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LETTER FROM
THE PRESIDENT

Every Mouth Has its Tongue

Giampietro Farronato
2015 SIDO President
and EJCO Editorial Director

Dear Colleagues,

In order to enhance its role in Europe and in the world, SIDO started time ago a process of internationalization as well as cultural and scientific dissemination which is now yielding excellent results. In recent years, the orthodontic profession has evolved to such a point as to require a thorough knowledge of the new scientific methods in order to appropriately apply increasingly advanced interdisciplinary techniques and methodologies. The "European Journal of Clinical Orthodontics" (EJCO) represents this scenario – and two years after the first issue was published, its "mission" in the field of scientific publication is fully confirmed. Along with Progress in Orthodontics (PiO), a journal dedicated to research, EJCO completes the cultural expression of an internationally recognized and long-standing scientific society based on shared ethics, technological evolution, professionalism and a strong identity as well as a close collaboration with other dental disciplines.

Today, the prestige and scientific value of SIDO are recognized also abroad, evidenced by the 990 international members and affiliates, as well as increasing number of subscribers, readers and editors from different countries.

This issue of the "European Journal of Clinical Orthodontics" (EJCO) coincides with the 46th SIDO International Congress entitled "Interdisciplinary Orthodontics in children and adults", which has attracted a record participation of international professionals.

The scientific sessions, which have been organized in collaboration with the Italian Society of Periodontology and Implantology (SIdP), present titles of great interest, such as "Combined Orthodontic and Periodontal treatment throughout life" and "The complex Orthodontic and Periodontal patient". These events are open to orthodontists, periodontists and dental hygienists.

During the preparation of the Congress, SIDO designed a multi-ethnic project called "Italy for oral health in the world - every mouth has its tongue", which has been presented along with other projects in the Italian Pavilion at EXPO. It is focused on the available scientific knowledge concerning oral health in its broadest sense, and it has developed a 'road map' to be completed during the workshop organised at the Auditorium of the Italian Pavilion on the last day of EXPO.

The event is scheduled to take place on the morning of October 30 and will be the conclusion of various workshops dedicated to multi-disciplinary and multi-ethnic issues. The great wealth of knowledge held by the participating scientific societies will be focused on issues to be discussed by professional experts coordinated by a moderator. Their activity has produced a collection of scientific articles published in our journal "Progress in Orthodontics" (PiO). On the same day, in the afternoon, SIDO has organized another event "Prevention for health preservation and money saving". The meeting is open to the public and will be attended by experts who have collaborated with our scientific society for several years.

Representatives of the Bracco Foundation, the Ministry of Education, Universities and Research, the University of Milan, teachers and students of some Milan schools will discuss the importance of certain behaviors which can help us maintain our good health. They will talk about healthy food which benefits the whole body underlining that it is essential to make the right choices from an early age. They will focus also on preventive healthcare starting at school through initiatives such as the one promoted by SIDO "Objective 0 caries" aimed at primary and middle school students and on other initiatives aimed at improving multi-ethnic integration, such as a medical education project promoted in collaboration with Opera Pia S. Francesco - a project which also required a mime play to overcome language barriers. The event will also include an official presentation of The Orthodontic Tutor, an app created and produced by SIDO which permits oral cavity monitoring of children and adults.

At the end of the day, the title of "Oral Health Ambassador" will be awarded to teachers and students who have created the prevention project with sincere thanks to all those who have collaborated as volunteers in order to promote the importance of oral health and healthy eating to protect the wellbeing also of those people who might not be confronted with these themes on their way through life.

Carlo Bonapace
Private Practice of
Orthodontics, Turin, Italy

Correspondence:
Corso Re Umberto, 97 - 10128 Turin, Italy
e-mail: doctor@studiobonapace.it

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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.

William Clark

William Clark graduated in dentistry in 1960 from the Dundee Dental School, at that time part of the University of St. Andrews. After graduating, he was House Surgeon in the Orthodontic Department, with James McEwen and Sandy Cockburn, who provided an excellent grounding in the orthodontics of that era.
Within a year he joined Peter Cousins in his orthodontic practice in Cardiff. This experience allowed him to return to the Glasgow Dental Hospital in 1963 as Registrar in Orthodontics, and to study for the Diploma in Dental Orthopaedics (D.D.O., R.C.P.S.) in Glasgow.
In June 1965 he set up the first full time orthodontic practice in Scotland. The practice was in his home and opened 6 weeks after the birth of his daughter. His wife, Sheila, was secretary and chairside assistant, as well as mother, cook and general factotum!
He developed Twin Blocks in 1977 and the first course on these appliances was held in his new practice in Kirkcaldy in 1979. He invited prominent orthodontists in Britain to witness the introduction of a new technique. Philip Adams and Harry Orton attended the second course in St. Andrews.
In 1991 he gave the first live teleconference in clinical dentistry. A full day course on Twin Blocks was televised in Chicago and streamed to 25 cities in the United States and Canada. This put Twin Blocks on the global map and Dr. Clark subsequently presented courses in more than 50 countries.
In 1995 Mosby published the first edition of "Twin Block Functional Therapy: Applications in Dentofacial Orthopedics", followed by the second edition in 2002, with editions in English, Spanish, German, Italian, Russian, Japanese and Korean.
The third edition was published recently by Jaypee Brothers Medical Publishers. Among other innovations, the book contains new information on Fixed Twin Blocks and introduces TransForce lingual appliances for arch development from mixed dentition to adult therapy.
William Clark has always been a clinician. He studied the bioprogressive technique with Carl Gugino in the 1980's. To complete his education in the fixed technique, he attended a 10-day course at the Tweed Foundation in 1986, and in 1990 was admitted to membership of the British Orthodontic Certification Board after examination to the same exacting standards as the American Board. After inventing Twin Blocks, he had to choose either to continue to practice full time or to reduce his practice commitments in order to travel and teach around the world. He retired from full time practice in 1990 but continued to practice part time, travelling to Portugal five times a year for the subsequent 23 years.
In the 1990's he travelled with Dr. Ricketts, supported by Rocky Mountain Orthodontics, teaching Twin Blocks, the bioprogressive technique, the Wilson modular system, arch development, the labio-lingual technique, and the straight wire technique.
Having practised lingual arch development for 25 years, he developed TransForce lingual appliances in cooperation with Ortho Organizers in 2004. Finally, he developed Fixed Twin Blocks after 15 years of clinical testing. A new design and protocol will be launched this year, subject to approval by world health authorities.
In 2010 he completed a thesis for Doctor of Dental Science, based on a lifetime of orthodontic practice and research.
He has published three e-books that provide a comprehensive account of advances in fixed and functional therapy. One of them, "Faces & Braces", is designed to educate patients and parents by illustrating the benefits of orthodontic treatment. These books represent an anthology of orthodontic technique in digital format.
Currently, he continues to travel and teach a wide variety of fixed and functional techniques. Of course his adventures in orthodontics have required many years of dedication and tolerance by his wife and family. In his own words, "My wife, Sheila, must be a saint!".
His interests outside orthodontics focus on sport, art and music. He plays golf and tennis, and enjoys playing jazz on clarinet and saxophone. He likes travelling with his wife and attending exhibitions, the theatre, concerts and recitals.

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CLINICAL ARTICLE

New Horizons in Orthodontics

William J. Clark
Private Practice of Orthodontics,
Lundin Links, Scotland, U.K.

Correspondence:
e-mail: twinblocks@mac.com

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Conflict of interest:
William Clark holds patent rights for Fixed Twin Blocks.

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Abstract

Paradoxically in the early development of orthodontics Edward Angle (1907) and Pierre Robin (1902), the founding fathers of fixed and functional therapy both developed techniques based on the form and function philosophy.
The subsequent evolution of fixed and functional therapy followed separate paths. After a century of progress these paths continue to diverge.
The genetic paradigm has remained the fundamental basis for orthodontic treatment throughout the last century. This concept fails to recognize the potential of functional appliances to influence significantly the pattern of facial growth by the application of orthopaedic forces. Twin Blocks use the forces of occlusion to maximise the growth response for functional mandibular protrusion. Twin Block appliances increase the pharyngeal airway.
Orthodontists have agonised over the question "Does functional therapy enhance mandibular growth?" New evidence continues to emerge from scientific studies using the improved technology of magnetic resonance imaging, 3D scanning, histological studies, and genomic studies at cellular and molecular level.
We can no longer rely on two dimensional cephalometric studies as the only source to perpetuate an outdated concept that has limited the objectives of orthodontic treatment to moving teeth through alveolar bone.
The challenge of functional therapy is to maximize the genetic potential of growth and guide the growing face and developing dentition toward a pattern of optimal development. Changes in posture and function aim to extend the holistic benefits of treatment beyond the limited objectives of correcting dental malocclusion.
In future we must grasp the nettle of growth to treat the face and help our patients breathe better.

Keywords
Twin Blocks, forces of occlusion, pharyngeal airway, functional treatment objectives, holistic benefits of treatment

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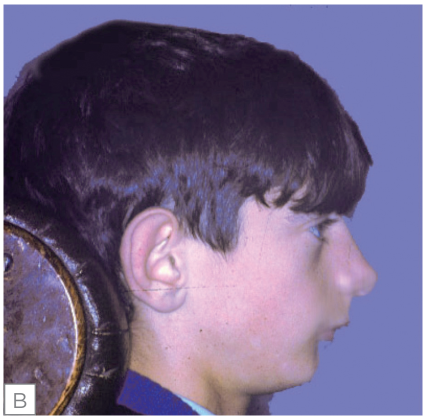

Figure 1: (A) Model of a severe Class II division 1 malocclusion treated in 1963 by extraction of upper first premolars. (B) The patient's profile after treatment failed to correct the mandibular retrusion.

