigenetics) available, Reichenbach's misapprehensions were perpetuated by Bell and Levy in 1972.<sup>25</sup> They studied "corticotomy" techniques in *Macaca mulatta*, with a lack of specific details combined with disparaging, but undocumented observations. They noted that it "had a destructive effect on maxillary incisors "but failed to elaborate specifically. Going further, they said that "...intraosseous and intrapulpal circulation also appeared to be imperiled" but did not follow patients long enough to distinguish between transient healing events and permanent undesirable sequella. Because they did not document permanent damage and, since ischemia or any kind of normal healing can be seen as temporarily "destructive," it appears that the authors committed a logical error common to many clinical investigators. They pathologized normal variations. Wherever this error is committed it overstates authors' cases and undermines their credibility. The wise writer knows that very few universals can be legitimately defended in clinical biology.

Their criticism is further unfair, because they had not replicated the Köle protocol exactly. Moreover, Bell and Levy luxated the operated tooth-bone segments with a chisel, a procedure which even they admit may have been a more proximate cause of the ischemia. We, on the other hand, reiterate, in full concert with the Wilcko-Ferguson collaborators, that *absolutely no luxation* of the bone should be attempted. Luxation of the tooth-bone segment suggests an invalid mechanical misapprehension and overlooks the critical biology of selective decortication, viz. alteration of the bone *physiology*, not the mere rearranging of surgical anatomical parts.

Later, Düker<sup>26</sup> replicated Köle's work more exactly, in dogs, moved an incisor segment 4 mm in 8-20 days and concluded that neither the periodontal attachment nor the pulps of teeth demonstrated significant injury. In fact, he stated correctly but vaguely that,

“...*weakening* (emphasis added) in the bone by surgery and consequent orthodontic treatment reduces these dangers.” (Emphasis added)

The authors seem to have grasped the central concept of SFOT but expressed the rationale too ineloquently for immediate implementation. This limited scope still haunts the literature today since many commentators, often uninitiated, feel a surgically induced and transient osteopenia (regional acceleratory phenomenon or “RAP”) is too transient for practical use. This myopic perspective misapprehends the central mission of SFOT, i.e. to induce constant internal bone strain by judicious tooth movement which can *perpetuate* the osteopenia state.

In 1976, Merrill and Pedersen<sup>27</sup> investigated SFOT further for “immediate repositioning” of “dental-osseous elements.” Ironically, after claiming to document the safety of the osteotomy and immediate repositioning of the dentoalveolar complex, the authors said that some unspecified complications had occurred, but were not sufficient to condemn the procedures. Based on our experience these complications may well have been papillary slough, clinically insignificant but cosmetically embarrassing ecchymosis or pain, all the hallmark of limited experience and naïve clinical management. Even more controversially, they stated that a corticotomy (a less morbid surgical manipulation) “...has not proved to be a successful method...in our hands...,” adding that “...resistance by cortical bone has little to do with the reaction of teeth to force...” and “...little if any time is saved when classical corticotomy is used...” This last quote stands in sharp

contrast to recent controlled studies, by orthodontists and periodontists, which have demonstrated stunning efficacy, comfort and safety with SAAD, AOO an PAOO.

Conceptually, the most common cause of this flagrantly unsubstantiated statement is a failure to understand the malleability of alveolus, its conflation with basal bone, or a failure to recognize that the spongiosa must be constantly stressed with bi-weekly clinical adjustments. Interestingly, even the last complication the authors mention, (often due to poor patient compliance) can be reversed with periodic and benign transmucosal perforation (TMP) of the alveolus with an irrigated high-speed bur.

Even though, Merrill and Pedersen offer no one-to-one comparisons or quantitative data to substantiate their claim, relying solely on the disclaimer that results were limited "...in our hands....", they suggested a meaningful alternative. They posit that two surgeries could be performed sequentially, first on the buccal aspect and then on the lingual side of the alveolus, which would provide collateral circulation for each surgery. A vascular anastomosis was proposed as the theoretical connection from the contra- lateral mucoperiosteal tissue which was not reflected. They also suggested that Mehnert's<sup>28</sup> 0.25 mm thin blade is preferred to a Stryker saw (0.80 mm), if safety for the adjacent roots is considered. We propose that a high-speed irrigated bur is the instrument of choice for is precision and control.

In their defense, SAD limited to the labial alveolar cortex is a reasonable variant where the surgeon may wish to facilitate simple labial movement and wants to maintain a copious blood supply form the lingual aspect. Bear in mind however that the facilitating osteopenia is commensurate with the degree of therapeutic surgical "trauma" to the alveolus and reflection of lingual mucoperiosteal flaps for labial movement may also contribute to greater stability by producing a more dissipated therapeutic osteopenia.

