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For a Friend...

Raffaele Schiavoni
Editor-in-Chief

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On November 27th 2011, Tiziano Baccetti passed away. He was "the greatest ambassador that Italy has ever had in the world of orthodontics".
In his honor, the SIDO established the "Lecture in memory of ", an event which happens every two years.
In 2012, Sheldon Peck delivered the first lecture to commemorate his friend, and he did it in very touching words, which we are pleased to repeat on the occasion of the second lecture that will be delivered by McNamara during the 45th International SIDO Congress.

Anyone, like me, who has had the pleasure to meet Tiziano... will agree with these words, which need no further comment...

You will always be in our hearts...

Reflections on the life of Tiziano Baccetti (1966–2011)

Prologue to the 1st Tiziano Baccetti Memorial Lecture, presented at SIDO, 12 October 2012, Florence

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I stand before you with mixed emotions this morning. On the one hand, I am honoured to be part of your educational programme at this 24th SIDO meeting. On the other hand, I am still in shock knowing that dear Tiziano is not here with us today. It's hard to believe that Tiziano Baccetti, who was full of life less than a year ago, teaching us, entertaining us, making us all feel better and become better, is no longer with us, is forever gone (*Fig. 1*).

Tiziano Baccetti was the greatest ambassador that Italy has ever had in the world of orthodontics. He lectured around the world, year after year. Everywhere he spoke, he always started his presentations with this kind of slide: "Firenze the beautiful" (*Fig. 2*). He easily showed his love for his country, his city, his people. His appreciative audiences around the world warmly loved Tiziano back and loved Tiziano's Italy.

First and foremost, Tiziano's greatest love was concentrated on his adored son Vittorio. I remember receiving Tiziano's email announcement two days after Vittorio's birth:

Dear Friends,
on Friday August 6, 2004, at 8.38 a.m., my son Vittorio came to the world. I want to share with you my great happiness. Enjoy his picture at 48 hours of life (Fig. 3).

Tiziano was a fully connected father. He had wonderful role models to follow since he was raised so lovingly by his parents and grandparents. As soon as he could, he taught little Vittorio the joys of sport and of experiencing fun in everything he did. What a remarkable legacy has fallen on the broad shoulders of this smart and handsome boy, the ultimate joy of his father's senses.

Tiziano Baccetti became a master at public presentation early in his acclaimed career. He was a natural at the podium and a marvellously effective speaker in Italian and English, his second language. His elaborate scientific visuals were studiously organized and entertaining to follow. Humour, a prominent thread woven into all aspects of Tiziano's life, was always evident in his engaging lecture style. Tiziano's special charisma and energy endeared him to the huge audiences at his courses and presentations around the world. He made learning fun and memorable, the hallmarks of a gifted teacher.

Figure 1: Tiziano Baccetti, 1966–2011
Reprinted from American Journal of Orthodontics and Dentofacial Orthopedics, Volume 141, Issue 2, McNamara JA, Franchi L, "Tiziano Baccetti, 1966–2011," p. 253, © 2012 The American Association of Orthodontists, with permission from Elsevier.

Early in his professional career, Tiziano Baccetti formed a bond with his classmate Lorenzo Franchi, who also was gifted in solving research problems. He and Lorenzo teamed up to do orthodontically related studies at the University of Florence. A truly complementary lifetime research partnership was born in the early 1990s.

I do not know of another intellectual partnership in the history of orthodontics that has been more productive or more famous than Baccetti and Franchi. They produced together and with others over 250 original important publications! This is simply an amazing output

Figure 2: "Firenze the beautiful." Slide created by Tiziano Baccetti for his worldwide presentations.

for such young scientists. We were blessed to have that "dream team" in orthodontics and are blessed to have Lorenzo carrying forward this scholarly tradition.

Tiziano was unquestionably the rock star of orthodontics, but he was also a down-to-earth friend and teacher. He was an unforgettable mentor to so many students. He gave his all to help them succeed in their projects and careers. Tiziano Baccetti unselfishly stayed long hours in the clinic and lab or on the podium to cater to his growing worldwide fan club.

Let's not forget that Tiziano was the consummate researcher. He spent hours and hours at the computer, interpreting data and radiographs, and coming up with new exciting discoveries. At age 45, Tiziano Baccetti had already achieved worldwide fame in fields he helped create, such as facial growth modification, timing of skeletofacial growth and orthopaedic treatments, and biological associations of dental anomalies. He was a master in the application and broadening of observational science in clinical orthodontics. Tiziano was an adventuresome scientific explorer, a modern-day Columbus, in our orthodontic world.

Then there was Tiziano the perceptive intellectual. He was remarkably broad in his interests and knowledge, utterly encyclopaedic. I remember his wonderfully animated and informed conversations on art, world history and wine. One evening in Boston, we shared a great bottle of red Bordeaux. Tiziano did not want to forget this exceptional wine, so he asked our waiter to wrap the empty bottle for him to take back to Italy. When the waiter offered to peel the label off to save him carrying the bottle, Tiziano replied: "The label alone will not do; only when I see the whole bottle will I be instantly reminded of the special experience of this evening." And I am told that special bottle was proudly displayed in his home.

Tiziano was also the caring humanist, so sensitive to the needs of others. Tiziano knew well how humans work and interact, and he was a marvellous person to work with and be with. He was a man for all seasons and all people.

I propose to you today that Tiziano Baccetti should be remembered as our modern-day Vitruvian man (*Background figure*). Leonardo's masterpiece, created around 1487, is probably a facial self-portrait meant to demonstrate the proportions of a well-shaped male according to the concept of the ancient Roman engineer Vitruvius. But it is more. According to history, the Vitruvian man's outstretched limbs fit within a circle and a square, two shapes that always have had special, symbolic powers. The circle represented the cosmic and the divine; the square represented the earthly and the secular. I think Vitruvian man ably represents much that was great about Tiziano Baccetti: Tiziano's unlimited reach and vision, his Leonardo-like mastery in all his accomplishments, his unique ability to merge verifiable science and art to help us better understand the nature of man. This is Tiziano, reaching out to the perimeter of knowledge – the frontier – discovering, synthesizing, making knowledge relevant to the working clinician. Tiziano Baccetti, our Vitruvian man for all time.

With this heartfelt reminiscence about Tiziano, I humbly and proudly dedicate my lecture this morning to the memory of Tiziano Baccetti, my unforgettable friend and our brilliant contributor, who has fully earned immortality in the minds and hearts of us all.

My presentation is in a field that Tiziano pioneered, a field that he and I discussed often, the field of "associated dental anomalies", which was the subject of his PhD dissertation.

Tiziano, this one is for you

Figure 3: Tiziano's adored son, Vittorio Baccetti, 8 August 2004, 2 days after his birth.

Background figure: Leonardo da Vinci, Vitruvius's Proportions of the Human Body, Venice, Gallerie dell'Accademia, Gabinetto dei disegni e stampe.

This masterful representation of the ideals, reach and vision of mankind fits the great legacy left to us by Tiziano Baccetti.

Image courtesy of Ministero di beni e delle attività culturali e del turismo, Venice

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WHO'S WHO

In this section we introduce an influential orthodontist who has given a significant contribution to the specialty. An article by the author featuring his landmarks follows.

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Rohit Sachdeva

Rohit Sachdeva was born and raised in Kenya, where he received his dental training. He then moved to England, where he served as an orthodontic registrar, and finally to the United States.
He was thrust into academia, the formative stage of his professional career, at an early age. He soon understood that the best way to learn was, and remains, to teach. He had the support and guidance of remarkable mentors – Andrew Richardson, Bill Houston, Charles Burstone, Michael Marcotte, Hans-Peter Bantleon and Birte Melsen – who questioned and challenged his way of thinking. Whilst in academia, Rohit Sachdeva embarked upon a path of research that culminated in the development of both copper nickel-titanium and titanium niobium alloys and titanium brackets for use in orthodontics. Post-academia, he has continued his research and development activities in the areas of clinical decision support systems and automation technology; he currently has over 90 patents.
His work with engineers, materials scientists and designers has allowed him to cross-pollinate ideas and recognize the value of transprofessional collaboration.
In addition, he has maintained his primary interests in improving clinical practices and patient care and has pioneered the practice of remote orthodontics. He continues to be actively involved in teaching and practicing remote patient care.
Sachdeva entered into industry when he co-founded the start-up OraMetrix Inc. and developed the Suresmile system. He currently designs and implements technology that will enable the orthodontist to practice in an all-digital environment.*
He believes we should all embrace failures. They evoke humility within us, making us receptive to our ignorance and clearing the path to new learning.
He is indebted to his patients for allowing him to learn from them and awakening empathy within him.
He is grateful and thankful for the support and insight of his friends and colleagues Carl Gugino, Doug Haberstock, John Lohse, Antonella Maselli, Jeff Johnson, Mark Knoefel, Takao Kubota and Larry White and his family at OraMetrix.
His greatest blessing in life has been and will always be his unconditionally loving, supportive family – his parents Shanti and Chaman Lal, his wife Benu and his three children Maya, Nikita and Arjun – who have served as both his inspiration and sounding boards.

*OraMetrix Inc., Richardson, TX, USA

Novus Ordo Seclorum: A Manifesto for Practicing Quality Care

Part I

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> “*Be a yardstick of quality. Some people are not used to an environment where quality is expected.*”
>
> *Steve Jobs*

Abstract

The current approach to orthodontic care is largely error-prone and, therefore, reactive. Such error-ridden care practices negatively impact the quality of the care delivered. In this article, the author discusses his manifesto for BioDigital Orthodontics, a proactive, quality-focused approach to orthodontics. The principles and practice of patient-centred care, patient safety and clinical effectiveness as they relate to the practice of quality care are presented.

Keywords
Quality, reactive care, proactive care

INTRODUCTION

Quality orthodontic care is a commodity. Why? Because almost all doctors believe they provide quality care to their patients. The reason this myth prevails is that the definitions of quality practices and metrics remain vague at best[1]. Currently, said practices measure the spatial relationships of the dentition and are not rooted in scientific evidence in terms of their clinical or physiological significance (such as blood pressure or body temperature), thus diminishing their validity as effective measures of well-being. Also, these measures are not universally accepted by the specialty or the profession of dentistry at large. In this way, the clinician acts as both judge and jury, rubber-stamping an autonomous verdict of 'all looks well; no harm done' in the treatment delivered to his or her patients. Such behaviour has a ripple effect within the orthodontic care ecosystem. For instance, this behaviour blunts the patient's understanding of quality care, diminishing the value of the genuine quality-driven orthodontist. Hence the rise of the 'non-expert expert' or the dentist-orthodontist.

The ambiguous definition of quality care has facilitated the proliferation of market-driven orthodontics. Practices measure their success on the basis of business metrics, such as profit and production, rather than patient care outcomes.

This is not all bad news. The recognition of these deficiencies provides us with the springboard from which to explore opportunities to better our specialty and reinforce the covenant of trust between specialist and patient.

So how do we cure our ills? First, we must redefine our metrics and build an engine that allows us to practice quality care. This requires improvements in both the relational and functional components of our care giving. Henry Ford described this notion best when he said: 'Quality means doing it right when no one is looking.' We must embrace and commit to a new cultural fluency that fosters patient centredness, patient safety and clinical effectiveness[2].

PATIENT-CENTRED CARE THE PAST AND PRESENT

Historically, a paternalistic, hierarchical model defined the doctor–patient relationship. The doctor 'knew best', effectively silencing the voice of the patient. Recently, however, the consumer-driven orthodontic care model has redefined the doctor–patient relationship, establishing a contractual relationship between buyer (patient) and seller (doctor)[3]. In this setting, the buyer 'knows best' and pays for his or her wants, not needs. The buyer's commonly misinformed expectations of care now muffle the voice of the well intentioned, evidence-driven doctor. Both of these models of doctor–patient relationships are flawed, warranting a more balanced doctor–patient relationship.

WHAT EXACTLY IS PATIENT-CENTRED CARE?

Patient-centred care is not just about giving patients whatever they want or educating them about their needs. It is, first and foremost, about the doctor establishing trust and credibility with the patient[4]. It is about orthodontists and their care teams showing empathy and humanity in embracing the patient as a person, not a case; a patient named John who is afflicted with a malocclusion, not a case labelled a Class I malocclusion.