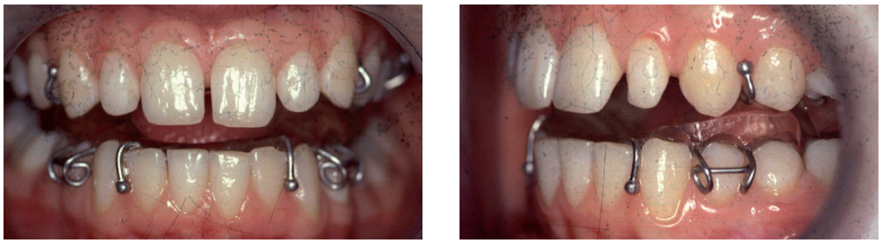

Figure 2: Twin Blocks are designed to be aesthetic and comfortable for full-time wear.

THE GENETIC PARADIGM

In the early 1960's British orthodontic education was based on the premise that genetic factors controlled all aspects of skeletal and dentofacial development. This included a genetic blueprint for skeletal craniofacial development and even extended to inherited traits of soft tissue posture and behaviour[1-3].

The concept of genetic control of the pattern of maxillofacial development in that era was based on clinical observations and serial growth studies following the development of the cephalostat by Broadbent[4].

These studies formed the basis for the genetic paradigm, a philosophical approach to orthodontic treatment, where the existing skeletal framework was accepted as genetically predetermined and not subject to environmental factors. This concept denied the influence of functional therapy on the development of the dentition and the underlying bony support.

THE TURNING POINT

In 1963 during my orthodontic training in Glasgow, I treated a patient with a severe Class II division 1 malocclusion due to mandibular retrusion. According to the prevailing view, it was not possible to advance the mandible. Case selection for functional therapy was confined to a favourable Class I or mild Class II skeletal base, where dental correction with night-time wear could be achieved. I was advised to extract the upper first premolars and retract the upper anterior teeth, accepting the retrusive position of the mandible and the lower dentition. This did not address the fundamental problem of mandibular retrusion. After treatment the upper incisors were severely retroclined with excessive overbite *(Fig. 1)*.

This patient's treatment had a profound effect on my subsequent approach to the treatment of Class II malocclusions. Whenever possible in the years following this experience, I used night-time functional appliances with partial success.

THE FUNCTIONAL MATRIX HYPOTHESIS

Melvin Moss[5,6], professor of anatomy at Columbia University, described the functional matrix hypothesis. This supports the premise that function modifies anatomy. The fundamental basis for this hypothesis is that bones do not *grow* but *are grown*, thus stressing the ontogenetic primacy of function over form. This is in contrast to the current conventional scientific wisdom that genomic (i.e. genetic), rather than epigenetic (non-genetic) factors, control such growth. Recent stem cell research now adds scientific support to the functional matrix hypothesis, confirming that stem cells move to a site in response to functional stimulus[7].

TWIN BLOCKS

Twin Block appliances are simple bite blocks that are designed for full-time wear. They achieve rapid functional correction of malocclusion by the transmission of favourable occlusal forces to occlusal inclined planes that cover the posterior teeth. The forces of occlusion are used as the functional mechanism to correct the malocclusion.

In 1977, I developed Twin Blocks for full-time wear including while eating. My goal was to employ a technique that could maximize the growth response for functional mandibular protrusion. Twin Blocks are designed to be comfortable and aesthetically acceptable to the patient *(Fig. 2)*.

Twin Blocks are constructed to a protrusive bite that effectively modifies the occlusal inclined plane by means of acrylic inclined planes on occlusal bite blocks. The purpose is to promote protrusive mandibular function for correction of the skeletal Class II malocclusion due to mandibular retrusion. The occlusal inclined plane acts as a guiding mechanism causing the mandible to be displaced downward and forward.

In 1977, I still believed that it was not possible to advance the mandible. My focus was to retract the maxilla and at the same time to try to advance the mandible to correct a distal occlusion. Initially the Twin Block Traction Technique combined extra oral traction to retract the maxilla with occlusal inclined planes to advance the mandible[8-10].

TREATMENT EFFECTS OF TWIN BLOCKS

My first statistical analysis examined 83 consecutively treated patients who commenced treatment between 1977 and 1982 with the Twin Block traction technique. A computer-literate friend developed a programme on a mainframe computer before we had

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access to desktops and laptops. Finally, I was able to demonstrate statistically significant improvements in correction of Class II skeletal base relationships, but mainly by maxillary retraction.

This study was completed in 1985 and confirmed the headgear effect, with excessive maxillary retraction and limited mandibular advancement. Upper incisors were retroclined after treatment with increased overbite. This convinced me to abandon extra-oral traction and I have never used it again to this day. I threw out my headgear, to the relief and benefit of my patients. Subsequent analysis showed improved mandibular growth and advancement without the addition of traction components.

TREATMENT TIMING

The response to treatment varies according to treatment timing. When treatment commences during a period of slow growth, treatment time is increased to compensate. The mandible grows slowly in early mixed dentition and treatment extends over a longer period and should be followed by a functional retainer until the permanent dentition is established.

Mixed Dentition Therapy

Case Report:
boy aged 8 years 9 months

This boy presents a disfiguring malocclusion in the early mixed dentition with the upper incisors extremely vulnerable to trauma as they rest completely outside the lower lip *(Fig. 3)*. The lower lip is trapped under an overjet of 15 mm. The lower incisors are biting into the soft tissue of the palate 5 mm lingual to the upper incisors. Early treatment is essential in this type of malocclusion in order to place the upper incisors safely under lip control.

Mandibular retrusion accounts for a convexity of 9 mm, which is evident in the profile. The maxilla is typically narrow with a full unit distal occlusion. The upper pharyngeal airway is severely restricted at 7 mm, due to the mandibular retrusion.

Orthopaedic correction to a Class I occlusion by Twin Blocks was followed in the permanent dentition by a short period of orthodontic treatment during which time fixed appliances were worn for a year to detail the occlusion.

The upper pharyngeal space increased from 7 to 11 mm after 1 year of treatment, then to 14 mm 2 years later and, finally, to 21 mm after 6 years.

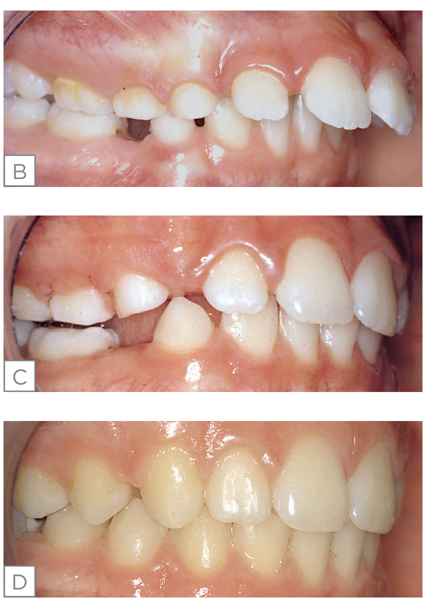
Adolescent Therapy

When treatment is timed to coincide with the pubertal growth spurt, it results in rapid mandibular growth and the treatment time is typically 6–9 months with Twin Blocks, followed by retention. This is typified by significant condylar extension.

Case Report:
girl aged 11 years 4 months

This young girl presents a disfiguring Class II division 1 malocclusion with an overjet of 17 mm and an excessive overbite *(Fig. 4)*. A combination of maxillary protrusion and mandibular retrusion has resulted in a severe distal occlusion and an equally severe transverse discrepancy with buccal occlusion of the upper premolars and a traumatic occlusion of the lower incisors in the palate. The malocclusion is further complicated by the congenital absence of the second lower premolar on the left side, resulting in displacement of the lower centre line to the left. The dramatic facial and dental changes in this case illustrate the benefits of a functional orthopaedic approach to treatment compared to a conventional orthodontic approach.

Before treatment, this patient has the typical listless appearance of many severe Class II division 1 malocclusions. This is evident in the dull appearance of the eyes and poor skin tone. A large overjet with a distal occlusion is



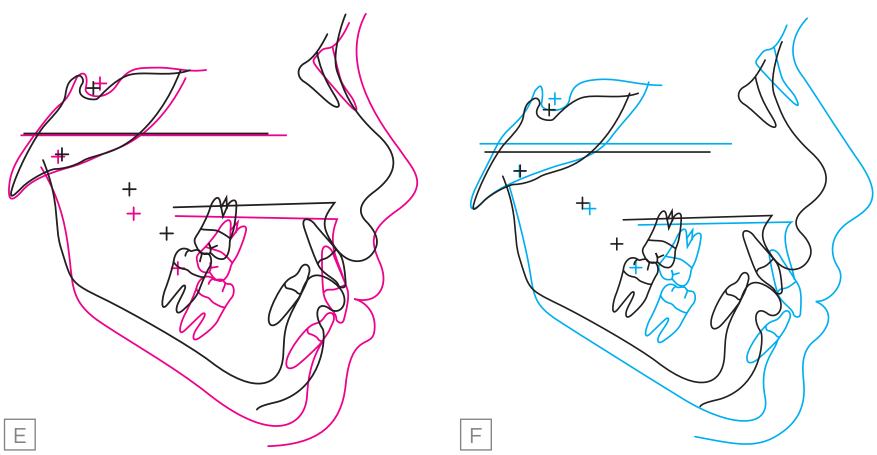


Figure 3 (A) Profile at ages 8 years 9 months (before treatment), 10 years 1 month and 14 years 11 months. (B) Occlusion before treatment. (C) Occlusion after 8 months. Twin Blocks were worn for 14 months. (D) Occlusion at age 14 years 11 months. (E) Growth response. T1: 8 years 9 months; T2: 10 years 1 month. (F) Before and after treatment. T1: 8 years 9 months; T2: 11 years 11 months.