Two years later, Generson and Porter<sup>29</sup> applied the decortication concept to the treatment of anterior open bites. They departed from aggressive osteotomies and segment mobilization explicitly, stating that "...the surgery was done from both the labial and lingual approaches... the bony cuts are made through the cortex ...marrow was able to maintain viability of the osseous segments. " They cite stability and speed as advantages to their technique, and emphasized full thickness (mucoperiosteal) flaps, resecting the neurovascular bundle of the incisive canal. They initiated orthodontic force 3 days after surgery. This is significant because Wilcko generally recommend a two-week hiatus between surgery and the initiation of tooth movement. In contrast, the senior author has been initiating tooth movement with fixed brackets and a 0.018 or 0.016 nickel-titanium archwire immediately after tying the last suture.

In 1985, Mostafa et. al.<sup>30</sup> diagrammed a surgical-orthodontic technique to treat over-erupted maxillary molars. It was a Köle-like decortication localized to the alveolus of one tooth, an extruded molar. They reported a survey of 15 patients, noting that only the cortex was incised with a surgical bur and osteotome. No indication was made if the surgery was done on the palatal aspect as well as the diagrammed buccal procedure. Further, no statistical analysis or even photographs were presented. So their data must be somewhat dismissed as too anecdotal. It was noteworthy, however, that the authors found a single tooth procedure helpful. As discussed below, the same issue was debated between Kim et.al.<sup>31</sup> and Murphy<sup>32</sup>, as late as 2010.

Goldson and Reck<sup>33</sup> reported a similar surgical-orthodontic treatment of malpositioned cuspids just two years later. They reported on the use of a bur and osteotome, combination to completely separate the dentoalveolar segment through both the buccal cortex and medullary bone. A blood supply from the collateral sources in the adjacent

mucoperiosteum was apparently sufficient for this procedure which went deeper than today's SAD. This procedure is not as conservative as modern SAD and perhaps presents unnecessary risk of vascular compromise. Although one needs to induce a thorough osteopenia, there are reasonable limits. For example, osteopenia is necessary only within 2-3 mm of the teeth to be moved. Keeping many other areas of the dentition un-operated with SAD provides a relative anchorage module.

Suya<sup>10</sup> revived academic interest in Asia<sup>34-36</sup> and America with a report on "corticotomy-facilitated orthodontics" by reporting his experiences in over 300 patients. He did not connect the buccal and labial incisions, like Kole, but relied on linear interproximal decortication. The style of decortication, divots, lines or other patterns is irrelevant. Only the sum total of therapeutic trauma is significant. It should be noted that the particular pattern of decortication, for example, divots, lines pints or other patterns, is irrelevant. Only the sum total of all therapeutic "trauma" (stimuli) is significant in its inducement of osteopenia. Suya's refinement of Kole's methods has essentially set the standard for decortication procedures that followed in the Modern era. Only the Wilcko-Ferguson collaboration, in the post modern era, exceeded Suya's influence.

Following communications with prior visionaries of the 1980's, periodontists and orthodontists collaborated in the first major university studies of the phenomenon at Loma Linda University in 1986.<sup>37-40</sup> Anholm et. al.<sup>41</sup> reported corticotomy facilitated treatment of a male patient but was sobered by minor attachment loss. This will sometimes occur if the periodontal (mucoperiosteal) flap is reflected for too long and thus dehydrated. Another source of error is the failure to completely debride the surgical site of infective detritus. The surgery should be "swift, sure and clean".

The issues of root resorption were brought up again by Gantes et al.<sup>42</sup> in 1990. They treated 5 patients, 21-32 years old, with Suya's protocol and removal of cortices adjacent to an extraction site. They observed accelerated TM, some mild root resorption, but no loss of root vitality. The issue of root resorption was subsequently dismissed as later controlled university studies finally revealed that SAD and PAOO/AOO, done correctly, indeed produced *less* root resorption than conventional non-surgical protocols. This is understandable due to the nature of a regional osteopenia. In a phrase OTE exploits all the benefits of the natural healing dynamic.

#### **V. The New Millennials (2000-2011)**

By the year 2000, collaboration between Professors Wilcko, Wilcko and Ferguson of Case Western Reserve University, St. Louis and Boston Universities,<sup>43-58</sup> resulted in significant documentation of the SAD efficacy. They resolved once and for all much of the contention among the earlier clinicians by subjecting SAD and PAOO to meticulous analysis and rigorous standards of evidence-based science. This is important because it positioned SFOT at the kind of exalted university-level intellectual analysis and controlled experimentation which changes history. The genius of the prodigious contributions of Professors Wilckos and Ferguson contributions cannot be overemphasized. At the time they were unparalleled; through the retrospective lens of history, they will be seen as epochal.