Patient-centred care means orthodontists recognize they are guests in their patients' lives[5]. In a patient-centred practice, the patient is aware of and understands her 'bill of rights'[6]. Patient-centred care teams value the patient's opinion, engage in active listening and shared decision-making with the patient and establish rapport with the patient in addressing care needs. These care teams respect the patient's ability to assert his or her individuality. Patient-centred care also means complete transparency; the care team offers full, unbiased information about the options, benefits and risks of any care measures planned.

Potential disconnects between the voice of the doctor and that of the patient are best resolved using a casuistic approach to clinical decision-making. This model considers patient values, backgrounds and preferences alongside empirical evidence, experiential evidence, pathophysiological rationale and system features[7].

As such, orthodontic patient-centred care practices carry the banner of a 'patient of one'[5].

PATIENT SAFETY THE PAST AND PRESENT

Conventional orthodontic care has been and continues to be craft-based and reactive. We practice 'wayfaring' orthodontics and manage patient care through the rear-view mirror. This model of care provides fertile soil for the seeding and proliferation of error-associated events.

It is important to note that human error is a consequence, not a cause. Human error is the product of a chain of causes in which precipitating psychological factors include lapses in attention, forgetfulness, misjudgement and preoccupation. Errors are generally described by what I call the 8 *M*'s: Miscommunicate, Misunderstand, Misdiagnose, Misplan, Mismanage, Misdesign, Misprescribe, Misadminister.

Errors are commonly 'long tail' in nature and are often the last and least manageable links in the chain. As such, errors are recognized in the *finishing stage* in orthodontic treatment, a stage in treatment in which the clinician intends to correct for errors, and the patient, accordingly, is admitted into the intensive care unit[8].

The *finishing stage* is challenging for both the patient and the doctor. If we were to enter the patient's mind during the *finishing stage*, we might encounter a patient who suffers from anxiety and orthodontic exhaustion. The patient falsely believes the treatment is complete and now must undergo additional treatment. Candidly put, the patient is burnt out. From the clinician's perspective, much treatment remains to be done. The clinician, too, is anxious, wrestling with his or her professional commitment to properly treat the patient, a patient who is now half-heartedly committed to treatment. At this point in treatment, patient adherence to the doctor's recommendations decreases, the timing of the patient's appointments becomes erratic, and the doctor's skills are put to the test. The *finishing stage* is therefore disruptive to both the patient's expectations of care and lifestyle, the clinician's mindset and schedule, and the orthodontic practice's operations.

The very fact that we accept *finishing* as a stage in patient care suggests that we condone a system that allows for error propagation. This practice must be prevented or, at the very least, contained.

Another shortfall in our practice model is that we lack both intrapractice and system-wide transparency. We neither report nor disclose error; failure is merely paid lip service, not action. If we do not document error, we cannot analyze, learn, and subsequently improve on our ways. Given our avoidance of error reporting, the waters always appear calm; nothing appears broken, so we convince ourselves that there is nothing to fix. Thus, our modus operandi continues with little recognition of the undermining forces that affect our quality of care. Such an error-prone environment comes at a substantial cost to both the patient and doctor and also delays care.

Unfortunately, failures in outcomes occur more often than not (one just needs to see transfer patients to appreciate the extent of this problem). Failures in outcomes are commonly attributed to biological and psychosocial factors, such as poor patient growth or cooperation. The patient bears the brunt of responsibility for a less than desirable result, and the doctor remains unaccountable for his or her probable misaction. If the doctor is 'brave enough' to report failure, this is at the risk of his or her reputation and potential litigation.

We have yet to mature into a blame-free culture and recognize that humans commit errors. Systems, processes and technology must be appropriately used by a skilled care team to prevent or arrest the propagation of errors.

WHAT EXACTLY IS PATIENT SAFETY?

Patients almost entirely depend on the skills and professional judgement of the orthodontist and his or her team to receive the best care. The overarching goal of an orthodontic practice that subscribes to patient safety is to protect patients from harm. This requires building a trustworthy system for the delivery of orthodontic care.

Patient safety is the prevention of errors that result in unwanted and adverse effects. It is also concerned with minimizing the incidence of and maximizing the recovery from spurious or adverse events. Errors must be continuously reported, analyzed and communicated to all team members in an ongoing effort to error-proof the care delivery system.

The practice of patient safety is grounded in the principles and practice of safety/reliability science[9]. Reliability refers to failure-free operation over time. Practically speaking, reliability is the ability of a process, procedure or service to perform its intended function in the required time under existing conditions. Reliability is measured by dividing the number of actions to achieve the intended result by the total number of actions[10].

Orthodontic practices must adopt the principles of High Reliability Organizations (HRO). An HRO is designed to minimize danger by balancing effectiveness, efficiency and safety. An HRO preserves a culture of system-wide transparency and error reporting. An HRO is both proactive and generative in its actions and also shares the cultural framework of learning organizations. Roberts and Bea note: 'More specifically HRO actively seek to know what they don't know, design systems to make available all knowledge that relates to a problem to everyone in the organization, learn in a quick and efficient manner, aggressively avoid organizational hubris, train organizational staff to recognize and respond to system abnormalities, empower staff to act, and design redundant systems to catch problems early'[11].

The success of an HRO is partly based on its ability to stay mindful. An HRO promotes five mindful practices to manage safety, including[12]:

Preoccupation with failure. Team members must incessantly seek ways to error-proof the system and mitigate risk.

Reluctance to simplify. Simple processes are strived for, but oversimplified explanations for error are avoided. Analyses of the root causes of error are performed.

Sensitivity to operations. Team members must be consistently mindful of noting and preventing risks.

Commitment to resilience. Team members are trained to

1. anticipate, or know what to expect;
2. pay attention, or know what to look for, and
3. respond, or know what to do.

Deference to expertise. Each and every team member carries an equal voice in calling out violations or reporting errors or adverse events.

The baseline of an HRO core processes operates correctly 99% of the time. In health care, the baseline of core processes is defective 50% of the time, as 50% of patients receive the recommended care[13].

Health-care practices are less reliable than industrial practices; as a result, the Institute of Health Care Improvement (IHI) recommends that health-care organizations should focus on process reliability as a first step on the road to safe care before focusing on the mindful practices of an HRO (I would tend to agree that orthodontics take the same approach). Baseline performance reliability for non-catastrophic processes in health care is currently said to be less than 80%. What does this mean? The IHI has established a measure termed '"failure rate" (calculated as -1 reliability, or "unreliability") as an index, expressed as an order of magnitude'[10]. Thus, 10^{-1} means approximately one defect (error) per 10 process opportunities. If 10 brackets were bonded on a patient and one of them was misplaced, the defect rate would be 10^{-1}. 10^{-2} is approximately one defect per 100 process opportunities[10].

Recognizing that strict adherence to this formula may pose difficulties in interpreting unsafe or error-prone practices, the IHI developed a broader classification to evaluate the failure rate (*Table 1*). As one can see, the rate of two defects per 10 process opportunities represents less than 80% success; this measure indicates a chaotic or unreliable process. Translating this measure into the world of orthodontics suggests that the incorrect placement of just 2 brackets on 100 teeth (5 patients) would be classified as an unreliable process. We know our defect rate is, unfortunately, much higher, begging the need for reliable processes in orthodontics.

The IHI's three-step reliability design model offers a path to consider in building safer care processes (*Table 2*). With a sense of urgency and commitment, the profession of orthodontics needs to embark upon a journey to develop and implement minimal error, ultra-safe practices.

CLINICAL EFFECTIVENESS THE PAST AND PRESENT

Reactive care orthodontics encourages a 'do first, think later' mentality. Clinically, this translates to: 'let's slap on the braces and see what happens.' This practice encourages epistemic complacency. Diagnosis, care design and planning provide little value to the reactive care practitioner in the management of patient care. The 'intelligence manufactured' into the appliance overrides the clinician's cognitive tools of reason, judgement and sense making. Evidentiary practices are reserved for the ivory tower and find little use for the wet-finger, reactive care orthodontist.

Unfortunately, unscientific, dogmatic care protocols primarily designed to maximize the use of latest and best 'smart' appliances are promoted by industry-appointed thought leaders. It then follows that the influencers who create the loudest echo chamber are responsible for defining the standard of care. As a result, the doctor becomes entangled in the web of *a la mode* or market-driven orthodontics, being distanced even further from science and value-based practice.

Recently, the orthodontic industry has adopted the practice of recruiting patients, or care customers, to promote products through the powerful channel of social media[14, 15]. To appeal to a wider audience, much of the messaging is emotional rather than evidence driven. This mode of communication commonly results in a misinformed patient who attempts to drive his care with little regard for

Definition	**Defect Rate**
Chaotic, or lack of defined, reliability-focused processes	More than two defects out of 10 (less than 80% success)
10–1	One or two failures out of 10 (80% or 90% success)
10–2	Five failures or less out of 100 opportunities (95% success)
10–3	Five failures or less out of 1000 opportunities

Table 1: Reliability labels [10]

Step 1	Prevent failure: use standardization to achieve 10^{-1} (80%–90% reliable or 10^{-1} performance expected)
Step 2	Identify failures and mitigate failures if possible to achieve 10^{-1} (of the 10% or 20% failures from Step 1, expect 80% or 90% identification and mitigation in Step 2)
Step 3	Prioritize failure modes and redesign Steps 1 and/or 2 if articulated goal of 10^{-2} performance has not been achieved

Table 2: Three-step reliability design model [10]

professional advice.
The combination of the reactive care model and the strong influence of industry and its appointed thought leaders has channeled the practice of orthodontics into a cafeteria or standardized, mass manufacturing product- and profit-driven approach. The orthodontic enterprise is populated with misguided doctors and misinformed patients.
The practice of orthodontics needs to reframe itself. Another cultural pill it needs to be prescribed is that of clinical effectiveness.

WHAT EXACTLY IS CLINICAL EFFECTIVENESS?

Clinical effectiveness is defined as 'the application of the best knowledge, derived from research, clinical experience and patient preferences to achieve optimum processes and outcomes of care for patients. The process involves a framework of informing, changing and monitoring practice'[16].
Clinical effectiveness is concerned with demonstrating continual improvements in quality and performance. The properties of clinical effectiveness are[16]:
Doing the right thing: Evidence-based practice requires that decisions about patient care are based on the best available, current, valid and reliable evidence;

- *in the right way:* Developing a care team that is skilled and competent to deliver the care required
- *at the right time:* Accessible services provide treatment when the patient needs them
- *in the right place:* Location of care services
- *resulting in the right outcome all the time:* Clinical effectiveness.

Clinical effectiveness is about improving the 'total care experience' of the patient. It requires thinking critically about what the care team does, questioning whether the team is achieving the desired result and making necessary changes to unreliable practices. This can only be accomplished if doctors and their care teams are committed to measuring the quality of care. Continuous improvement methodologies such as the Plan-Do-Study-Act cycle may be used to effect improvement[17]. Measures from such initiatives are critically evaluated to seek evidence of what is effective in order to improve a patient's care and experience.
The doctor and the care team should always be attentive and respectful of the patient's care preferences. Patient-reported outcome programs such as Patient-Reported Outcome Measures (PROM) and Patient-Reported Experience Measures (PREM) should be implemented to directly seek the voice of the patient in care improvement initiatives[18]. Also, patient literacy programs to better educate patients in evaluating the quality and source of health-care information and judge doctor skills should be considered.

> “*Never underestimate*
> *the power of a small group*
> *of committed people*
> *to change the world.*
> *In fact, it is the only thing*
> *that ever has.*”
>
> *Margaret Wheatley*

CONCLUSIONS

Our profession is at a crossroads. We have a unique opportunity to better patient care by implementing creative solutions.
Change can only be achieved if we act with a sense of purpose; purpose defined by the values and the belief system we adopt - our culture. We need to acculturate ourselves to a 'patient-first' care model. This requires that we migrate to a platform that supports mindfulness, is proactive in its practices and is performance based.
The orthodontic practice of the future will be designed around what I term the **EAAR** model: **E**mpathy for patients, **A**nticipate issues to prevent problems, **A**ttention to processes and procedures and **R**eflective thinking to continuously improve.
Four important points must be noted. First, the quality of our outcomes is driven by the quality of how we practice. Second, change without measurement is not change. Third, we must rid ourselves of our mindset of orthodontic exceptionalism and restore humility within ourselves and our practices. Fourth, we must take the initiative to measure our personal performance and practice performance on the basis of our deeds, patient feedback and professionalism - profit or production should be secondary determinants of success.
More specifically, we should implement broader system-wide measures at multiple levels to understand and improve upon the quality of care we offer patients. At the patient level, measures should include whether patient care expectations are met, the number of disruptive episodes in the patient's life (e.g. wait times, discomfort) and the patient's understanding of his or her care needs and treatment. Such measures would provide a gauge for the effectiveness of the patient's care experience in the practice.
At the doctor level, measures should include the proximity of the initial plan to the outcome and the conformity of the treatment approach to the prevailing evidence. Such measures would provide a basis for assessing the doctor's knowledge and skills and also shed light on the effectiveness of the quality assurance program in the practice. I also believe that the doctor should periodically make his or her report card available to the public. The societal benefit of such transparency outweighs the limited loss of professional autonomy.
At the process level, measures should include error rates, acts of commission and omission, resource utilization and cost-effectiveness of

care. Learnings from these measures would provide an understanding of the effectiveness of the practice's quality control program. Furthermore, quality should be measured temporally. The trend line would reveal the effectiveness of continual improvement initiatives in the practice. Generative practices would tend to show a positive trajectory in their efforts to continually improve.