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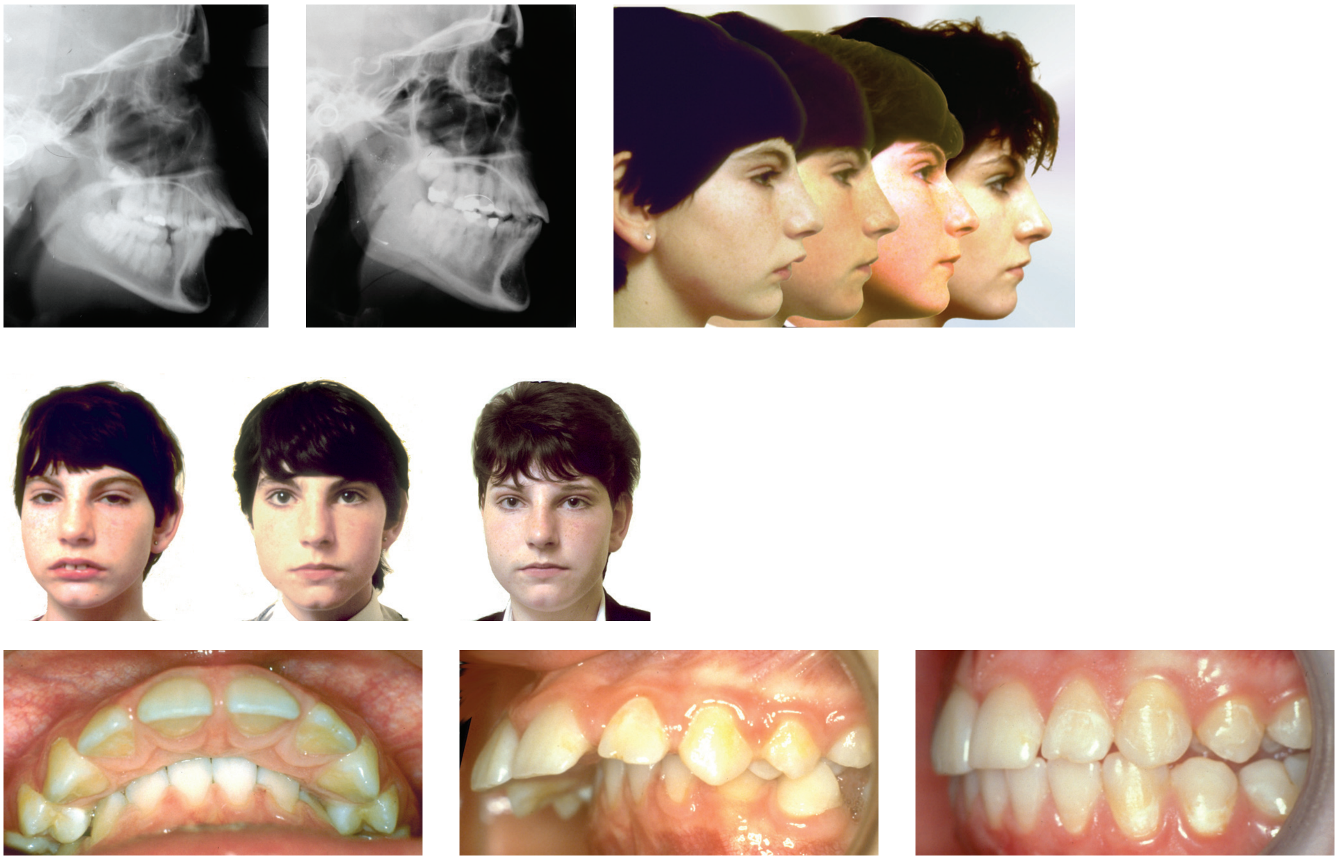

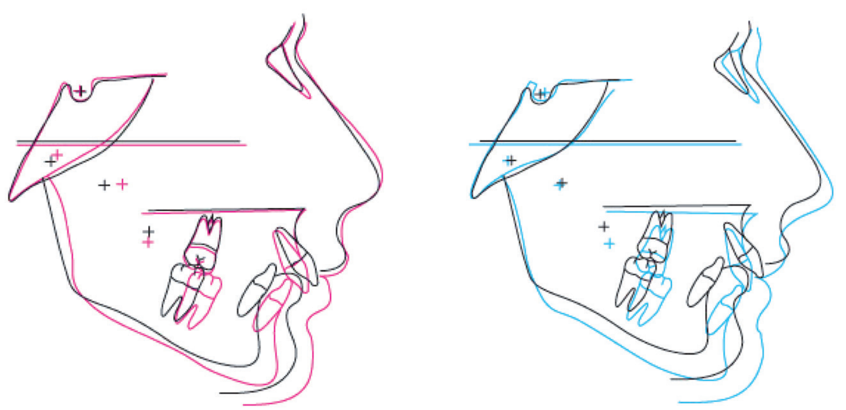

Figure 4: This patient with a severe Class II division 1 malocclusion experienced dramatic changes in facial appearance and profile within the first 3 months of treatment with Twin Blocks. After 11 months the occlusion was corrected to Class I. The profile before treatment, after 3 months, after 11 months, and 5 years later out of retention is shown. Cephalometric films before and after Twin Block therapy confirm that there is a significant improvement in the post-treatment pharyngeal airway.

frequently associated with a backward tongue position, and a restricted airway. These patients cannot breathe properly and, as a result, are subject to allergies and upper respiratory problems due to inefficient respiratory function.

After only 3 months of treatment, the patient undergoes a dramatic change in facial appearance, which exceeds the parameters of orthodontic treatment in this time scale. The patient appears more alert and there is a marked improvement in the eyes and the complexion. This is a fundamental physiological change, extending beyond the limited objective of correcting a malocclusion. The upper pharyngeal space increased from 5 mm before treatment to 20 mm after treatment. Increasing the airway achieves the crucially important benefit of improving respiratory function and may influence basal metabolism as a secondary effect. An increase in the pharyngeal airway is a consistent feature of mandibular advancement with a full-time functional appliance. This is the most significant functional effect of advancing the mandible, as opposed to retracting the maxilla in the treatment of Class II malocclusion.

Conventional fixed appliances with brackets cannot produce equivalent physiological changes in the treatment of patients with severe malocclusions. A functional approach achieves a rapid improvement in the facial appearance and can be followed by a simplified orthodontic phase of treatment to detail the occlusion. The treatment phases are as follows:

- active phase: Twin Blocks for 7 months;
- support phase: 6 months of full-time wear;
- orthodontic phase: 12 months.

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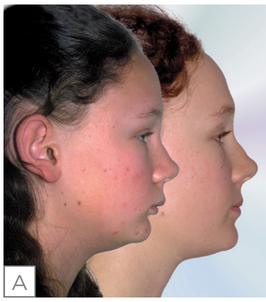
The composite profile photograph in *Fig. 4* shows the changes in appearance after 3 months, 11 months and 5 years. The facial photographs show the change after 3 months and 11 months.



Post Pubertal Therapy

Post-pubertal treatment is also slower and condylar extension does not occur. Instead a favourable response is more likely to be due to distal growth of the condyle. This response can be identified by an increase in the gonial angle.

Case Report: post-pubertal growth (teenage girl)

This girl was a late starter and was approaching 15 years of age when Twin Blocks were fitted *(Fig. 5)*. It may be tempting to consider surgery to assist correction for a girl who is past

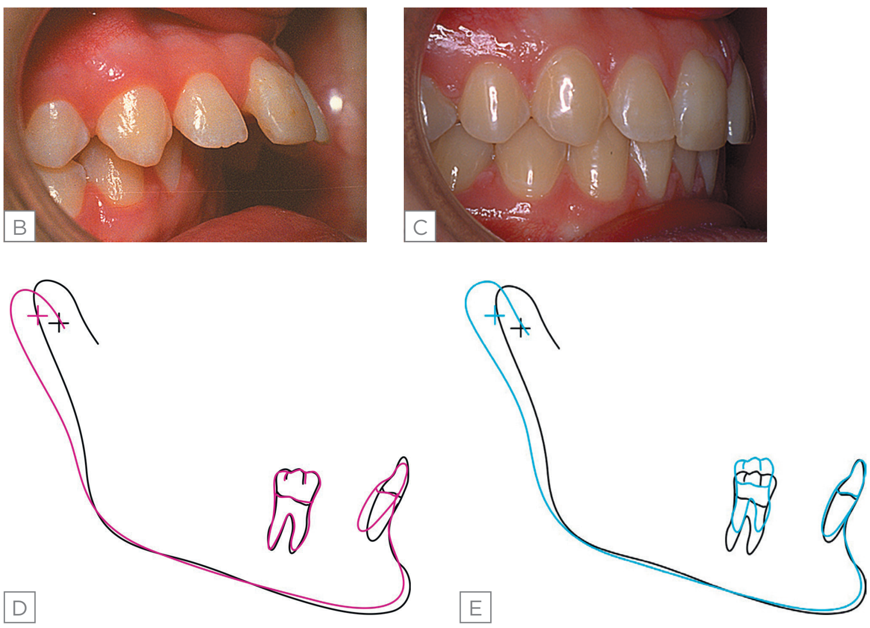


Figure 5: Progress during treatment of this severe malocclusion. (A) Profiles at ages 14 years 9 months (before treatment) and 20 years 2 months (out of retention). (B) T1: 14 years 9 months, occlusion before treatment. (C) T2: 17 years 3 months, occlusion after treatment. (D) Growth response during the Twin Block phase. T1: 14 years 9 months; T2: 15 years 10 months. (E) Post-treatment growth response. T1: 14 years 9 months; T3: 20 years 2 months.

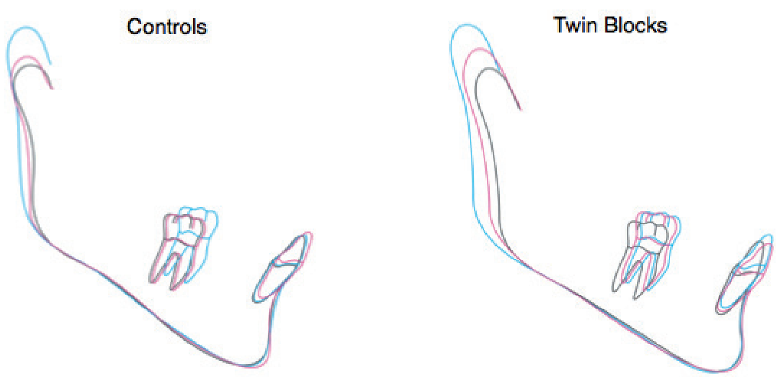


Figure 6: Tracings to compare the growth response in Twin Blocks and matched controls from the Burlington Growth Series in the Mills and McCulloch studies[10,11].

the pubertal growth phase and whose growth is virtually complete, especially as the pretreatment profile is poor.