Meanwhile as Professors Wilcko published their work in the United States, Chung et. al.<sup>59</sup> in Asia also reported a decortication-assisted orthodontic method. Also, Hwang and Lee<sup>60</sup> introduced a technique for intrusion of over erupted molars, using a combination of decortication and magnets. Kim and Tae<sup>61</sup> moved teeth facilitated by

decortication, referring again to the phenomenon as “distraction osteogenesis,” and citing it as a “new paradigm in orthodontics.” They removed part of the cortical bone, which resulted in “a speedy rate” compared to “conventional” OTM. They noted that intrusive movements were without side effects, such as root resorption or periodontal breakdown, and considered the procedure was actually clinically superior to conventional methods.

Kim, Park and Tang<sup>63</sup> developed an interesting technique that is often contrasted with flap reflection methods. Although it does not allow the surgeon to visualize periodontal pathosis, and may indeed exacerbate pre-existing lesions, they successfully used a method of transmucosal incision “corticision,” wherein a reinforced scalpel is used as a thin chisel to separate the interproximal cortices trans-mucosally, without a surgical flap reflection. Transmucosal manipulation of alveolar bone minimizes morbidity but may fail to recruit significant RAP, which occurs simply with mucoperiosteal flap reflection as reported by Yaffe in 1974.<sup>64</sup> Nonetheless, used prudently in cases without periodontal problems, the corticision appears to have earned a place in the pantheon of legitimate and meaningful SAD modifications.

Germec, et.al.<sup>65</sup> reported in 2006 what they called a “modified corticotomy,” where they demonstrated a “conservative” technique, to shorten the treatment time during lower incisor retraction. After the extraction of four first premolars with maximum anchorage, a Köle-like corticotomy was employed without lingual cuts. This method dramatically reduced TM time without any adverse effects on the periodontium or the vitality of the teeth. The main advantage of this technique was reduced postoperative morbidity, by eliminating lingual cuts and flap. This is a logical modification, because the surgically induced transient osteopenia (regional acceleratory phenomenon or RAP) of Frost<sup>12</sup> is sufficiently elicited for most kinds of OTM labial movement. Germec’s use of

minimal intervention to achieve a specific clinical objective suggests a keen knowledge of RAP and respect for a discrete surgical technique.

Germec's technique respects the important psychosocial dimension so critical for patient acceptance, by reducing the time in surgery and minimizing discomfort to the patient. However, the potential for the non-operated lingual surface "pull" of gingival and periodontal tissues post-operatively presents a theoretical caveat. A simple circumferential supracrestal fiberotomy (CSF) or transmucosal penetration (TMP) with a high speed irrigated bur may preclude or ameliorate this potential relapse factor if the acceleration of the incisors retraction begins to slow.

Iseri, et.al.<sup>65</sup> may have come closest to reconciling long bone TE with OTE in the alveolus. They reported a new technique of rapid canine retraction through the misnomer "distraction osteogenesis." Their study consisted of 20 maxillary canines in 10 growing or adult subjects. First premolars were extracted and the canines were subjected to retraction therapy in a surgical site using a customized, rigid, tooth-borne retraction device. They moved the cuspids about 0.8 mm per day! The full retraction of the canines was achieved in a mean time of  $10 \pm 2$  days. There was no evidence of root fracture, root resorption, ankylosis, periodontal or soft tissue problems. Patients experienced moderate discomfort but the outcome probably represents the limits in TM speed without frank luxation. While the speed seems rapid to most orthodontists, when the nature of alveolar bone and surgical orthopedics is understood, it is not particularly unusual. What makes this report so notable is that their rate of OTM, 0.8mm/day, approximates the rate of long bone lengthening of 1mm/day.

The increasing popularity of peri-orthodontic surgery caught the attention of academics, who developed many analytic projects. In a classic scholastic manner they



discovered that that selective alveolar decortication (SAD) produced: increased labio-lingual width (increased alveolus bone mass)<sup>43-45</sup> faster OTM<sup>46,47</sup> less root resorption<sup>48,</sup><sup>49</sup> equal or higher quality outcome than the non-surgical techniques of conventional orthodontics during the retention period, even when judged according to the exalted standards of the American Board of Orthodontics (ABO).<sup>50,51</sup>

Concomitant to these studies, Asian clinicians more or less corroborated these observations independently, with clinical and animal model studies by Kim and Tae,<sup>61</sup> but a note was made that some pulpal atrophy and degeneration can occur in the monkey model due to "anemia during operations".<sup>62</sup> The putative and ill-defined "anemia" did not seem to have any clinical significance and probably was simply a normal variant which physiologic healing induced after a traumatic surgery.