At the system-wide level, the profession must implement a total quality assessment program and patient literacy program to educate the patient on the metrics of quality care. Furthermore, we must establish a national registry to report the errors or adverse events we see during our patient care. It is only by sharing and collectively learning from our failures that our specialty can better patient care.

Academia should implement educational and effective training programs on patient safety and improvement science for the residents and the practicing community. They should also take the responsibility to regularly report on their institutional care performance to both the public and professional communities.

The industry must take an active and responsible role in working with the professional community to educate the public on quality care.

Our calling as orthodontists is to carry the slogan 'always do right by the patient'. Let this be the mantra that raises our professional conscience to the highest of levels. Let it also be a reminder to us to serve our patients to the best of our abilities. A positive externality of quality patient care is the sustainability of the orthodontic profession.

This manifesto forms the bedrock of BioDigital Orthodontics, a philosophy of care that I have developed. In my next article, I will discuss the principles and practice of BioDigital Orthodontics with specific reference to building reliable care practices through error minimization.

> “*Always do right,*
> *this will gratify some*
> *and astonish the rest*”
>
> *Mark Twain*

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Treatment of a Class II Extremely Deep Bite by the Tip-Edge Technique and Mandibular Distraction Osteogenesis

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> *“.....orthodontic treatment combined with mandibular distraction osteogenesis to treat an extremely severe deep bite and obtain a good result stable in the long term......”*

Abstract

This case report describes the integrated orthodontic surgical management of a 20-year-old Chinese male with a decreased lower facial height and skeletal class II, Angle class II division 2 malocclusion with an extremely severe deep bite (23 mm and 200%).
The upper anterior teeth occluded on the lower vestibule and the lower anterior teeth occluded on the palatal mucosa. Both upper and lower anterior teeth were very retroclined and supra-erupted, causing a severe reverse curve of Spee in the upper arch and an exaggerated curve of Spee in the lower arch.
The treatment comprised of:

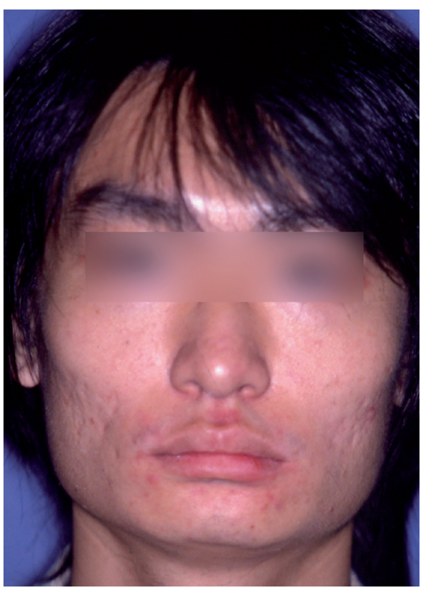
1. pre-surgical orthodontics using the Tip-Edge light force system with double-wires to level the occlusal planes, alignment and rounding of the dental arches;
2. mandibular distraction osteogenesis to lengthen and advance the mandible;
3. removal of the mandibular distractors;
4. post-surgical orthodontics; and
5. retention.

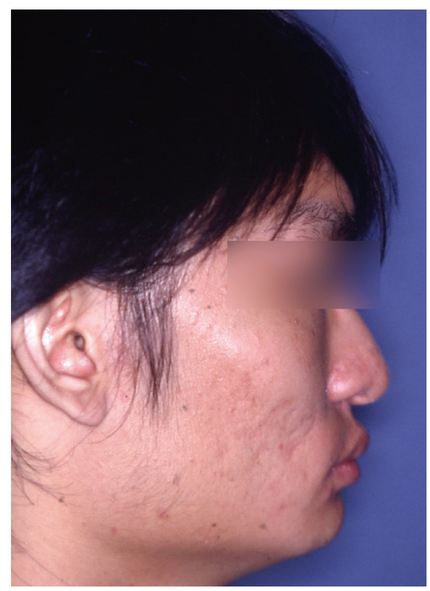
In conclusion, the treatment adopted for the management of this extremely deep bite was very successful and the good result remained stable in the long term.

Keywords
Deep bite, light wire mechanics, distraction osteogenesis

INTRODUCTION

The prevalence of severe deep bite – more than two-thirds of mandibular central crown length – was reported to be 4% in Chinese adults[1]. Many of these patients have a Class II division 2 incisor relationship, which was reported to be 3.5% in Chinese adult males[2] and 3.4% in an Asian cohort of adolescents[3]. The correction of severe deep bite in Class II division 2 malocclusion is a challenge for orthodontists and the stability of treatment results uncertain. In the literature, various treatment strategies have been proposed to treat Class II division 2 malocclusion in adolescent and adult patients, such as the use of a fixed appliance with/without extraction of the first maxillary premolars with/without temporary anchorage devices (TADs), a fixed functional appliance, and orthognathic surgery. Common surgical procedures are a combination of advancement of the mandible with bilateral sagittal split osteotomies (BSSO) of the mandible with/without maxillary osteotomy[4-19]. According to the literature on Class II division 2 malocclusion, optimal aesthetic results are difficult to achieve and long-term stability is uncertain. 'Camouflage' treatment with extraction of the maxillary first premolars and use of a fixed appliance is usually lengthy, and may compromise facial appearance with the nose becoming 'magnified' due to retraction of the upper lip. Moreover, anchorage position is critical due to retraction and palatal root torque, the upper anterior teeth usually becoming retroclined. A better appearance is typically achieved with the non-extraction approach aiming at normalizing the angulation of the incisors to allow forward positioning of the mandible with Class II mechanics with/without



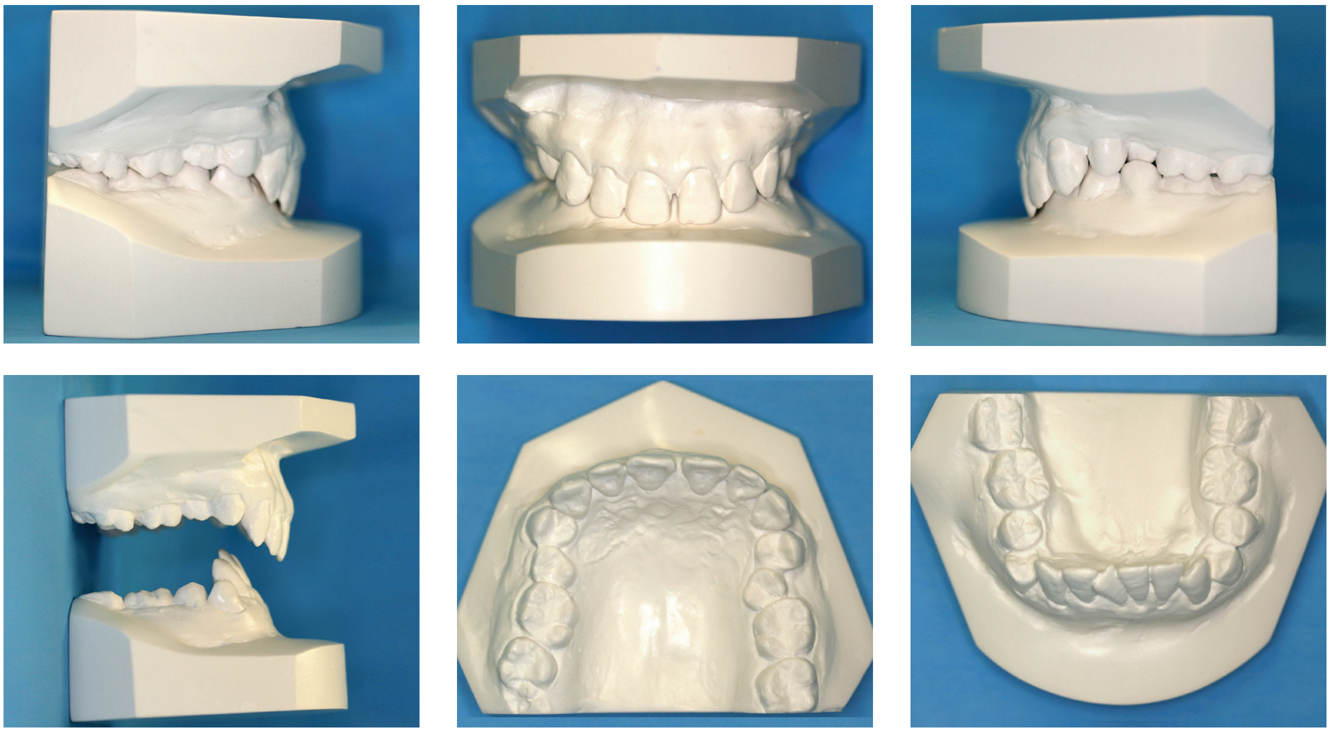


Figures 1 - 3: Pre-treatment (T0) extra-oral photographs.






Figures 4 - 9: Pre-treatment (T0) intra-oral photographs.



Figures 10 – 15: Pre-treatment (T0) study models.

fixed functional appliances or orthognathic surgery[17, 20]. Treatment results have been reported to be less than ideal particularly in severe Class II division 2 malocclusion because of limited mandibular advancement by conventional orthognathic surgery. In patients who underwent first maxillary premolars extraction and fixed appliance treatment in combination with TADs, the nasio-labial angle was reported to become more obtuse[18]. Yousefian et al.[10] described a 15-year-old male who underwent treatment with extraction of the first maxillary premolars, which resulted in a worsening profile. Later, the spaces for the missing premolars in this patient were opened up and implant supported restorations and BSSO were carried out to advance the mandible, making it more prognathic and achieving a better profile. The addition of TAD support to the extraction strategy, so-called camouflage treatment, improved the occlusion but put the patient's profile at risk. Use of a fixed functional appliance did not correct the skeletal Class II discrepancy[18]. Bock et al.[14] reported that the profile became straighter after treatment with a Herbst-multibracket appliance in adults but that treatment outcome was less stable in adults compared to adolescents[12]. In adults with Class II division 1 malocclusion, it was reported that minimal skeletal changes occurred following the Class II correction and the occlusion was maintained at 3 year follow-up[22].

BSSO is a widely used surgical procedure to lengthen the mandible in order to improve the sagittal mandibular position and its occlusal relationship with the maxillary teeth. The average forward positioning exceeds 5–6 mm, and the average relapse was reported to be about one third after 1–2 years[6, 23, 24].

In a systematic review, distraction osteogenesis was reported to have a more stable result than BSSO. However, the difference in skeletal relapse between BSSO and distraction osteogenesis in the preliminary result of a randomised controlled trial was reported to not be statistically significant[25].

The aim of this case report is to present the treatment plan and result in a 20-year-old Chinese male with Angle Class II division 2 malocclusion with an extremely deep bite (23 mm and 200% of mandibular central crown length) with the use of Tip-Edge orthodontics and distraction osteogenesis to achieve a satisfactory aesthetic result and occlusion.

EVALUATION OF A PATIENT WITH AN EXTREMELY DEEP BITE

A 20-year-old Chinese male was referred to the Orthodontic Department of the Prince Philip Dental Hospital with the chief complaint of ugly front teeth (*Figs. 1–17*). The upper front teeth were found to be biting on the mandibular labial gingiva and the mandibular teeth were biting on the palatal mucosa. The overclosure of the occlusion had caused pain in the temporomandibular joint, which subsided following conservative treatment. The patient's medical history was unremarkable.