This is an example of forward positioning of the mandible due to an alteration in the angle of growth of the condyle, as clearly shown in the mandibular superimposition. The distal direction of condylar growth is evident from the increased gonial angle. As a result the mandible rotates forward, significantly changing the shape of the lower face in profile.

Growth Response To Twin Block Therapy

The results are recorded in a thesis entitled "New Horizons in Orthodontics & Dentofacial Orthopaedics. Aspects of Twin Block Functional Therapy" for a D.D.Sc. degree completed in 2010 at Dundee University[11].

DOES FUNCTIONAL THERAPY ENHANCE MANDIBULAR GROWTH?

Mills and McCulloch[12,13] published studies of the treatment effects of Twin Blocks and post-treatment changes. This confirmed that Twin Blocks produced approximately three times the amount of mandibular growth compared to matched controls from the Burlington Growth & Research Centre in Toronto. Three years after treatment much of the gain in mandibular length during active treatment with Twin Blocks was maintained *(Fig. 6)*.

Condylar extension occurs during the Twin Block phase, increasing ramus height. This is followed by corpus extension during the support phase and retention as the posterior border of the ramus remodels more slowly to restore the original shape of the mandible.

It is important to observe that the condyle grows vertically in the controls, whereas the gonial angle increases in the Twin Block phase, due to a more distal growth vector of the condyle. This factor is responsible for improvement in the profile in post-pubertal patients, who do not exhibit condylar extension as observed in adolescents.

Paulsen[14] confirmed the formation of new bone in the posterior aspect of the condyle in response to hypertrophic chondrocytes in a sample of 100

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consecutively treated adults in Herbst treatment. These recent research findings using new technology contrast with Johnston's[15] lecture "Early and often: growing jaws for fun and profit", suggesting that functional appliances work temporarily by using up the mandibular growth potential in advance. Johnston proposes that there is a limited or pre-ordained amount of mandibular growth that can occur in any patient. This is pure speculation. There are no long-term studies to deny the potential of functional appliances to increase condylar growth beyond a pre-ordained amount. It is virtually impossible to prove. An article entitled "Functional appliances: a mortgage on mandibular position"[16] begs the question: "Did anyone tell the stem cells?".

SCIENTIFIC RESEARCH

Recent scientific research at the genomic, cellular and molecular level challenges this view in an article entitled "Functional appliance therapy accelerates and enhances condylar growth"[18]. This research studied the effects of a bite jumping appliance compared with untreated controls in a group of 150 rats at the cellular and molecular level.

A substantial increase was observed in the amount of newly formed bone when the mandible was positioned forward. Forward mandibular positioning accelerates and enhances chondrocyte differentiation and cartilage matrix formation in the mandibular condyle by accelerating and enhancing the expression of Sox 9 and type II collagen. This enhancement of growth did not result in a subsequent pattern of subnormal growth for most of the growth period, indicating that functional appliance therapy could induce true enhancement of condylar growth.

A second article by Rabie, Wong and Tsai[18], "Replicating mesenchymal cells in the condyle and the glenoid fossa during mandibular forward posturing" demonstrated the technique with histological results.

This research has important implications for case selection for functional therapy in the future. The mesenchymal cell count can be determined from a blood sample or salivary swab. This information may be used to identify patients with a high or low mesenchymal cell count, which has a direct bearing on the potential enhanced growth response to functional mandibular advancement.

Johnston and others observed that it was not possible to interpolate the results of animal experiments as identical to the response of patients to functional therapy. However, clinical studies now show conclusive evidence of the deposition of new bone in the condyle and glenoid fossa, confirmed by magnetic resonance imaging studies. The topics are summarized in publications on:

- temporomandibular joint remodelling in Herbst therapy[19];
- the pattern of bone remodelling that occurs in the mandibular condyle during Twin Block therapy[20];
- relocation of the condyle in the glenoid fossa after 6 months with Twin Blocks[21].

FIXED TWIN BLOCKS

After 38 years of experience using Twin Blocks, we have come a long way to proving conclusively that full-time functional appliances significantly increase mandibular growth when used correctly. I have tested Fixed Twin Blocks for the past 15 years. A new design and protocol for Fixed Twin Blocks is due to be released later this year as the next logical development to integrate fixed and functional techniques.

We should not forget that Pierre Robin's monobloc[22] was the first sleep apnoea appliance. He was not trying to correct a malocclusion, he was trying to keep his patients alive. More than a century later we are beginning to wake up to the potential of functional appliances to deliver significant holistic improvements to the health of patients by increasing the pharyngeal airway[22,24].

Dentofacial orthopaedics represents a positive approach to the treatment of craniofacial imbalance by addressing the underlying cause of the malocclusion in an effort to maximize the natural potential for corrective growth. It is in the treatment of muscle imbalance and skeletal disproportion that functional appliances come into their own.

Orthodontic and Orthopaedic Forces

In the Jacob A. Salzman lecture at the AAO Congress in 2008 Professor Peter Ngan presented the results of a study from the University of West Virginia of forces measured intra orally during function.

Orthopaedic forces are measured in pounds, as opposed to orthodontic forces measured in grams:

- chewing 58 pounds;
- swallowing 68 pounds;
- incising 85 pounds;
- posterior teeth 160 pounds;
- nocturnal grinding, 120 to 975 pounds.

It is quite staggering to observe the forces applied to the dentition. It is no wonder that patients wear down their teeth by nocturnal grinding.

Bony adaptation is a normal process in growth and development of the dentofacial skeleton. The muscles are the prime movers in dentofacial growth as a child matures into adolescence and adulthood. Functional therapy modifies muscle behavior to apply a stimulus, resulting in bony remodeling in the mandibular condyle and glenoid fossa.

Orthopaedic forces are beyond the level of tolerance of the periodontal membrane. The objective is not to move the teeth, but to harness the forces of occlusion to influence the underlying supporting bone.

Many spring loaded appliances are attached to conventional fixed appliances for correction of Class II malocclusion. However it is important to distinguish between appliance mechanisms that apply light forces to move teeth through alveolar bone and heavy forces that aim to correct jaw position. A recent cephalometric study[24] compared Twin Blocks and Forsus functional appliance. Both Twin Blocks & Forsus appliances stimulated mandibular growth compared to controls.

- control group increase 0.3 mm;
- Forsus appliance 1.6 mm, significant ($p<0.05$);
- Twin Block patients 6.02 mm, very highly significant ($p<0.001$);
- increase in mandibular length with Twin Blocks was equivalent to 3.75 times the increase with Forsus Appliance;
- there was no significant reduction in maxillary growth.

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The study concluded:
The Twin Block appliance produced greater skeletal effects in terms of mandibular advancement and growth stimulation while the Forsus caused significant proclination of the mandibular incisors.
The author participated in a finite element analysis to identify the localization of mandibular changes in a series of 99 patients with Class II Division 1 malocclusion treated with Twin Blocks[26].

INTEGRATING FIXED AND FUNCTIONAL THERAPY

We are still confined by the same restrictive concept that I was taught 55 years ago: the genetic paradigm persists as the basis of orthodontic teaching today.
We cannot continue to ignore a growing body of scientific evidence supporting the conclusion that functional appliance therapy produces significant modification in the temporomandibular joint with increased condylar growth and remodelling of the glenoid fossa.
We must move into the 21st century and be prepared to review outdated concepts. The younger generation are living in a brave new world with new knowledge based on advances in technology, magnetic resonance imaging, 3D scans, genomic research and improved investigative techniques.
This is a new paradigm.
To combine the best of both worlds it is necessary to integrate the disciplines of fixed and functional appliance therapy.

FACE THE FACTS

Functional	**F**ixed
Appliances	**A**ppliances
Create	**C**orrect
Esthetic faces	**T**eeth

REFERENCE LIST

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Great Expectations of Patients with Missing Lateral Incisors: When are Space Opening and Space Closure Appropriate?

Mohammed Almuzian
Glasgow Dental Hospital & School, Glasgow, United Kingdom

Fahad Alharbi
Dundee Dental Hospital & School, Dundee, United Kingdom

Grant McIntyre
Dundee Dental Hospital & School, Dundee, United Kingdom

Correspondence:
e-mail: dr_muzian@hotmail.com

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Abstract

On average, 2% of the UK population have agenesis of the permanent maxillary lateral incisors. Reopening the space for restorative replacement or closing the space and subsequent reshaping of the canine depends on a number of factors. Among these are the aesthetics of the canines, level of the smile line, gingival architecture and occlusion. Joint orthodontic and restorative planning to determine the appropriateness of space opening or space closing, with a discussion of these in context with the expectations of the patient/parent, is important before commencing treatment. Despite advances in materials and techniques within both restorative and orthodontic specialties resulting in improvements in the aesthetic outcomes of hypodontia cases, the management of patient/parent expectations is key to overall success. This paper details the contemporary restorative-orthodontic treatment options for the management of missing lateral incisors, the orthodontic biomechanics and restorative approaches involved in treatment.

Keywords
Hypodontia, lateral incisors

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INTRODUCTION

The term hypodontia is generally used to describe the developmental absence of teeth excluding the third molars[1]. The ratio of hypodontia in females to males is around 3:2[2-4]. As a general rule, the absent tooth will be the most distal tooth of any given tooth type[5,6]. Lower premolars are the most frequently absent teeth with a prevalence of 2.6% (mainly symmetrical) followed by missing upper lateral incisors at 2% (more frequently bilateral than unilateral)[3,4,7]. The treatment options for missing upper lateral incisors usually include space closure with canine substitution or space opening with subsequent restorative replacement. Only on rare occasions are patients either happy to accept the aesthetics of the missing lateral incisor, or is the space ideal for a direct prosthetic tooth or canine build up. A recent systematic review found no scientific evidence to support any of the treatment options over any other[8]. The selected treatment option should therefore be based primarily on clinical indications, being realistic rather than idealistic. Patients with hypodontia often have great expectations of treatment and are unaware that in some situations a compromise between the pre-treatment occlusion, skeletal relationship and the aesthetics of the canines, smile aesthetics, gingival architecture and biotype may be necessary. This article details the clinical indications of both space opening and space closure.