Comparing the clinical, anecdotal and controlled studies, it seems that when the technique is well controlled with respect to alveolar bone physiology and orchestrated with appropriate OTM techniques, significant benefits can accrue to patients. The success of these peri-orthodontic surgeries appears to be a function of the technique but is quite surgeon-specific. Clinically, SFOT, SAD and PAOO/AOO work well and are well accepted by a significant cohort of patients. The relative maturity of the literature at this point suggests that future studies should follow the example of Ferguson et.al.<sup>56</sup> in developing pharmacologic adjuncts. This requires a better understanding of the molecular or biochemistry of wound healing in a field of strain. Moreover, it compels orthodontic educators to reconcile the mechanical art to the idealistic demands of post-modern science and the rigorous imperatives of evidence-based clinical practice.

In 2006 the Ferguson group has made great strides in that direction and should inspire others. They characterized the regional acceleratory phenomenon as an increased

anabolic modeling of the alveolus adjacent to the SAD. The amplification of anabolic activity in the rat appears to be increased by 150% at 3 weeks. This increase represents about a 2-3 fold greater anabolic modeling activity in the spongiosa compared to same-animal contra lateral controls. This same year, Sebaoun<sup>57</sup> reported a 200% multiple of spongiosa catabolic activity, and a 400% increase in osteoblastic activity at 3 weeks in the rat model. It was concluded that this effect represents the mechanism explaining the rapid OTM. This emphasis on biochemical ushers into our professional dialogue the concept of pharmaceutical manipulation to elicit so-called “optimal response” to “optimal force”. Yet this concept is controversial among traditional biomechanical artisans.

More germane to the specific protocol of surgical manipulation, where clinicians do not maintain a strict, technique-sensitive Wilcko protocol, one may certainly expect predictably poor results and wide variance in outcomes. This variance and occasional untoward outcomes is the reason that the protocol was trademarked by Wilckodontics, Inc. The trademark can protect patients and doctors from advertised facsimiles which may not work as well as the evidence-based original taught at Case Western Reserve University and at the Wilckodontics proprietary school in Erie, Pennsylvania, USA.

## **VI. Educational Imperatives**

Twentieth Century orthodontists have the option of continuing only the 1901-1911 dogma, but that is fraught with significant risks to clinical identity. The fate of the new generation of orthodontists can lie within a greater vision, one of biological engineering that transcends wire bending. On a practical level, traditional wire bending art, in the age of evidence-based dentistry may fade into an interesting anachronism as straight wire biomechanics becomes commoditized in the hands of non-specialists. Tissue

engineering<sup>14</sup> in contrast, does not lend itself to commoditization. Therefore, new orthodontists, heirs apparent and champions of the specialty have an existential choice upon graduation from their training: to what degree will they become corporate minions, distributing a mere commodity of short order smiles, plebian artisans, or applied tissue engineers, thinking independently for each individual patient.<sup>18</sup>

As history has demonstrated, time carries us to new vistas often only hinted at,<sup>66</sup> Sometimes these vistas are presaged in other specialty literature<sup>67-71</sup>, or in discussions of other subjects<sup>72-74</sup>, or from even non-academic sources.<sup>75</sup> It is only the thorough scholar who will pick up these nuances. Then the future arrives at our doorstep whether we like it or not. The challenge is to separate transient fashion from tidal change.

OTE is not going away; the question is whether OTE will go along with it. Defining new frontiers has always been the credo for the orthodontic specialty but that legacy will endure only by younger generation of orthodontists who wish to supplement the mantle of clinical artist with “surgical dentofacial orthopedics.” This “NewThink”, like the existential choice of personal optimism, can define both the specific nature of each case and the specialty in general.

## **VII. CONCLUSIONS**

This treatise purposely evokes controversial issues in a historical context to give the thoughtful clinician pause for reflection of the dialectic. The dialectical progression, borne of controversy and its consequent explication of important nuance, should continue today and never eschewed. What is heartening to any progressive orthodontist is that the moderate and collegial dissonance can produce evolutionary progress in thought.

Scholastic dissonance is the very heart of scientific progress and inevitably occurs, (even in a salutary way), where dialogue between experienced clinicians and neophytes, academics and private practitioners, pessimists and optimists and certainly between assiduous and passive students produces a meeting of minds. Certainly the assiduous scholar cannot run from scholastic conflict and the conscientious clinicians must endure the caldron of controversy for the sake of his or her patients.

This transcendent biological approach we have reviewed in this paper is not merely a parochial view of rarified academics, but rather a categorical imperative for any learned profession. Freud said it best:

“...there is one feature of culture which characterizes it better than any other...the value it sets upon the higher mental activities— intellectual scientific and aesthetic achievements...”

- S. Freud, Civilization and its Discontents.

The future waits for us to define it. The ultimate unanswered question is: “Will we choose to?” *Quo vadis?*

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