Extra-oral evaluation (*Figs. 1–3*) revealed that the patient had a

Variable	T0	T1	T2	T3	T4	T1–T0	T2–T1	T3–T2	T3–T0	T4–T3	T4–T0
SNA (º)	82.8	83.6									
	82.8	83.3°	83.4	0.8	–0.8	0.5	0.5	0.1	0.6		
SNB (º)	79.4	80.4	83.7	83.7	84.7	1.0	3.3	0.0	4.3	1.0	5.3
ANB (º)	3.4	3.2	–0.9	–0.4	–1.3	–0.1	–4.1	0.5	–3.8	–0.9	–4.7
Wits (mm)	0.5	2.0	–4.0	–4.5	–4.0	1.5	–6.0	–0.5	–5.0	0.5	–4.5
U1/MxPl (º)	94.9	124.0	127.8	125.5	125.9	29.1	3.8	–2.3	30.6	0.4	31.0
L1/ MnPl (º)	73.2	105.4	106.9	105.4	106.0	32.2	1.5	–1.5	32.2	0.6	32.8
Interincisal angle (º)	170.8	125.0	119.4	122.2	122.3	–45.8	–5.6	2.8	–48.6	0.1	–48.5
MxPl/MnPl (º)	2.8	5.6	5.9	6.8	5.8	2.8	0.3	0.9	4.0	–1.0	3.0
Upper face height (mm)	62.2	60.7	61.8	62.0	61.5	–1.5	–0.2	0.2	–0.2	–0.5	–0.7
Lower face height (mm)	62.6	69.6	71.4	72.4	71.3	7.0	1.8	1.0	9.8	–1.1	8.7
Face height ratio (%)	50.2	53.4	53.6	53.9	53.7	3.2	0.2	0.3	3.7	–0.2	3.5
L1 to APo line (mm)	–14.5	–2.1	2.2	1.8	1.8	12.4	4.3	–0.4	16.2	0.0	16.3
LL to E line (mm)	1.0	–1.6	–2.1	–2.5	–2.7	–2.6	–0.5	–0.4	–3.5	–0.2	–3.7

Table 1: Dentofacial morphology and changes
Dentofacial morphology before treatment (T0), at the start (T1) and end (T2) of distraction osteogenesis, at completion of treatment (T3) and at 1 year follow-up (T4) is indicated. Changes during pre-DO (Distraction Osteognenesis) orthodontics (T1–T0), DO (T2–T1), post-DO orthodontics (T3–T2), treatment period (T3–T0), 1 year follow-up (T4–T3) and the whole observation period (T4–T0) are indicated. MnPl, mandibular plane; MxPl, maxillary plane.

square-shaped, symmetric face, with a mild convex profile with an acute nasolabial angle and deep labiomental fold. His lower facial height was reduced with a prominent gonial angle and a shortened chin. His lips were competent at rest. The upper lip was slightly protrusive and the lower lip was everted. Maxillary gingival display was 3 mm when smiling (*Fig. 2*). There was no tenderness of the temporomandibular joints and involved muscles, but clenching of bilateral masseter muscles was noticed and the movement was within normal range.

Intra-oral examination (*Figs. 4–9*) revealed that the maxillary midline was coincident with the facial midline, and the mandibular midline was displaced 2 mm to the right of the facial midline. Mild gingival recession and attrition of lower central incisors were seen in the lower anterior region. Generalized mild gingivitis and inadequate oral hygiene were noted.

The study model analysis (*Figs. 10–15*) showed that the patient had severe Class II division 2 malocclusion. There was a full unit Class II molar and canine relationship on the right, and three-quarter unit Class II molar and canine relationship on the left. Overbite was extremely deep at 23 mm and 200%, with upper anterior teeth occluded on the lower vestibule and lower anterior teeth occluded on the palatal mucosa. Both upper and lower arches were omega shaped with a constricted arch in the premolar regions. Both upper and lower anterior teeth were severely retroclined and over-erupted, causing a very marked increase in the reverse curve of Spee of the upper arch, and an exaggerated curve of Spee of the lower arch (*Fig. 13*). The overjet between the retroinclined incisors was only 2 mm. Diastema was present between the maxillary central incisors. Space analysis showed a 2 mm space deficiency in the maxillary arch and 7 mm in the lower arch. Upper second premolars were palatally displaced and rotated. The upper left second premolar was in crossbite with the lower left second premolar.

The panoramic radiograph (*Fig. 16*) showed that all permanent teeth were present with the third molars impacted, and a supernumerary upper right molar was noted.

Cephalometric analysis before treatment (T0) (*Fig. 17* and *Tab. 1*) showed a markedly reduced lower facial height, an extremely parallel maxillary to mandibular plane (MxPl/MnPl) angle of 2.8º which was about 4.5º SD below the normal mean value of 26º (SD 5.1º) (for details see Wu et al.[26]. The SNB value (79.4º), which indicated a 'normal' sagittal position of the mandible, was very misleading, as was the ANB value (3.4º). This is likely related to the severe overclosure of the mandibular occlusion making the mandible autorotate upwards assuming a more forward position. Both upper and lower incisors were extremely retroclined. The position of the mandibular incisors to the APo line was –14.5 mm (SD –8.3 mm) compared with the normal value for Chinese individuals (mean 5.4 mm, SD 2.4 mm). The maxillary incisors inclined

94.9º to the maxillary plane, tipped palatally approximately 22º (SD −3.7º) lower compared to the normal value (mean 117º, SD 5.9º).

To summarize, this adult male patient presented with severe Class II division 2 malocclusion, extremely deep bite, on a skeletal Class II base and low mandibular plane angle. He had a square-shaped face, decreased lower facial height, a deep labiomental fold, and excessive gingival display on smiling. Both upper and lower anterior teeth were severely over-erupted and retroclined, causing an increased reverse curve of Spee in the upper arch and an exaggerated curve of Spee in the lower arch. The upper anterior teeth occluded on the lower labial vestibule and the lower anterior teeth occluded on the palatal mucosa, causing mild labial gingival recession on the lower incisors. There was also a 7 mm space deficiency in the lower arch.

TREATMENT OBJECTIVES

The treatment objectives were to increase the lower facial height while maintaining the position of the mandible in a correct sagittal plane position, and normalize the smile and soft tissue profile. Therefore, the primary skeletal objectives were to improve the sagittal and vertical basal relationship by correcting the skeletal Class II pattern and increasing the lower-third facial height. Dentally, the objectives were to procline the upper and lower incisors, align the arch and level the occlusal plane, decrease the overbite, eliminate crowding and midline diastema, correct the dental midline, and achieve molar and canine Class I occlusion. The skeletal and dental treatment objectives also aimed to improve the soft tissue profile, and reduce the excessive gingival display upon smiling and the accentuated labiomental fold.

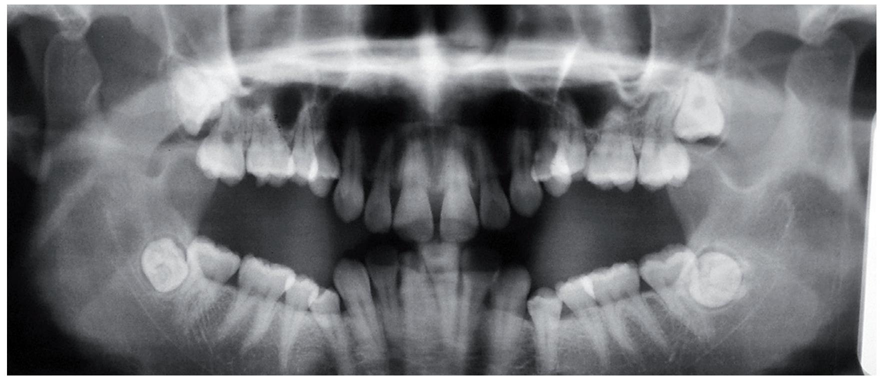
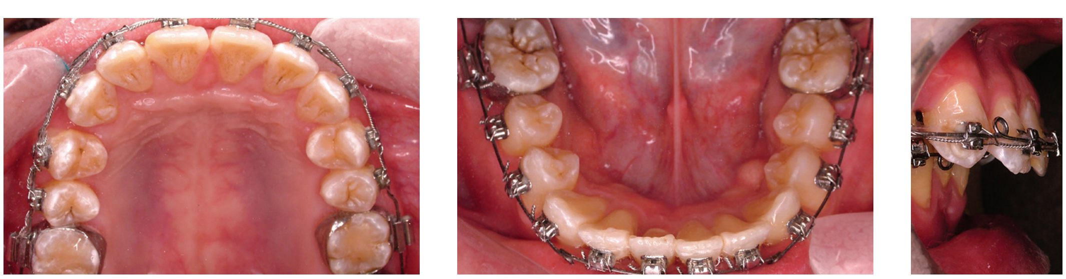


Figure 16: Pre-treatment (T0) radiograph

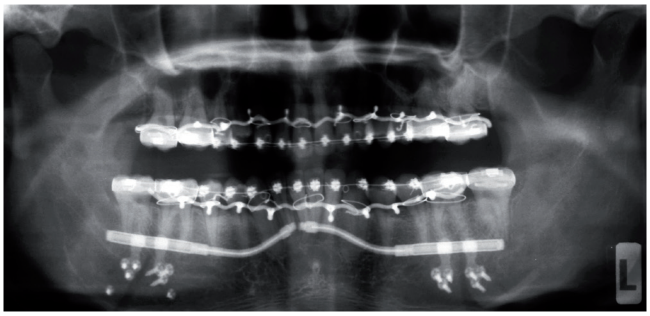
Figure 17: Pre-treatment (T0) lateral cephalogram.

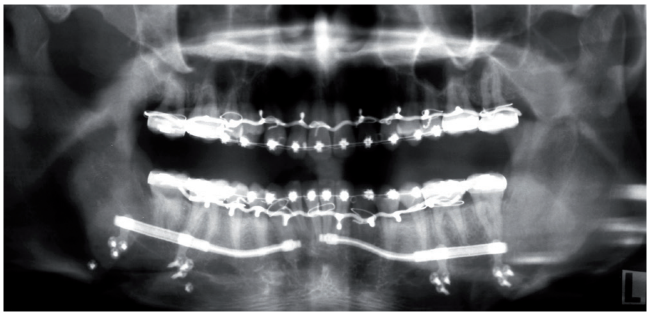
TREATMENT PLAN

Due to the extremely severe deep bite, the extent of the retroclination of both upper and lower incisors, the Class II skeletal pattern, and the age of the patient, orthodontic camouflage alone would not be able to achieve a good and stable result for this patient. However, orthognathic surgery in combination with orthodontics was an option. Since large movement of the mandible was required in this case, it was felt that mandible distraction



Figures 18 - 23: Intra-oral photographs after (T1) pre-surgical orthodontics.





Figures 24 - 25: Radiographs before (T1) and after (T2) distraction osteogenesis of the mandible.

was preferable to BSSO. This patient would benefit both functionally and aesthetically from appropriate pre-surgical orthodontic treatment revealing the full extent of the skeletal discrepancy allowing correction by mandibular distraction.

With an extremely deep bite, the challenge to the orthodontist was how to level such exaggerated curves of Spee (*Fig. 13*) and how to 'normalize' the angulation of the severely retroclined incisors. The Tip-Edge light wire technique was chosen for this patient with severe deep bite as the special design of the Tip-Edge bracket would facilitate intrusion and proclination of the anterior teeth in combination with extrusion of the posterior teeth, resulting in flattening of the occlusal planes and subsequent bite opening[27-29].

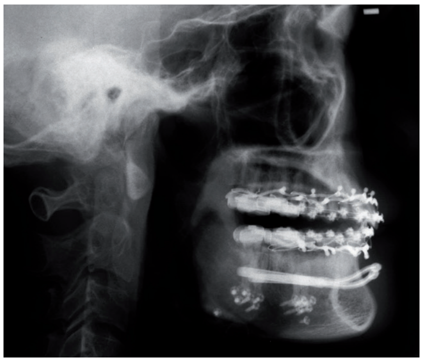
TREATMENT

The treatment comprised preparation, pre-surgical orthodontics, mandibular distraction osteogenesis and removal of distractors, post-surgical orthodontics and retention.

1. *Preparation* consisted of jaw exercise, restorative dentistry, oral hygiene therapy, and surgical removal of all third molars and the supernumerary upper right molar.
2. *Pre-surgical orthodontics* used the Tip-Edge light force technique[27-29] to reveal the true extent of the skeletal discrepancy, and hence allow full surgical correction of the anomaly. The treatment objectives were to round off and harmonize the dental arches, and reduce the curve of Spee in both arches. The treatment plan was to align the teeth, procline and intrude the anterior teeth, and extrude the posterior teeth.
3. *Surgical procedures* included bilateral mandibular distraction to lengthen the mandible and increase its prognathism and improve the lower facial height.
4. *Removal of distractors* was performed when the distraction regenerate of the mandible matured to mineralized bone as confirmed by orthopantomograph.
5. *Post-surgical orthodontics* completed minor postoperative adjustment by correcting axial inclinations, alignment, closing interdental spaces, and closing posterior inter-occlusal spaces.