DIAGNOSTIC TOOLS

Systematic and careful treatment planning before commencing orthodontic or restorative intervention is crucial. A comprehensive clinical assessment, study models, clinical photographs, radiographs and trial wax set-ups (Kesling set-up) are usually required to aid in treatment planning *(Fig. 1)*.

In general, where the plan is to restore the missing tooth/teeth, the amount of space required is determined using the dimensions of the contralateral tooth, or alternatively by relying on the average tooth dimension (6.5–7 mm). Where the contralateral incisor is diminutive or malformed, the required space can also be mathematically derived using the golden proportion or from a Bolton tooth size ratio analysis. Not only is the intra-coronal dimension crucial during the treatment planning stage, but the intra-radicular space (distance between the adjacent roots) is also important, particularly when a single implant-retained crown is being planned[9-11]. For an implant-retained crown, a safety margin of at least 1.5 mm at the implant–root interface should be available as this has been shown to be associated with an improved success rate[12]. If a bridge is planned at the end of orthodontic treatment, the inter-radicular space and root parallelism are less critical, but these are still important for optimal aesthetics and to leave the option open for potential implant-retained crown replacement. On the other hand, when space closure is planned, the effect of this approach on the occlusion needs to be assessed usually using a trial wax set-up. A trial wax trial set-up aids in planning orthodontic biomechanics, anchorage requirements, and obtaining informed consent from the patient/parent before obtaining funding for the treatment.

FACTORS INFLUENCING TREATMENT OPTIONS

The factors that have an impact on treatment planning and mechanics are classified into four categories: macro-aesthetic, mini-aesthetic, micro-aesthetic and general factors *(Table 1)*.

Macro-aesthetic

The type of malocclusion, profile and soft tissue pattern play an important role in determining if the canine substitution approach is feasible. There are two types of malocclusions where canine substitution is appropriate. The first is a Class II malocclusion where the space of the missing tooth can be used to reduce an increased overjet and provide a Class I incisor relationship at the end of treatment. The second is a Class I malocclusion where space is required to relieve crowding elsewhere in the upper arch. On the other hand, a patient with a straight or convex profile with a protrusive mandible and/or a prominent chin may

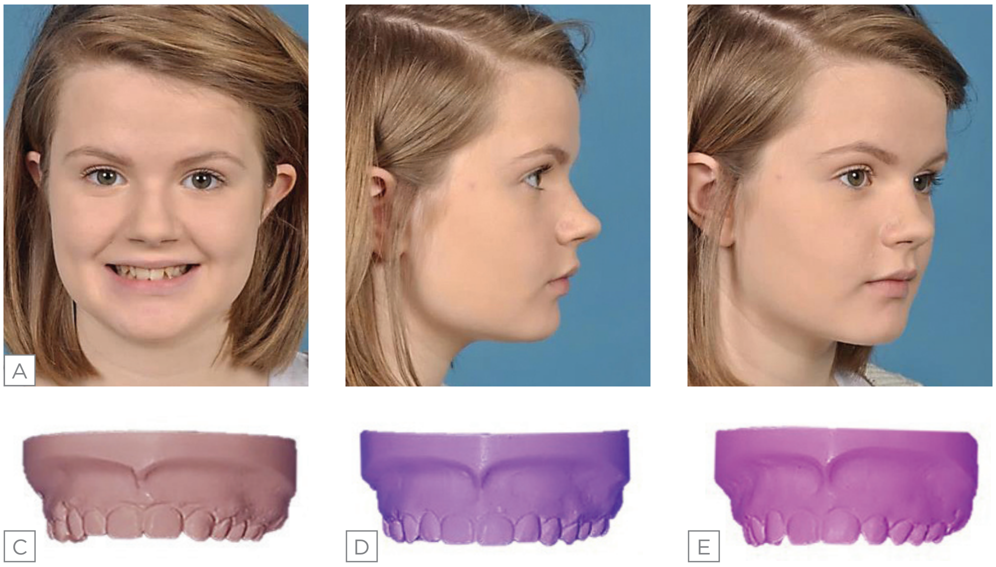

Figure 1: Case with unilateral missing of the lateral incisors and diminutive contralateral incisor (A) extraoral photographs; (B) frontal intraoral photograph; (C-E) Kesling set up with unilateral space closure, space opening (with prosthetic tooth) and bilateral space closure following extraction of the diminutive lateral incisor.

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	Space closure	Space opening
Prosthetic replacement	Not required	Required
Retention	Long term retention required	Long term retention required
Patients satisfaction	Good	Good
Periodontal health	Good	Good
Effect on profile	May flatten the facial profile	Can support the facial profile
Dental midline	May result in midline shifts where hypodontia is unilateral	Coincident midlines are usually established
Colour and shape matching	Colour and morphology of canine replacing a lateral incisor may be problematic	Not a concern
Dental arch constriction	Constriction of the dental arch and dark buccal corridor can be a concern	Rarely results in constriction of the dental arch
Functional occlusion	Moving the canine mesially may result in loss of canine guidance	Maintenance of existing canine guidance
Cost	Relatively cheaper than space opening as only orthodontic costs and straightforward restorative dentistry is required	In addition to the cost of orthodontic treatment, there is an additional cost for bridge or single implant replacement

Table 1: Space closure and space opening case selection[9-20,32,33].

not be an appropriate candidate for canine substitution unless adjunctive orthognathic surgery is considered to address an underlying skeletal problem[9,13].

Mini-aesthetic

Part of the mini-aesthetic assessment process is to assess the gingival and lip line both at rest and during function. If the patient presents with excessive gingival exposure on smiling or a prominent canine root eminence, canine substitution could result in aesthetic concerns and would be the least favourable option[9,11,13,14].

Micro-aesthetic

The canine shape, size, eminence and colour should be evaluated carefully as part of the micro-aesthetic assessment process. The ideal scenario for canine substitution is a canine that has a similar colour as the central incisor, is narrow at the cemento-enamel junction, narrow bucco-lingually and mesio-distally with a relatively flat labial surface.

General factors

The gender and age of the patient are important factors to be considered during treatment planning of missing lateral incisors. The vertical growth of the facial skeleton is sexually dysmorphic and it continues past the pubertal growth spurt. This has an impact on the preferred final restoration particularly if implant-retained crowns are chosen[15]. On average, female facial growth continues until about 17 years of age compared to 21 years of age for males, which is the optimum time for osseointegrated implant placement[16]. Furthermore, unless there is some occlusal factors including traumatic deep bite or aesthetic requirements, it may be desirable to defer orthodontic treatment to just prior to implant placement.

Additional general factors are the advantages and limitations of each option especially in borderline cases. In these cases, the patient's decision is important *(Table 1)*.

It is worth mentioning that a considerable amount of grey evidence is available that supports both options. These should be critically analysed before being adopted in routine clinical practice. For instance, there is a claim that space closure by incisor retraction results in constriction of the dental arch and wide buccal corridors. However, a study by Johnson and Smith based on opinions of lay judges rejects this hypothesis[27]. Another claim is that the loss of canine guidance secondary to space closure of missing lateral incisors is associated with poor functional occlusion, a high risk of relapse and development of tempro-mandibular dysfunction (TMD)[18,19]. DiPietro in 1977, investigated the frequency of naturally occurring patterns of occlusion, found that canine guidance exists in only one third of normal occlusions while group function is more frequent with no substantial functional difference

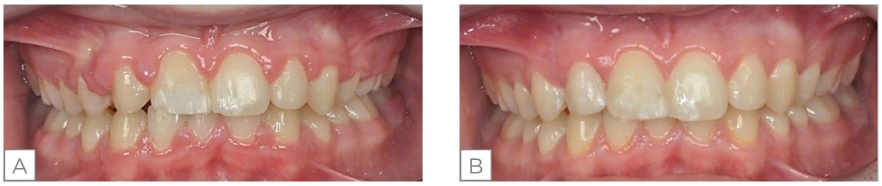

Figure 2: Canine substitution and restorative camouflage of the canines to resemble a lateral incisor (A) immediately aafter orthodontic space closure (B) after restorative camouflage of the canine.

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between both[28]. In addition, many well-designed studies have shown that the relationship between the loss of canine guidance and occlusal stability and/or development of TMD is either weak or non-existant[29,30].

Similar to the claimed detrimental effect of extraction-based orthodontic treatment on the facial profile, some believe that incisor retraction secondary to space closure in canine substitution cases might be linked to 'flattening' of the facial profile. This viewpoint is still a matter of controversy and has been subjected to many criticisms since the beginning of 20th century[31]. Although a retrospective study by Talass et al. showed that the ratio of the upper lip:upper incisor retraction is approximately 1:0.3 mm,[32] a randomized clinical trial found that the long-term soft tissue changes have non-detectable aesthetic effects[33]. From a clinical standpoint, such effects depend on many variables such as individual variation, lip thickness/tonicity and the amount of dead-space between the labial surface of upper incisors and the mucosal surface of the upper lip at rest[34]. If the clinical and soft tissue profile examination contraindicate space closure through incisor retraction, then space closure should be achieved using auxiliary devices, such as extraoral protraction appliances or temporary anchorage devices, to mesialize the posterior teeth[35,36]. However, it could be argued that incisor retraction might be associated with reduction of the interlabial gap and with potential improvement in lip competence, so this should be evaluated on an individual basis[32].

BIOMECHANICAL CONSIDERATIONS DURING SPACE CLOSURE (CANINE SUBSTITUTION)

Space closure in the maxillary lateral incisor region with orthodontic fixed appliances is usually straightforward and achieved using a power chain or closed coil nickel-titanium alloy springs. However, positioning the canine crown to optimize dental aesthetics and function necessitates more careful biomechanics *(Table 2)*.

One suggested approach is bonding the canine bracket further gingivally. This extrudes the canine and allows the gingival margin to be positioned more incisally to mimic the gingival margin of the lateral incisor. However, this potentially increases the buccal root torque for the canine as the extrusive force is adjacent to the centre of canine rotation. Therefore, incorporation of palatal root torque within the archwire or using a canine bracket with positive torque (such as the Roth prescription or the +7 degree MBT prescription canine bracket) can reduce the amount of canine torque that is expressed. Alternatively, a lateral incisor bracket can be used[37]. Another potential side effect of offsetting the canine bracket is that the thicker portion of the canine crown comes into premature contact with the mandibular incisors, thus selective grinding of the canine cingulum becomes mandatory[38].

Another approach involves bonding the first premolar brackets more disto-occlusally to intrude and rotate them mesio-palatally. This improves the dental aesthetics, as the first premolars appear wider therefore resembling the canine, and reduce any interference with the lower canine during function. Additionally, this locates the gingival line of the first premolar more apically to simulate that of the canine. However, the potential side effect of this approach is the reduction of the buccal root torque of the premolars as the intrusive force is buccally positioned in respect to the centre of rotation. This can be minimized through the incorporation of individual buccal root torque within the archwire or using a canine bracket with a -7 degree MBT prescription.

The anchorage and restorative requirement are crucial and should be planned from the beginning. The use of reverse-pull headgear or temporary anchorage devices (TADs) may be required during space closure followed by cosmetic reshaping to camouflage the canine *(Fig. 2)*[1,39].

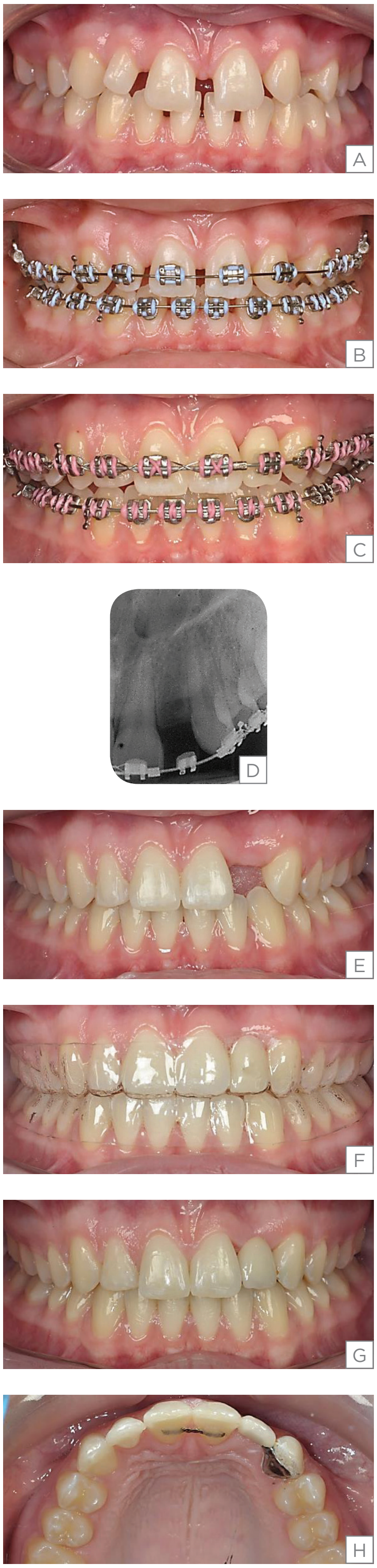

Figure 3: Case treated with space opening and placement of a resin bonded bridge. (A) Before treatment. (B) Bracket set up (note that U2 bracket was bonded on U3). (C) Acrylic tooth attached to the archwire. (D) Intra-operative periapical radiograph to assess root parallism; (E) End of active orthodontic treatment. (F) During transitional phase using pressure-formed retainer with acrylic tooth. (G-H) Final result after fitting RBB.

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	Space opening	Space closure
Bracket bonded to canine	Normal canine bracket	Inverted lateral or canine bracket with additional palatal root torque to reduce canine eminence (can be achieve by finishing wire bending)
Position of canine bracket	Normal canine bracket position	More gingivally to extrude the canine to position the gingival margin more incisally
Selective grinding	Not required	Required to reduce premature contact of the upper canine with lower incisors
Bracket bonded to first premolars	Normal premolar bracket position	Canine bracket placed: more distally than normal to produce mesio-palatal rotation to resemble the canine; more occlusally or adding additional palatal crown torque to reduce 'hanging down' effect of the palatal cusp of the first premolar and adjusting the gingival line of the first premolar more apically to simulate that of the canine.
Mechanics	Push-pull mechanics	Closing mechanics using power chain or nickel-titanium closing coils

Table 2: Biomechanics of space closure and space opening[14,19-21,23,24].

BIOMECHANICAL CONSIDERATIONS DURING SPACE OPENING

A fixed orthodontic appliance is required for three-dimensional tooth control during the space opening treatment option for the missing upper lateral incisor. In general, there is no specific bracket set-up or positioning in comparison to canine substitution. However, various mechanics are available to create space for the missing tooth and the method selected depends on the malocclusion and operator preference[11,40,41]. Once appropriate space has been opened, a closed-coil spring or an acrylic denture tooth attached to the archwire via a bonded bracket can be placed to maintain space and restore the space temporarily. Alternatively, a wire bend or crimpable archwire stop can be used.

During the finishing stages of orthodontic treatment, idealized root parallelism for potential implant placement may require wire bending or bracket repositioning. As an interim retention regime, a pressure-formed retainer or alternatively a Hawley-type retainer incorporating a prosthetic tooth, with wire stops mesial and distal to the acrylic tooth, can be used to prevent relapse. The Hawley retainer can be alternated with a pressure-formed retainer at night-time to allow recovery of the gingivae in the lateral incisor area *(Fig. 3)*[35].

COMPLICATIONS DURING ORTHODONTIC MANAGEMENT OF PATIENTS WITH HYPODONTIA

Orthodontic treatment for patients with hypodontia can be associated with multiple problems. The most common is that patients with hypodontia often suffer from microdontia which is associated with a greater risk of plaque accumulation. Subsequently, this increases the risk of gingivitis and/or decalcification, and requires specific oral hygiene advice and preventive measures[9]. One biomechanical difficulty related to microdontia is the problem of increased bracket bonding failure[9,14,18,40].

RESTORATIVE OPTIONS

Although a variety of restorative options are available, the restoration type and design should be planned from the beginning of treatment according to the clinical situation and the expectations of the patient/parent *(Table 2)*[35].

For adult patients after cessation of vertical growth, the use of single-tooth implant-retained crowns is preferable for missing lateral incisors. This is associated with a high success rate (85–90%), aesthetic benefits and the elimination of preparation of teeth when compared to other restorative options *(Fig. 4)*[47,48]. However, implant placement has many prerequisites which are not easily achieved. Olsen

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Figure 4: Case treated with space opening and placement of an implant-retained crown.

and Kokich[49] recommended at least 6.3 mm of inter-coronal space and 5.7 mm of inter-radicular space between the central incisor and canine to ensure adequate room for implant placement and to compensate for any relapse. It has been reported that after successful orthodontic opening of an implant-retained crown space, the central incisor and canine roots re-approximate in 11% of cases during retention, precluding implant placement. To ensure sufficient space is maintained for implant placement, a bonded wire or resin-bonded bridge can help to reduce root re-approximation that can occur during the transitional phase[49]. Additionally, it is desirable to obtain a minimum of 1–1.5 mm at the root–implant interface to allow adequate post-implant healing and adequate interdental papilla development.

Figure 5: Long term restoration with resin-bonded bridges.

Resin bonded bridges (RBB) are an alternative restorative option where osseointegrated implants cannot be placed due to insufficient alveolar bone, financial pressures or where patients/parents prefer to avoid surgery *(Fig. 5)*. RBBs can also be used as a transitional restoration for late adolescent patients until implant placement is feasible[50,51]. Although RBB are relatively simple to construct with no or minimal tooth preparation, survival rates are relatively high (80%) especially with cantilever designs[52,53]. However, some complications are associated with the use of RBB such as bond failure, the 'metal shine through' effect and the potential for dental caries affecting the abutment tooth[43,44,51].

Removable prostheses for patients with missing upper lateral incisors are only suitable for short-term use due to the bulkiness of the prosthesis and the removable nature of the appliance, which most patients dislike[54]. Nevertheless, removable prostheses are simple to construct and can restore both missing hard and soft tissues as well as act as orthodontic retainers *(Fig. 6)*. Alternatively, a cobalt-chromium overdenture remains a suitable option for severe hypodontia (oligodontia), patients with poor dental health, as a temporary restoration for growing patients and for those with insufficient bone for implant-retained crowns.

On the other hand, if canine substitution is the planned option, the canine can be easily disguised to resemble the missing lateral incisor. This can be achieved through gradual interproximal stripping during the orthodontic phase of treatment to reduce canine width followed by build-up of its mesial and distal incisal edges[38]. Build-up of the canine is usually performed using a composite material

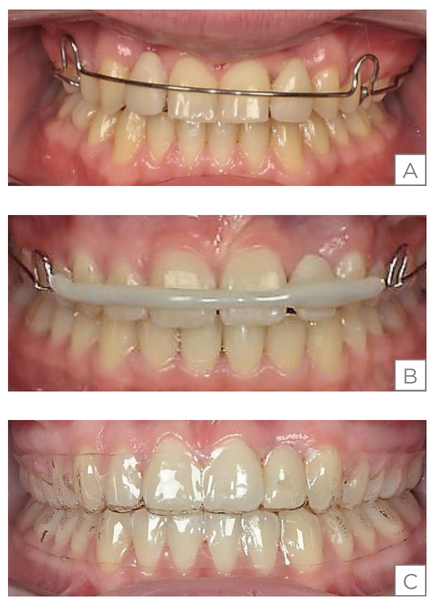

Figure 6: Removable restorative prostheses. (A) Hawley retainer; (B) modified Hawley retainer with aesthetic labial arch and (C) pressure-formed retainers.