PRE-SURGICAL ORTHODONTICS (T0–T1)

All permanent teeth were included in the orthodontic appliance, with the band cemented initially on all first permanent molars, and later also on the second permanent molars, and 0.022 inch slot Tip-Edge* brackets were placed on the remaining teeth (*Figs. 18–23*). Initial alignment and levelling was accomplished with 0.014 inch nickel-titanium archwires. Glass ionomer cement was placed on the occlusal surface of the upper molars to raise the bite. After 5 months, a 0.016 inch A.J. Wilcock Australian archwire with a sweep curve was used for the upper arch, while a nickel-titanium archwire was applied to the lower arch to align the posterior teeth and procline the incisors. To further enhance flattening of the curve of Spee on both arches, a 0.016 inch Australian archwire with anchor bands was placed on the first permanent molars with auxiliary gingival tubes 2 months later, combined with 0.014 inch and 0.016 inch thermo nickel-titanium archwires inserted in the main tubes



Figures 26 - 27: Lateral cephalograms before (T1) and after (T2) distraction osteogenesis of the mandible.

*TP Orthodontics, La Porte, Indiana, USA

Figures 28 – 30: Post-treatment (T3) extra-oral photographs.

of the molar bands in the maxillary and mandibular arches, respectively. After 24 months of treatment, a 0.018 inch Australian archwire and bilateral E-links were used to close the residual space of the upper arch. In the lower arch, a 0.0215×0.028 inch rectangular stainless steel archwire was placed to achieve the anterior lingual root torque. The pre-surgical orthodontics (T0–T1) was completed after 31 months of orthodontic treatment. Stainless steel ligature ties were placed on all teeth and the patient was ready for surgery (*Figs. 18–24, 26*).

SURGICAL TREATMENT (T1–T2)

Surgical treatment (T1–T2) was conducted in the 32nd month of treatment and bilateral mandibular distraction osteogenesis was conducted under general anaesthesia. Osteotomy cuts were performed with a 0.18 mm Lindemann bur at the mandibular body behind the last molar on each side. Buccal cortical bone was cut from the alveolus to the lower border of the mandibular body until cancellous bleeding was seen through the cut. Confirming the vertical relationship of the inferior alveolar canal, the osteotomy cuts penetrated the lingual cortex above and inferior to the inferior alveolar canal in an oblique backward position. The residual middle lingual cortical connection was fractured by placing an 8 mm thick osteotome above and below to achieve mobilization of the mandible and confirmation of the integrity of the inferior alveolar bundle in this case. Upon completion of mobilization of the mandible on both sides, the occlusion was placed in a pre-fabricated surgical wafer with the vector for the distractor

Figures 31 - 36: Post-treatment (T3) intra-oral photographs.

Figure 37: Post-treatment (T3) radiograph.

indicated by an embedded wire. Temporary intermaxillary fixation with stainless steel wires was used to stabilise the occlusion. The concept and fabrication of this vector guidance splint was described by Cheung et al.[30]

A pair of mandibular internal distractors of clover leaf design with a body length of 30 mm (KLS Martin, Mühlheim, Germany) were selected pre-operatively for this case. The mesh plates were adapted over the mandibular body with the foot plates in front and behind the osteotomy cut. Mono-cortical fixation was by three 2×8 mm titanium screws on each side. The vector director of the distractor body rod was checked to ensure it was parallel with the vector guidance splint before the placement of the second screw on the second plate. Once the vector was determined, the remaining screw holes were drilled and screws placed with final tightening. Intermaxillary fixation was released and the distractors were turned with an activator rod to confirm smooth opening of the distraction gap without resistant. The wound was then closed primarily with 3/0 Vicryl sutures.

Activation of the distractor by 1 mm per day started 6 days after surgery, and after 18 days activation, the overjet was reduced to 2 mm (*Figs. 25* and *27*). A posterior open bite was noted due to the lower exaggerated curve of Spee, which the treatment was designed to close post-surgically in order to restore the lower anterior facial height. Panoramic and lateral cephalographs were done at 1 week, 6 weeks and 3 months. Upon radiographic confirmation of ossification in the distraction gaps at 34 months, the distractors were removed under general anaesthesia.

POST-SURGICAL ORTHODONTICS (T2–T3)

Post-surgical orthodontics (T2–T3) started 35 months into treatment and lasted for 10 months, i.e. the total treatment time was 45 months. The final positioning of the teeth was

Figure 38: Post-treatment (T3) lateral cephalogram.

Figures 39 – 41: Follow-up (T4) extra-oral photographs.

accomplished with 0.0215×0.028 inch stainless steel archwires and side winders to make the teeth upright, and Class II elastics.

RETENTION DEVICES

Retention devices were made using a fixed permanent lingual retainer bonded to the lower anterior teeth and removable retainers on both upper and lower arches (*Figs. 28–38*). The use of the removable retainers was gradually reduced.

ONE-YEAR FOLLOW-UP (T3–T4)

At 1 year follow-up (T3–T4) after 1 year in retention (*Figs. 39–49),* the patient was advised to use both retainers one night per week 'indefinitely'.

TREATMENT AND POST-TREATMENT CHANGES (TABLE 1)

This adult with Angle Class II division 2 malocclusion presenting with an extremely deep bite, a deep lower curve of Spee, and a flat mandibular plane angle was successfully treated by a combination of orthodontics with Tip-Edge brackets and mandibular distraction osteogenesis.

INITIAL PRE-SURGICAL ORTHODONTIC PHASE (T0–T1)

During the initial pre-surgical orthodontic phase (T0–T1), the overjet was increased from 2 mm to 13 mm and overbite was decreased from 23 mm to 9 mm before surgery (*Figs. 4–27*). The teeth were aligned, levelled and decompensated, i.e. the upper and lower anterior teeth were markedly changed (proclined from 94.9º and 73.2º to 125.9º and 106.0º , respectively, with the lower incisors protruding a total of 12.4 mm (*Table 1*). The lower face height was also increased by 7.0 mm due to the advancement of the mandible with a deep curve of Spee, hence improving the anterior facial proportion ratio from 49.8/50.2% to 46.6/53.4%, which is close to the normal value. The increase in the lower face height was mainly due to extrusion of the posterior teeth in the upper arch, initially presented with a severe reverse curve of Spee, which in combination with the intrusion and proclination of the upper anterior teeth resulted in flattening of the upper occlusal plane. In the lower arch, the flattening of the occlusal plane was mainly due to a combination of proclining of the lower anterior teeth and extrusion of the posterior teeth (*Fig. 50*). Tip-Edge appears to have a superior effect on reducing a severe curve of Spee when compared with the conventional continuous archwire technique, which was reported to be effective to treat a curve of Spee of 2–4 mm only (11). Moreover, the intrusion of the maxillary anterior teeth in this case (*Fig. 51*) seems to be no less than that reported using mini-screws[15]. During the pre-surgical phase, the sagittal jaw-base relationship became 2 mm more Class II according to Wits appraisal (*Table 1*), probably because of posterior rotation of the mandible caused by extrusion of the upper molars, which also supports findings that the mandible was not posteriorly displaced in Class II division 2 malocclusion[9, 31].

DISTRACTION OSTEOGENESIS PHASE (T1–T2)

After completion of the activation of the distractors (T2) , the sagittal forward movement of the mandible was quite favourable, the overjet was reduced from 13 mm to 2 mm, and the distance between the markers (assessed from the cephalometric radiographs; *Figs. 26 and 27*) had increased by 11 mm. The distraction process went smoothly with the patient being very cooperative in turning the activation rods twice a day at home. No overcorrection was performed as the occlusion reached stable contact with the anterior teeth with good cooperation from the orthodontist, and the posterior open bite was closed by extrusion of the intruded teeth, particularly from the reverse curve of Spee of the upper arch. Bone ossification occurred at

Figures 42 - 47: Follow-up (T4) intra-oral photographs.

Figure 48: Follow-up (T4) radiograph.

about 3 months after distraction and hence the distractors were removed. However, after distraction, a posterior open bite was presented which was regarded as too difficult to correct with post-surgical orthodontic treatment alone. Subsequently, the mandible was partially positioned with an additional osteotomy to reduce the posterior open bite when the distractors were removed.

POST-SURGICAL ORTHODONTICS (T2–T3)

During the post-surgical orthodontics (T2–T3), the residual posterior space was closed and occlusion settled well (*Figs. 31–33, 36*). After 45 months (T3), although some anterior teeth could have benefited from further treatment, the patient was very happy with the result and urged us to finish the active treatment. The treatment time of 45 months seemed long, but was within the expected duration for orthognathic patients treated in the UK (mean 33 months, SD 11.3 months)[32] but markedly longer than that reported from Norway[33].

Figure 49: Follow-up lateral (T4) cephalogram.

FOLLOW-UP (T3–T4)

During follow-up (T3–T4), the lower facial height was seen to have markedly increased, and the lower lip was no longer everted (*Figs. 1–3, 17, 28–30, 38, 50*). The excessive gingival display on smiling was eliminated because of the intrusion of the maxillary incisors (*Figs. 2, 30, 51*). No gingival recession was noted. No symptoms of temporomandibular disorders were recorded. Dentally, the overjet and overbite were normal, the midline was on, and a good intercuspation of occlusion had been achieved (*Figs. 31–33, 36*).

Panoramic radiographs obtained at post-treatment and at 1 year follow-up showed good bone support of all the teeth, normal angulation of the roots without evidence of root resorption, and no signs or symptoms of temporomandibular joint pathology (*Figs. 37* and *47*).

The cephalometric radiographs (*Figs. 17, 27, 38, 49–52* and *Table 1*) showed that, after treatment, the mandibular prognathism and lower face height had increased and markedly improved. During the pre-surgical orthodontics before mandibular distraction osteogenesis (T0–T1), both occlusal planes were flattened and the anterior teeth decompensated, with the upper incisors markedly proclined and intruded (*Fig. 51*), and the lower incisors similarly proclined but not intruded (*Fig. 52 and Table 1*).

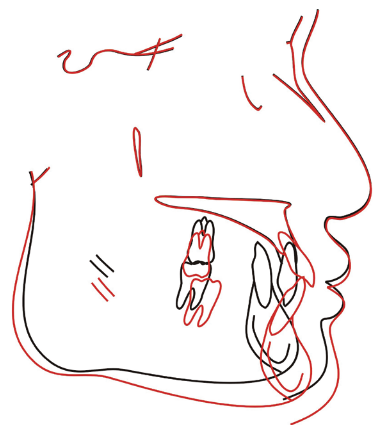


Figure 50: Superimposition before (T0) and after treatment (T3) registered on the anterior cranial base.

Figure 51: Maxillary superimposition before (T0) and after treatment (T3) registered on the anterior palatal contour.

Figure 52: Mandibular superimposition before (T0) and after treatment (T3) registered on Björk's stable mandibular structures.

POST-TREATMENT CHANGES AND OVERALL CHANGES

One year after completion of treatment (T3–T4), the patient retained an excellent facial balance and stable Class I molar, canine and incisor relationships (*Figs. 39–49*).

FINAL COMMENTS

Although deep overbite malocclusion is not commonly seen, it needs a throughout investigation and treatment plan in accordance with the dental and skeletal diagnoses contributing to the excessive overbite[20, 21]. Clinically, incisor deep overbite has always been considered as an anomaly difficult to correct orthodontically[21]. Nanda[20] classified the correction of deep overbite by four types of tooth movement: extrusion of posterior teeth, flaring of anterior teeth in the case of lingual tipping of the incisors, intrusion of incisors, and by surgical methods. The severe deep bite with extremely retroclined incisors presented in this case required all four types of tooth movement as proposed by Nanda[20], mainly flaring of the palatally or lingually tipped incisors of the upper and lower jaws, intrusion of the upper incisors and extrusion of the posterior teeth of both jaws, particularly the upper in correction of the reverse curve of Spee and the lower in correction of the exaggerated curve of Spee for restoration of anterior facial height. In order to avoid root resorption and gingival recession, it is extremely important to use a very light force to align the incisors and level the reverse or exaggerated curve of Spee of the upper and lower jaws, respectively.