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or veneer and can be preceded by vital bleaching, where required[55]. Similarly, the first premolar can be reshaped to resemble a canine tooth aesthetically and functionally through veneering the facial surface, grinding the palatal cusp and occasionally gingivectomy[29,35].

CONCLUSION

The management of patients with missing lateral incisors requires joint restorative and orthodontic treatment planning to determine if space closure and reshaping the canine or opening the space for subsequent restorative replacement is more appropriate. The interaction between the patient/parent, orthodontist, general dentist and restorative dentist is a key factor for satisfactory results.

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Non-Surgical Treatment for Severe Bimaxillary Protrusion in UCLP Using Temporary Anchorage Devices (TADs)

Prasad NK Koteswara
Department of Orthodontics,
Faculty of Dental Sciences,
Sri Ramachandra University,
Chennai, India

Ronald Hathaway
Craniofacial and Surgical Orthodontics,
Division of Craniofacial Plastic and
Reconstructive Surgery, Cincinnati
Children's Hospital, Cincinnati, OH, USA

Siva Subramanian
Department of Orthodontics,
Faculty of Dental Sciences,
Sri Ramachandra University,
Chennai, India

Arun Chitharanjan
Department of Orthodontics,
Faculty of Dental Sciences,
Sri Ramachandra University,
Chennai, India

Correspondence:
e-mail: orthoprasad@yahoo.com

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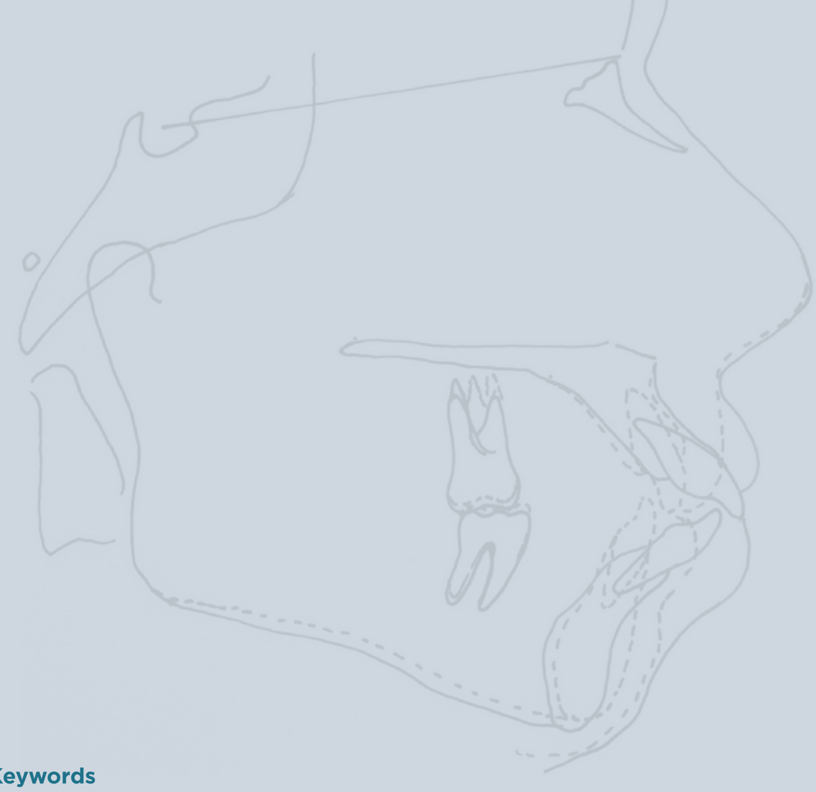
Abstract

Orthodontic management of cleft lip and palate patients is often complicated by concomitant dental problems and skeletal disharmonies. Common examples of this include dysmorphic teeth, missing teeth in addition to the cleft site, maxillary hypoplasia in all dimensions and varying degrees of maxillo-mandibular discrepancy. However, delayed treatment can also cause developmental problems superimposed on the cleft condition which can challenge the clinician who wishes to avoid orthognathic procedures without compromising facial aesthetic outcomes. The advantages and versatility of temporary anchorage devices (TADs) is demonstrated in this paper for the non-surgical correction of unusual bimaxillary protrusion in a patient with unilateral cleft lip and palate (UCLP).



Keywords
Temporary anchorage devices (TADs), bimaxillary protrusion, dentoalveolar protrusion, cleft lip and palate, unilateral

INTRODUCTION

Standards for cleft lip and palate care involve an interdisciplinary team approach even before primary repair of the lip and palate. Of particular concern over past decades has been iatrogenic scarring of the palate which produces soft tissue contractures which function as a tight restraint and may interfere with the growth of the maxilla[1-4]. In addition to intrinsic growth factors, mechanical restriction on the growth of the maxilla can contribute to a hypoplastic maxilla resulting in alteration of the dentofacial profile[5,6]. On the other hand, it has been observed that when palatal repair has been delayed into adulthood for various reasons, then minimal or no growth disturbances are observed in the maxilla[7]. Such patients typically present with either good maxillary growth or frequently with maxillary dentoalveolar protrusion[8,9]. This case report describes the non-surgical management of unusual severe bimaxillary protrusion in a patient with a cleft maxilla treated using temporary anchorage devices (TADs).

CASE REPORT

A 21-year-old male patient presented to the cleft and craniofacial centre with the chief complaint of dissatisfaction with his facial appearance and excessive fullness of his upper and lower lips *(Figs. 1–3)*. He had been born with incomplete left unilateral cleft lip and palate. Cheiloplasty using a modified Millard technique was performed at 2 years of age and palatoplasty using the von Langenbeck technique at 12 years of age. There was no familial history of skeletal malocclusion. The patient had a convex profile with marked protrusion of the lips, mentalis muscle strain and lip incompetence. Intra-oral examination revealed a missing maxillary left permanent lateral incisor and a previously extracted mandibular left permanent first molar. The maxillary left deciduous lateral incisor had been retained and was carious. There was also severe proclination of the maxillary and mandibular incisors, and a Class I molar relationship with generalized spacing in both arches. The maxillary left permanent first molar had supra-erupted.

Cephalometric analysis showed a skeletal Class II relationship with severe bimaxillary protrusion. The maxillary incisor inclination was 41° and 9 mm ahead of the NA line. The mandibular incisor axial inclination was 50° and linear distance was 11 mm ahead of the NB line. The IMPA was 121° *(Table 1)*. There were no signs of temporomandibular disorders and the patient denied any painful symptoms.

TREATMENT OBJECTIVES

Treatment objectives were to:

1. avoid orthognathic procedures while establishing a functional and aesthetic occlusion;
2. level and align the teeth in both arches employing the required magnitude of biomechanical forces;
3. normalize the overjet and decompensate the excessively flared incisors;
4. replace the missing permanent teeth for aesthetic and functional rehabilitation;
5. correct lip procumbency and improve facial profile and lip competency.

TREATMENT PLAN

The treatment included extraction of the first bicuspids in all quadrants. A 0.022 slot pre-adjusted edgewise appliance was employed followed by placement of 0.016 NiTi wires in both arches for initiation of levelling and aligning. TADs included 2 mm diameter, 11 mm length LOMAS BENEFIT (PSM Medical Solutions, Tuttlingen, Germany) hook screws placed bilaterally at the infrazygomatic crests of the maxilla. The pilot hole was prepared at 60–75° and 13–15 mm above the occlusal plane from the maxillary first molars. In the mandible, 2 mm diameter, 9 mm lenght LOMAS BENEFIT hook screws were placed bilaterally on the external oblique ridge[10]. TADs were utilized for retraction of the six anterior maxillary and mandibular teeth along with reciprocal protraction (mesialization) of the left lower second molar *(Fig. 4)*. The TADs were immediately loaded

Figure 1: Pre-treatment intra-oral views.

Figure 2: Pre-treatment extra-oral views.

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using NiTi coil springs onto the bracket hook of the canines. This technique has been used effectively in the retraction of incisors and mesialization of posterior teeth in non-cleft patients[10].

A total active treatment time of 28 months was required to achieve ideal results. The maxillary left retained deciduous lateral incisor was extracted and the resulting edentulous space was restored with a fixed bridge. A maxillary Hawley retainer appliance and a mandibular anterior lingual bonded retainer were selected for the retention treatment phase after active treatment.

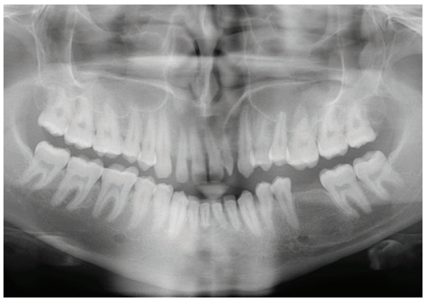

Figure 3: Pre-treatment radiographs.

	Parameters			
Skeletal	Pre-treatment	Post-treatment	Difference	Norm
SNA	88°	85°	−3°	82± 2°
SNB	81°	80°	−1°	80±2°
ANB	7°	5°	−2°	2-4°
WITS	4.5 mm	2 mm	−2.5 mm	0 mm
Dental				
Upper 1-NA	41°	16°	−25°	22°
Upper 1-NA	9 mm	3 mm	−6 mm	4 mm
Lower 1-NB	50°	24°	−16°	25°
Lower 1- NB	11 mm	3 mm	−8 mm	4 mm
MP	26°	24°	−2°	32°
Soft tissue				
NLA	86°	108°	22°	90-110°
E-line upper lip	2 mm	−7 mm	−3 mm	−4 mm
Lower lip	7 mm	−1 mm	-8 mm	−2 mm

Table 1: Comparison of pre-treatment and post-treatment cephalometric measurements.

TREATMENT RESULTS

After 28 months of treatment, the patient's objectives were achieved. The patient's facial profile, lip posture and smile had improved. A post-treatment cephalometric evaluation showed that U1 to NA angulation had changed from 41° to 16° and the U1 to NA distance had changed from 9 mm to 3 mm. Similarly, L1 to NB angulation had changed from 50° to 24° and the linear distance had changed from 11 mm to 3 mm *(Table 1)*. The mandibular plane had decreased by 2° after treatment.