From the technique point of view, a straight wire appliance gives excellent control and finishing potential[34], but there can be difficulties during the overbite reduction phase because of the continuous arch mechanics. The Begg appliance[35] is well known for its superb ability to reduce overbite and overjet because it is able to provide the consistent low forces required for dental intrusion. It does, however, often require a prolonged stage III to finish the case to a high standard. The originality of the Tip-Edge technique[27–29] lies in its ability to combine the advantages the Begg and Edgewise techniques. With different anchorages, bite opening is more rapid and correction of all occlusal abnormalities is easy during stage I. During stage III, the original design of the Tip-Edge bracket permits a progressive torque, the uprighting of roots and an Edgewise finish.

In this case, both upper and lower incisors were proclined about 30º by using the Tip-Edge technique. Despite this large amount of proclination, no root resorption, gingival recession or other periodontal damage was found in this patient (*Figs. 31–38*), which was in agreement with the findings of Melsen and Allaia[36] who studied important factors influencing the development of dehiscence during labial orthodontic movement of mandibular incisors. They noted that the amount of proclination was not correlated with changes in the periodontium. They concluded that, if orthodontic treatment is carried out under controlled biomechanical and sound periodontal conditions, the risk of periodontal damage secondary to proclination of the incisors is small. Moreover, there was a risk of pronounced root resorption when the alveolar osseous housing was narrow relative to the extent of tooth movement required[37, 38]. No root resorption was noted throughout treatment in this male patient despite large dental treatment changes (*Fig. 37*), which might be due to the good width of the anterior mandibular dentoalveolar bone and the light forces applied with the Tip-Edge technique.

In additional to the appropriate pre-surgical orthodontic preparation, the key procedure contributing to the successful treatment of this very difficult case was the application of mandibular distraction osteogenesis. This patient presented with a 13 mm overjet after pre-surgical orthodontics (*Figs. 23* and *26*), and mandibular advancement of about 11 mm was required to achieve a final overjet of 2 mm. However, the distractors required to be activated by 1 mm a day for 13 days (from day 6 to day 18), which was slightly (2 mm) more than required. This was not an overcorrection but was necessary in light of the slight backward movement of the mandibular ramus from the distractors which pushed the mandible forward but also pushed it slightly backwards. The extent of backward movement was minimized mostly by maintaining pterygomandibular sling stability with the osteotomy cut in front of the masseter muscles and the use of heavy Class II orthodontic elastic during the activation period by suspending the occlusion in a forward position. This post-surgical elastic suspension has the added advantage of minimizing the compression of the mandibular condyle pushing against the condylar fossa during the activation period. This would theoretically reduce the chance of condylar resorption, which was supported in this case with no condylar changes being noted.

The most common surgical method to advance the lower jaw is by sagittal split osteotomy. Advancing the lower jaw by 11 mm is possible with this technique. However, maxillofacial surgeons are fully aware of the literature stating that mandibular advancement with BSSO exceeding 6 mm will induce marked postoperative skeletal relapse (24, 39) and risk of condylar resorption. (40, 41) Hence overcorrection of the mandible is required. In this case, the mandible had to be advanced by 13–14 mm with the incisors touching edge-to-edge to allow for the anticipated occlusal relapse to take place. Relapse can be immediate in many cases because mandibular advancement also causes the soft tissue to be pulled forward, and hence the condyles with their ligaments commonly cannot be seated back in their posteriorly condylar position even with a lot of pressure applied to force them into the retruded contact position during fixation. Further relapse will occur with condylar remodelling as this instant mandibular advancement causes a significant increase in condylar compression on the glenoid fossa. Patients with pre-existing small condyles are particularly prone to condylar resorption, which we consider an exaggerated response of condylar remodelling to mechanical compression. Furthermore, one of the most common morbidities of sagittal split osteotomy is numbness of the inferior alveolar nerve, which can occur in 20–50% of cases. Although the severity and extent of numbness will reduce with time, some patients will experience permanent paraesthesia, particularly in cases where the nerve was exposed when the mandible was cut, the nerve requires dissection from its malpositioned segment, or there is large mandibular movement. The extent of mandibular movement in this case required consideration of whether an alternative treatment with less relapse and less neurosensory numbness was available; distraction osteogenesis was considered the most suitable technique.

The above considerations are well covered in the literature when large mandibular advancement is required. Distraction osteogenesis has several advantages: less postoperative skeletal relapse due to the relatively slow expansion of the soft tissue complex, a lower incidence of progressive condylar resorption, and less inferior alveolar nerve damage[42–45]. In particular, it was reported that mandibular distraction osteogenesis was effective in patients particularly with an average to low mandibular angle in a skeletal Class II malocclusion[46–47] as this case. However, the preliminary results from a clinical trial by our centre[25] showed that the outcome of mandibular distraction osteogenesis was not significantly better than that of sagittal split osteotomy when the mandible was advanced 6–10 mm. This insignificant finding was likely due to the small sample size and the study is still on-going.

In the current case, the orthodontic treatment combined with mandibular distraction osteogenesis achieved the desired results as assessed clinically and radiographically. The skeletal problem was resolved and a good facial profile was achieved by increasing the mandibular length and the facial height to correct the severe dentofacial skeletal deformity. The patient showed an excellent post-treatment outcome of Class I occlusion and good dental interdigitation. The patient also has no inferior nerve numbness in the mental region on either side. No periodontal damage and no signs or symptoms of temporomandibular disorder or resorption were noted at the end of treatment. No dental or skeletal relapse was noted at 1 year follow-up.

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New-Generation Light-Emitting Diode Versus Halogen Light-Curing of Orthodontic Brackets: A 24-Month Case-Control Study of Bond Failures

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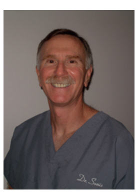

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“The study results add validation to LED curing lamp technology as a reliable, effective and evermore efficacious polymerization method for the placement of orthodontic brackets.”

Abstract

OBJECTIVES To compare survival of brackets polymerized with a new-generation light-emitting diode (LED)-based or a halogen-based lamp unit.

MATERIAL AND METHODS This case-control study involved 60 patients who received comprehensive orthodontic treatment. Patient records were assigned to the case (LED) or control (halogen) group for analysis. Second premolar to second premolar brackets were bonded in both arches for a total of 1200 brackets examined. The exposure variable was the type of curing unit: FlashMax 2 LED (3 sec) versus Optilux 501 halogen (30 sec). The outcome variable was the mean survival time of brackets. Multivariate statistical analysis was performed, setting $p<0.05$ as significant.

RESULTS Both methods performed similarly, irrespective of arch or anterior-posterior bracket location. No differences were found in the overall bracket failure rate ($p \approx 1$), survival time ($p=0.83$) or failure risk ($p=0.79$). Posterior teeth ($p=0.001$) failed more frequently; neither the LED nor halogen method decreased this tendency ($p \approx 1$).

CONCLUSION The bracket survivals produced by LED and halogen were similar. More brackets failed in posterior than anterior teeth irrespective of polymerization method. The LED unit provided 9 min of time saving per patient when compared to the halogen unit.

Keywords
LED, bracket failures, clinical time savings

INTRODUCTION

The advent of light-activated polymerization of resins introduced by Buonocore in 1970[1] revolutionized the practice of orthodontics by allowing clinicians to transition away from chemically cured resins with limited bracket placement times[2-4]. Although a marked improvement, this method produced poor curing depths needed for adequate bonding strengths and it required an ultraviolet light source for polymerization, potentially exposing patients to hazardous radiation[5-9]. In 1978, Bassiouny and Grant introduced visible-light polymerized resins, an advance made possible by camphorquinone (a photo-initiator), which reacts to light with 470 nm of wavelength, causing hardening of the polymer resin and concurrent bracket bonding to teeth[10-13]. Resin polymerization is a function of the intensity, wavelength and length of time of exposure to light. Improvements in curing lamp technology have thus focused on the production of light with wavelengths close to 470 nm, increasing light output intensities which produce a concurrent decrease in exposure times[11,13].

Tungsten filament halogen lamps produce blue light of 400–500 nm with output intensities near 1000 mW/cm², resulting in reliable bracket bondings in 30 sec of exposure[14,15]. Because of their efficaciousness and long-term presence in dental settings worldwide, they have become the standard for comparing newly introduced curing lamps[14-20]. More powerful curing systems, such as argon lasers and xenon plasma arc lamps, were introduced beginning in the 1980s, allowing for a reduction in curing times to as low as 3 sec[21,22]. However, their high cost compared to halogen units and concerns about high pulpal temperatures during exposure have hindered their adoption by clinicians compared to halogen units[23-25].

Light-emitting diodes (LED) were proposed in 1995 as a new light source for polymerization lamps[26,27]. In gallium nitride LEDs, electrons and holes recombine under forward biased conditions at the p-n doped semiconductor junctions for the generation of unfiltered blue light.[28] Much of the radiant energy of blue LEDs lies in the 468 nm region, close to the 470 nm optimal value necessary for photo-initiation of camphorquinone[16].

Further development of LED technology has allowed for new lamps that produce intensities higher than 4000 mW/cm², thus improving the speed of the bonding process without sacrificing reliability[29,30]. In addition, LEDs produce high bond strengths[31-33] and acceptable temperature levels on pulpal tissues[34,35], have lifetimes of 10,000 hours or more[36] and are affordable. Furthermore, they are resistant to vibration[20] and have low energy consumption[28], making them suitable for battery operation. As LED technology evolves, it is necessary to test new models and compare them with established halogen-based standards. Therefore, this study aims to compare the survival of brackets cured with a well-documented halogen light unit and a new generation of LED curing lamp.

Figure 1: Polymerization lamps. Halogen Optilux 501, Kerr/Demetron, Orange, CA, USA

Figure 2: Polymerization lamps. LED FlashMax2, CMS Dental ApS, Copenhagen, DK.

	LED	Halogen
Model	FlashMax2	Optilux 501
Mode of use (sec)	3	30
Nominal power (W)	15	80
Output intensity (mW/cm2)	4000–5000	ffi1000
Wavelength (nm)	450–470, peak 460	400–505
Manufacturer	CMS Dental ApS, Copenhagen, Denmark	Kerr/Demetron, Orange, CA, USA

Table 1: Technical specificationos of curing lamps

MATERIALS AND METHODS

This case-control study reviewed the treatment records of orthodontic patients whose brackets were bonded using two different types of curing light systems. Sample selection was derived from the population of patients that received comprehensive orthodontic treatment in a private practice setting in Newton, MA. The treatment records of 60 patients (28 males, 32 females) were randomly selected and reviewed for meeting the following inclusion criteria:

1. having a full permanent dentition and undergoing non-extraction therapy;
2. exhibiting no dental anomalies

that could affect bonding including enamel hypoplasia, dental restorations, moderate to severe dental fluorosis (Dean's index) and morphologic variations affecting adaptation of the bracket base to the enamel surface;

3. having predicted treatment times of 24 months or longer. The mean age of patients was 13.1 years (CI: 10.86, 15.28); the age range was 11.08–16.42 years. No exclusion was based on the type of malocclusion.

All patients were treated with full orthodontic appliances in the maxilla and the mandible. This study was approved by the Institutional Review Board (IRB) at Boston Children's Hospital.

Selected patients' records were assigned to either the case (LED) or the control (halogen) group depending on the type of curing light used during treatment. Both the case and control groups each had a total of 30 patients. Since all treated patients were close in age, had similar inclusion criteria and were treated in a controlled environment and by one clinician, matching of case and control groups was assumed. All bracket bondings were completed with a single curing lamp (FlashMax 2 LED or Optilux 501 halogen) following the manufacturers' specifications (*Tab. 1, Figs. 1,2*).

A total of 1200 bracket bondings were examined: 600 cured with the LED and 600 cured with the halogen unit. Both curing units were purchased new on the open market.

Direct bracket bondings, assessment of bond failures and data collection were conducted by one operator (A.L.S.). In all patients, teeth were isolated with cheek retractors and cleaned with a mix of water and fluoride-free pumice using a rubber polishing cup and a low-speed handpiece. Bands were then fitted and cemented on the first permanent molars. Then, second premolar to second premolar teeth of both dental arches were rinsed, dried with an oil-free air syringe and etched with 37% phosphoric acid for 30 sec. After thorough washing, the teeth were carefully dried and brackets were bonded with composite resin (Transbond XT, 3M Unitek Monrovia, CA), according to the manufacturer's guidelines.

The bonding technique was standardized. All patients received new stainless steel brackets with the same bidimensional prescription: 0.018x0.025" slot on incisors and 0.022x0.028" on canines and posteriors (GAC MicroArch).

Brackets were placed in an ideal tooth position to avoid, as much as possible, premature contacts. Resin was polymerized by aiming the curing lamp at the occlusal surface of the bracket base for the total curing time. Brackets of patients in the LED and halogen groups were polymerized for 3 and 30 sec respectively. Patients were given standardized instructions to avoid excessive occlusal pressure should tooth–tooth or tooth–bracket interarch interferences occur.

All brackets were bonded in one appointment and patients were unaware of which curing light system was used. Active wires were placed immediately thereafter. The wire sequence in all patients was

	LED	Halogen	Total
Brackets (n)	600	600	1200
Failures (n)	11	12	23
Percent failed (%)	1.83	2.00	1.92
Two-sided Fisher's exact test (p)	1.00 (ns)		
Mean survival time (days)	721.20	719.56	720.38
95% Confidence interval			
Lower bound	714.91	712.52	715.76
Upper bound	727.49	726.60	724.99
Logrank test of equality (p)	0.83 (ns)		
ns, Not significant			

Table 2: Bracket failure comparison between LED and halogen lamps

	Bracket failures (%)		
Months	LED	Halogen	Total
0–6	30.40	43.50	73.90
6–12	8.70	0.00	8.70
12–18	4.30	0.00	4.30
18–24	4.30	8.70	13.00
TOTAL	47.80	52.20	100.00

Table 3: Bond failure percentages according to time period

0.014”, 0.016x0.016”, 0.016x0.025” nitinol and 0.016x0.022” stainless steel (G&H, arch form Europa). Patients received the same appliance home care instructions and were seen at 6-week intervals. They were instructed to brush with a manual toothbrush, according to the modified Bass method[37] twice daily and with toothpaste.

Both patient groups were monitored for a period of 24 months. Data collected during the retrospective chart review included type of curing light, date of initial bonding, date of reported bond failure and tooth number associated with the failure.

The duration of retention of each bracket was calculated as the difference between the initial bonding date and date of reported bond failure. Only the first bond failure event per tooth was recorded for analysis.

Because of the retrospective nature

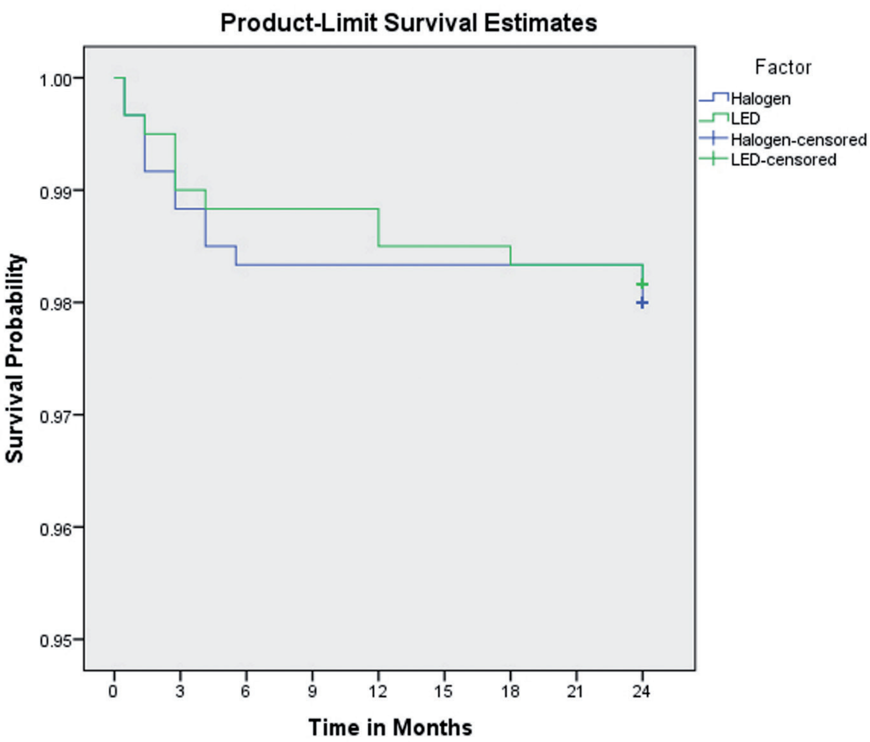

Figure 3: Kaplan–Meier survival plot

Parameter	Standard robust error	Wald χ^2	z	p>{z}	Hazard ratio (HR)	95% Confidence interval		Label
						Lower	Upper	
Factor	0.31	0.07	-0.27	0.79	0.92	0.48	1.76	LED
Standard error adjusted for 60 clusters in patient								

Table 4: Cox proportional-hazards regression analyzing LED curing lamp

Parameter	Standard robust error	Wald χ^2	z	p>{z}	Hazard ratio (HR)	95% Confidence interval		Label
						Lower	Upper	
Factor	0.32		-0.09	0.929	0.97	0.50	1.87	LED
Gender	0.34		0.10	0.919	1.03	0.54	1.98	Male
Age (years)	0.13		-0.92	0.357	0.87	0.65	1.16	-
Position		18.65						
Posterior vs. anterior	2.07		3.02	0.003	4.30	1.67	11.09	Posterior
Maxilla vs. mandible	0.28		-1.02	0.307	0.64	0.27	1.51	Maxilla
Standard error adjusted for 60 clusters in patient. Also, adjusting for age, gender and tooth position.								

Table 5: Cox proportional hazards regression analysis accounting for confounding factors

of the study and because all patients previously had full-mouth bondings completed in a single visit, a split-mouth study design was not possible. Statistical analyses were computed with SPSS© Statistics Version 20 (IBM Corporation, New York). Variables were curing method (LED vs. halogen), gender, arch (maxilla vs. mandible), location within the arch (anterior vs. posterior) and time saving. Cumulative bracket survivals were plotted using the Kaplan–Meier method and the cumulative survival between groups was compared using the logrank and Fisher's exact tests. Risk factors affecting survival were assessed by the Cox proportional hazards regression model. The level of significance was set at $p<0.05$.

RESULTS

No pulp, gingival or other negative side effects were reported during the course of the study. No patients ended treatment or transferred during the 24-month observation period. Of the 1200 initially bonded brackets, there were a total of 23 failures (1.92%), of which 11 (1.83%) occurred in the LED and 12 (2.00%) in the halogen group (*Table 2*). The difference in the overall bracket failure recorded between the case and control groups was not statistically significant ($p=1$) (*Table 2*). Most bracket failures (73.90%) occurred during the first 6 months of treatment (*Table 3*). The Kaplan–Meier survival analysis showed that the total mean survival time of brackets was 720.38 days (23.66 months). The mean survival time was 719.56 days (23.64 months) for brackets in the halogen group and 721.20 days (23.69 months) for brackets in the LED group (*Tab. 2, Fig. 3*). No difference in bracket survival was found between the two curing methods (logrank test $p=0.83$) (*Tab. 2*). Using the Cox proportional hazards regression analysis (HR) and clustering within patients, there was no significant difference in bracket failure probability between the two curing methods (HR=0.92, $p=0.79$) (*Table 4*).
Adjusting for variables such as age, gender and arch, the HR remained non-significantly different for both groups (HR=0.97, $p=0.929$) (*Table 5*). The only significant category in the analysis was posterior teeth, which had a higher probability of bracket failure compared to anterior teeth (HR=4.30, $p=0.003$) (*Table 5*).
Although pooled data from both curing light groups and dental arches showed an increased failure rate on posterior teeth ($p=0.001$), no advantages could be attributed to the use of either curing light in

	Total bonded (n)	Failed (n)	Failure (%)	Two-sided Fisher's exact test (p)
Bracket position				
Anterior	720	6	0.83	0.001 (s)
Posterior	480	17	3.54	
Posterior segment only				
LED	240	9	3.75	Approx. 1 (ns)
Halogen	240	8	3.33	
s, Significant; ns, not significant				

Table 6: Segment failures in pooled arch bondings and effect of curing method on posterior segment

Type of light	Total brackets	Polymerization time per bracket (sec)	Polymerization time per patient* (sec)	Total polymerization time in the study (h)	Time saved per patient bonding by LED light use	Total time saved by LED light use during the study
LED	600	3	60	0.50	9 min	4.5 h
Halogen	600	30	600	5		
*Assumes bonding of 20 teeth (second premolar to second premolar in both arches)						

Table 7: Time savings represented by usage of LED lamp.

decreasing this tendency ($p>0.05$) (*Table 6*).

The use of the LED lamp resulted in 9 min of time saved per patient compared to the use of the halogen lamp in a 20-teeth bonding procedure (*Table 7*).

DISCUSSION

This study demonstrates that there are no differences in bracket survival between brackets bonded with the Optilux 501 halogen and the FlashMax 2 LED lamps during the first 24 months of treatment. This finding remained consistent independently of age, gender or interarch appliance position. Brackets located on posterior teeth had a lower survival probability compared to those located on anteriors, independent of the curing method used. Neither the use of LED nor the use of halogen units proved advantageous in decreasing posterior failures. The use of the LED lamp resulted in significant time savings. Kaplan–Meier survival analysis showed that bracket survival probability was equal during the 24-month observation (censored) regardless of the type of light-curing unit used. Although a slightly higher probability of survival was present in the LED group during the first 18 months of treatment, this difference was deemed not significant by the logrank test. The bracket failure rates of 1.83% in the LED group and 2.00% in the halogen group were more favourable than those previously reported in the literature.[6,16,38–40] Possible explanations for this could be differences in patient habits, diet and operator skill. In a three-month study by Layman and Koyama,[41] which compared LED to halogen light polymerization, bracket failure rates of 1.9% were seen in the LED and 4.9% in the halogen group, with no statistically significant difference between the two groups. These rates are more comparable to those from our study considering that all brackets were placed by a resident in the Layman study.

When comparing bond failures of brackets in the LED versus halogen groups, no significant differences were detected. This finding is consistent with those of a similar study, by Krishnaswamy and Sunitha[16]. In their 15-month study, even though the curing time was much longer (10 sec) and the LED unit less powerful (440–480 nm, up to 1000 mW/cm²), bond failure rates in the LED group were not significantly different from those in the conventional halogen light group. In contrast to our finding, a significant difference was seen in bond failure rate between the maxillary and the mandibular arches, but this was not related to the type of polymerization lamp.

A significantly higher bracket failure rate was found in the posterior (probability of failure four times higher) versus the anterior segment, independent of curing method used. This is in agreement with previous reports, which suggest that difficulty of moisture isolation and poor access and visibility in the posterior dentition may result in more failures for posterior teeth.[6,23,38,42] Other factors such as the surface of premolars having more aprismatic enamel that could affect micromechanical bond properties may also contribute to higher bond failure rates[16].

Most bond failures occurred within the first 6 months of bracketing, which was also not related to the type of light used in curing the adhesive. Early bond failures were also seen by Krishnaswamy and Sunitha[16] and O'Brien et al.[38] Factors such as patient acclimatization to appliance, occlusal interference with brackets during the early stages of treatment and poor technique during bracket placement could explain the early nature of bracket failures.

In vitro studies on bond strength have reported no significant differences between LED and halogen lights[20,32] and have asserted that exposures ranging from 10 to 20 sec for LEDs are sufficient for producing optimal resin bond strength.[43,44] The Penido et al. study, which examined shear bond strength of brackets bonded to enamel using LED or halogen, concluded that the type of light-curing unit does not interfere with shear bond strength in both in vitro and in vivo settings.[31] Although our study did not test bond strength, the comparable debonding rates between the LED and halogen curing units would suggest that curing brackets for 3 sec with the LED light provides sufficient bond strength for orthodontic bracket retention.

We conducted an analysis to quantify the time-saving benefits of the LED light compared with the halogen unit. The aggregate light exposure time for the bonding of 600 brackets with LED light took approximately 30 min (0.5 h) considering each bracket was cured for 3 sec. In contrast, the aggregate light exposure time for bonding the same number of brackets with the halogen light took a cumulative time of 300 min (5 h). Thus, the total clinical time-saving advantage provided by the LED unit was 4 h and 30 min. This translates to 9 min of time savings per patient assuming a bonding from second premolar to second premolar. Other studies have shown similar time saving advantages of LED over halogen-curing units.[33,38]

Because there were no negative symptomatic reports from patients at any point during treatment, it is our opinion that the higher power of the FlashMax2 LED light is not iatrogenic to dentoalveolar tissues. This is likely due to the short exposure time required for polymerization[29]. Ophthalmic tissues, however, do require protection as focused short-wavelength light could predispose them to premature retinal ageing and macular degeneration[45]. Therefore, eye protection allowing transmission of less than 1% of light with wavelengths below 500 nm is recommended during bracket polymerization[46]. This point

becomes critical for operators and possibly patients as technological developments allow for the introduction of lamps producing increasingly higher intensities.
Despite the limitations present in case-control trials such as unknown confounding factors, we feel the results of this study are highly reliable since all bondings were conducted by a single experienced operator and a limited number of variables were analyzed. Our results are similar to those of prospective studies that have demonstrated the reliability of LED curing units in orthodontic bonding procedures[16,47].
Future research should concentrate on the evolution of LED lamp technology as it will arguably become the most efficient of all polymerization methods.

CONCLUSIONS

In this case-control trial, we conclude that there are no differences in resulting bond failures between brackets cured with FlashMax 2 LED and Optilux 501 halogen. Brackets on posterior teeth were four times more likely to fail compared to anterior teeth, independent of polymerization lamp. The LED unit provides a 9 min timesaving per patient compared to halogen, without increasing the probability of bracket debonding.

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X-RAY ODDITIES

Many times, when we see in our practice a radiograph, we have the opportunity to note images that may or may not influence directly our diagnosis and our treatment plan.
This column of EJCO gives us the opportunity to show these images and to make some brief observations about them. The style is concise: the images largely speak for themselves.
Your suggestions for future topics as well as your comments will be very welcome.

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An Unusual Crepitus

The patient, a 55-year-old woman, presented to the dentist with crepitus of the left temporomandibular joint (TMJ) during opening and closing of the jaws. Anamnesis showed that the patient had breast cancer with cerebral metastasis and for this reason had received radiotherapy (RT) to the head. Clinical examination revealed no pain, and no limitations in functional movements were present. Computed tomography of the left and right TMJ showed air in the upper and lower compartments of the left TMJ with perforation of the intra-articular disk (*Figs. 1, 2*). The images showed discontinuity of the posterior wall of the left TMJ cavity corresponding to the anterior wall of the external auditory canal (*Fig. 3*).

DISCUSSION

Crepitus of the TMJ during functional movements of the jaw generally appears very late in degenerative joint disease according to Piper's classification of intracapsular temporomandibular disorders. A palpable crepitus is detectable in Stage V when a perforation of the disk is present together with chronic degenerative joint disease. In most patients, the TMJ can support a firm load with no discomfort[1]. In some cases, air inside the joint can create a sensation like crepitus palpable or heard by the patient during functional movements of the mandible. The presence of air in a closed joint space like the TMJ is a vacuum phenomenon called cavitation. Lack of fluid within the articular cavity creates a negative pressure that attracts gas from adjacent tissues into the spaces[2]. Sometimes air can be also present in the glenoid fossa of the TMJ in the case of temporal bone fractures[3]. The anatomic relationship between this part of the temporal bone and the TMJ enables air to pass from the auditory canal into the joint[4]. Moreover, osteoradionecrosis after RT for head and neck tumours can induce resorption of the bone of the posterior wall of the TMJ cavity, allowing the passage of air from the external auditory canal into the articular capsule of the TMJ.

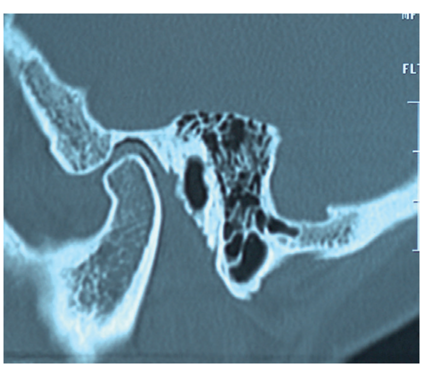

Figure 1: Sagittal reconstruction of the left temporomandibular joint. Note the air in the upper and lower compartments of the joint.

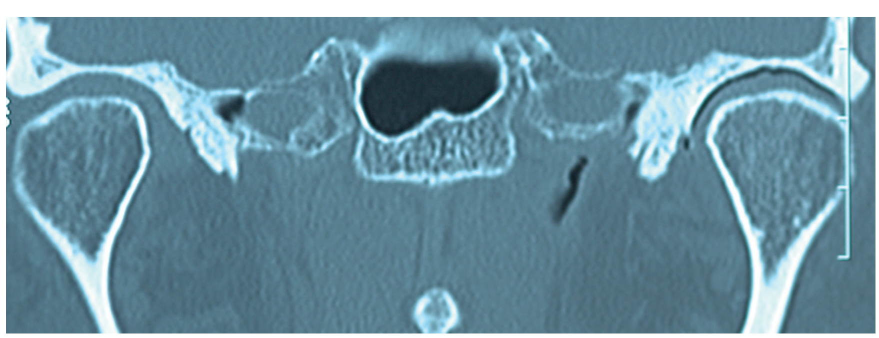

Figure 2: Coronal reconstruction of the left temporomandibular joint. Note the air in the upper left compartment.

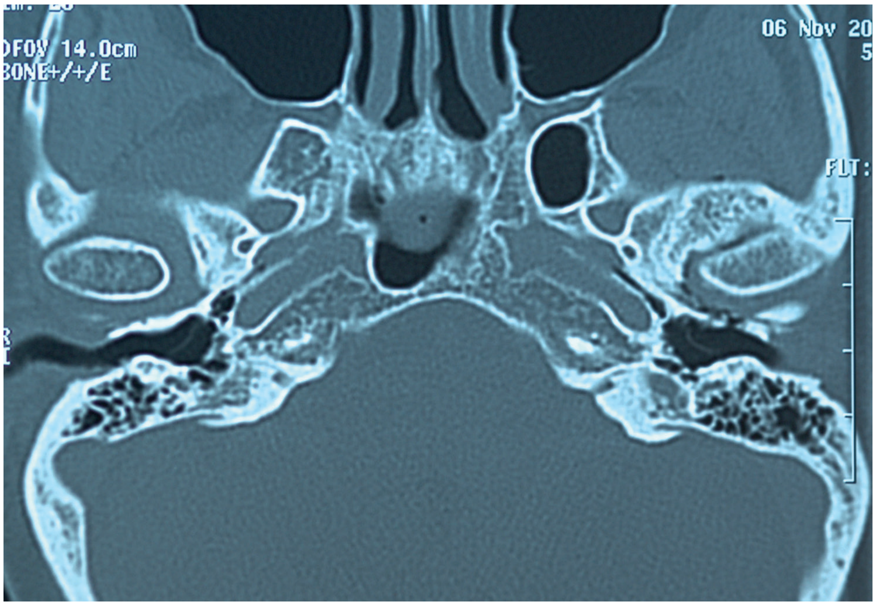

Figure 3: Axial scan of the temporomandibular joint (TMJ). Note the discontinuity of the posterior wall of the left TMJ cavity corresponding to the anterior wall of the external auditory canal, allowing air to pass in.

Images courtesy of Studio Radiologico D'Ambrosio, Rome, Italy

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Case Reports and Case Series

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Case Reports and Case Series are descriptive observational studies[1]. Their characteristic is that there is no control group so they do not permit of effective or reliable analysis. The case studies are the base level of hierarchy of evidence[2], and even though very exposed to the possibility of bias they do have great clinical utility.
The simplicity of Case Reports mean that in theory any clinician can organise and carry them out.
Despite a high number of dentistry publications being Case Reports, little attention is paid to appraisals of their quality.
Recently a series of publications[3-5]took into consideration the CARE guidelines that give the key points that should figure in a good Case Report.
The Case Reports website (http://www.care-statement.org/index.html) provides a template for the proper writing of Case Reports and has some interesting links to other resources that we shall look at in the next issue.

According to the instructions on how to prepare case reports published in the BMJ (British Medical Journal) Case Reports - "Instructions for authors" section - case reports should address the following subjects

- *Remind of important clinical lesson*
- *Findings that shed new light on the possible pathogenesis of a disease or an adverse effect*
- *Learning from errors*
- *Unusual presentation of more common disease/injury*
- *Rare disease*
- *New disease*
- *Novel diagnostic procedure*
- *Novel treatment (new drug/intervention; established drug/procedure in new situation)*
- *Unusual association of diseases/symptoms*
- *Unexpected outcome (positive or negative) including adverse drug reactions*

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The Columbus Spring

Ensuring torque movement of front incisors is one of the most challenging tasks when planning orthodontic treatment.
The Columbus spring is a simple device that has recently been patented and introduced to the market with CE certification.
The kit comes with a 0.017×0.025 TMA auxiliary arch and two laser-welded SS springs.
The arch intrudes or extrudes the teeth according to the bends provided (*Fig. 1*). The springs are placed at the level of the teeth that require torque, with the spring's free end engaged within the 0.020 vertical slot of the bracket (*Figs. 2 and 3*).

The auxiliary archwire must then be tied to the main arch.
As the torque is provided by the Columbus spring, a full thickness archwire is not required for this task; this allows torque movements to be planned at the initial phase of treatment and in association with other mechanics.
The segmented approach that is proposed allows:

- compatibility with most common brackets on market;
- torque control from the early stages of treatment, in association with other mechanics;
- more gentle forces applied on the element;
- low load/deflection ratio thanks to TMA wire and snail shape of the spring;
- more rational selection of the anchorage teeth

Moreover this device avoids:

- friction
- bone-anchorage need
- patient compliance

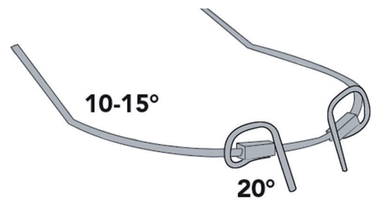
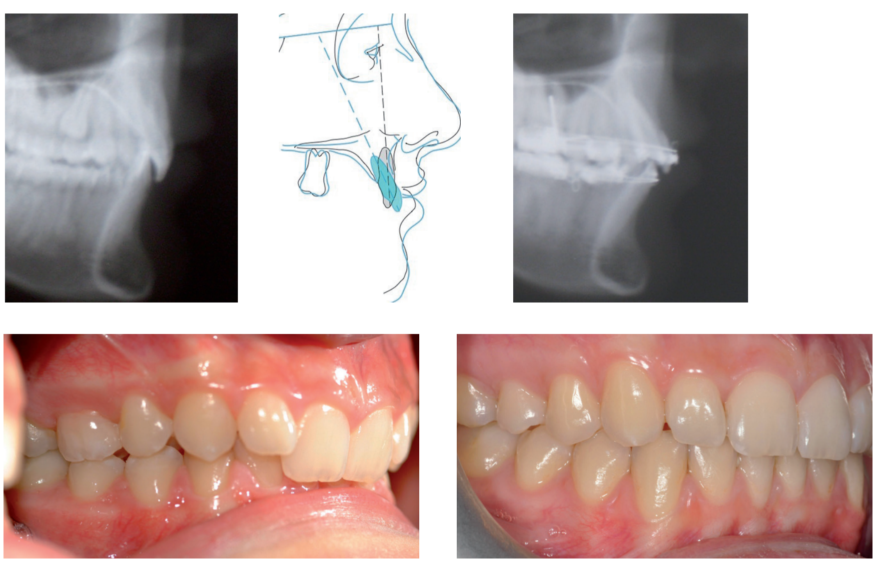


Figure 1: The Columbus springs device consists of a 0.017×0.025 TMA archwire with two crimpable springs (0.018 SS) in the anterior region.



Clinical example: 25° Of incisor torque in 6 months

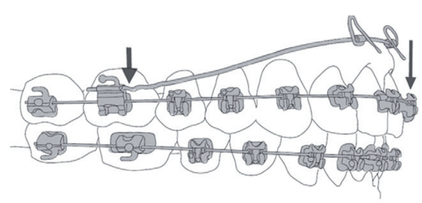


Figure 2: The auxiliary archwire, with activation, before engagement.

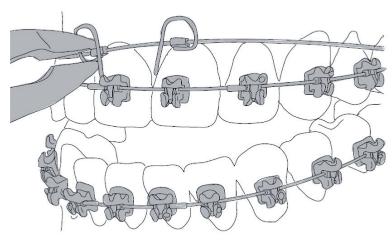


Figure 3: The Columbus springs, activated for torque correction (20° bend), are crimped to correspond with the vertical slots of the incisor brackets and then inserted in them.

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