Cephalometric superimposition *(Fig. 5)* confirmed that the maxillary and mandibular incisors were retracted and intruded, the maxillary molars were intruded, and thus forward and upward rotation of the mandible had occurred showing an orthognathic-like effect.

The TADs provided great anchorage in achieving considerable orthodontic movement and orthopaedic alveolar bone remodelling was demonstrated at the anterior maxilla and mandible. The retraction process starts immediately after the extraction of all bicuspids.

This process takes advantage of the regional accelerated phenomenon (RAP) of bone turnover previously documented for dentoalveolar surgical extraction procedures[11]. Orthognathic-like treatment results with non-surgical intervention were achieved *(Figs. 6, 7)*.

DISCUSSION

The treatment of Class II skeletal bimaxillary protrusion in unilateral cleft lip and palate has received little

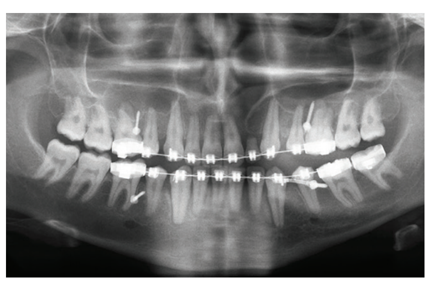

Figure 4: En masse retraction in progress.

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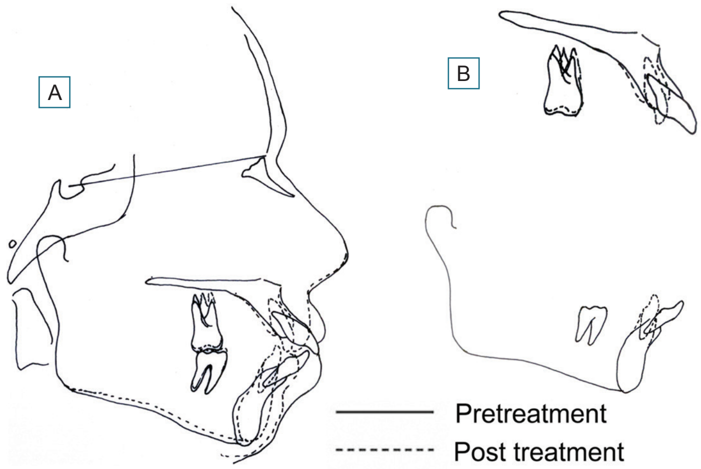

Figure 5: Superimposition of pre-treatment and post-treatment cephalograms. (A) The overall superimposition revealed a reduction in convexity along with a decrease in proclination. The mandible moved upward and forward. (B) Maxillary superimposition revealed that the upper molars are intruded along with upper incisor retraction and intrusion. Mandibular superimposition revealed that the mandibular incisors were retracted and intruded.

Figure 6: Post-treatment intra-oral views.

Figure 7: Post-treatment extra-oral views.

attention in the literature. Treatment can include the extraction of the first bicuspids and retraction of the anterior teeth under maximum anchorage[12]. Alternatively, surgical correction can be considered with maxillary and/or mandibular osteotomies[13].

Surgical intervention alone would not have completely solved the occlusal problems in this case, especially with regard to non-prosthetic closure of the edentulous mandibular space. Although surgical intervention may have reduced the patient's treatment time, the patient strongly preferred a non-orthognathic approach.

Extraction of the first bicuspids and retraction of the six anterior teeth can lead to anchorage loss[14,15,16] considering the magnitude of retraction that would be required in a non-surgical approach. Without TADs for skeletal anchorage, the concomitant incisor retraction and mesialization of the mandibular left second molar is difficult and risks loss of biomechanical control.

TADs are absolute anchorage devices as they permit control of tooth movement in all three planes[10]. The NiTi coil springs are attached to the LOMAS hook screw from the cuspid bracket hook for retraction of the six anterior teeth. On the mandibular left side, a power chain was attached to the LOMAS hook screw and second molar buccal tube for mesial movement into edentulous space. The mini-screws were stable during the entire treatment period. Left first bicuspid extraction space was used for complete distalization of the anterior segment, and hence the molar was protracted into the edentulous space

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to obtain a Class II molar relationship. Alternatively, a power chain can be placed for mesial movement of 37, but large movement may result in lingual rolling of the molar. Superimposition revealed that the maxillary incisors were retracted by 11 mm and intruded by 3.5 mm. Mandibular superimposition revealed that the mandibular incisors were intruded by 2.5 mm and were retracted 11 mm. The mandibular plane angle reduction of 2° demonstrated counterclockwise rotation and this autorotation aided a more forward chin projection. This case report has shown how surgical-like movements can be achieved using a non-surgical approach *(Fig. 8)*. While there are reports of the treatment of similar conditions in patients with a cleft[13,17-21], this treatment approach is rarely mentioned. Composite reshaping was done on 13 as there is a Bolton tooth size discrepancy. The labial cortex plate thickness in the area of the cleft[22] was thin, which was not an ideal indication for an implant, and hence a bridge was considered.

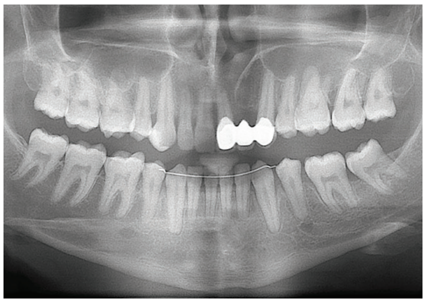

Figure 8: Post-treatment radiographs.

CONCLUSION

The combination of reinforced anchorage and fixed orthodontic appliances with RAP can effect orthopaedic changes which were previously considered could only be achieved through orthognathic surgery involving corticotomies[22,23]. However, effective usage of TADs with NiTi coil springs can provide skeletal anchorage and exert orthopaedic forces for facial-skeletal remodelling as an alternative to a surgical treatment plan.

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CLINICAL ARTICLE

Lower Incisor Intrusion Using Self-ligating Lingual Bracket Mechanics

Aldo Macchi
Department of Surgical and Morphological Sciences, University of Insubria, Varese, Italy

Matteo Beretta
Orthodontic Division, Department of Surgical and Morphological Sciences, University of Insubria, Varese, Italy

Nunzio Cirulli
Private practice in Orthodontics, Bari, Italy

Piero Antonio Zecca
Orthodontic Division, Department Surgical and Morphological Sciences, University of Insubria, Varese, Italy

Elia Kodjo Chardey
Orthodontic Division, Department of Surgical and Morphological Sciences, University of Insubria, Varese, Italy

Rosamaria Fastuca
Orthodontic Division, Department of Surgical and Morphological Sciences, University of Insubria, Varese, Italy

Alberto Caprioglio
Orthodontic Division, Department Surgical and Morphological Sciences, University of Insubria, Varese, Italy

Abstract

Objectives: The present study proposes an original mechanism for lower incisor intrusion using a self-ligating lingual bracket system on adult patients with dental and skeletal changes evaluated after treatment using cephalometric assessment.
Materials and methods: 24 adult patients (11 women, 13 men) underwent fixed lingual orthodontic treatment with a self-ligating lingual bracket system; the mean overbite at the beginning of treatment was 5.35±1.52 mm. Lateral cephalograms were taken before treatment (T0) and at the end of treatment (T1) and eight linear and seven angular measurements were traced at the two time points. A paired sample t-test was employed to assess the significance of the differences between the time points.
Results: The overbite significantly decreased by 3.34±0.85 mm ($p<0.05$) and the final mean overbite was 2.01±1.24 mm. Intrusion of the lower incisors was 2.22±1.22 mm ($p<0.001$) with no significant buccal inclination of the incisal edge. No significant extrusion of the first molars or premolars was seen. No significant changes were reported in mandibular plane inclination and the lower facial height remained stable.
Conclusion: The employed self-ligating bracket appliance system allowed significant lower incisor intrusion to be obtained with negligible undesired extrusion of the posterior teeth and no significant differences in vertical skeletal dimension in adult patients.

Keywords
intrusion, lingual appliance, muscular anchorage

Correspondence:
e-mail: rosamariaf@hotmail.it

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INTRODUCTION

An increased overbite is the main characteristic of deep-bite malocclusion. Diagnosis plays an important role in classifying skeletal and dental deepbite, greatly influencing treatment plan and facilitating correction. An increased overbite can occur in most malocclusions, regardless of the vertical growth pattern. The potential negative periodontal consequences of deep-bite malocclusions have been described[1], raising the need for treatment. When the treatment plan is limited to orthodontics, intrusion of the anterior teeth, extrusion of the posterior teeth, or both might be considered strategy options. The choice of treatment modality depends on the diagnostic implications and objectives. The age of the patient is the most important factor, as different responses were described depending on the presence or absence of residual vertical growth[2]. Vertical dimensions and interocclusal space should be taken into account as well as aesthetic characteristics. Moreover, intrusion of the upper incisors might reduce gingival display when smiling, especially as the patient ages[3,4], and consequently cannot be performed in many patients where intrusion of the lower incisors is preferred.

Lower incisor intrusion can be accomplished using either continuous or segmented mechanics[5-7] (reverse Spee arch, three piece intrusion arch, utility arch). Previous methods to achieve lower incisor intrusion were reported to attain up to 1.9 mm of intrusion[8], although unwanted side effects often occur, such as buccal tipping of the incisors associated with distal and/or buccal tipping of the anchorage units usually represented by the posterior teeth. Recently, the use of temporary anchorage devices (TADs) was proposed[9-11] in order to reduce unwanted effects during lower incisor intrusion. Lingual fixed appliances were also described with the aim of achieving lower incisor intrusion while minimizing side effects due the different points of force application compared to buccal appliances[12]. Two mechanisms of lower incisor intrusion accomplished by means of lingual appliances have been reported: (i) a bite opening mechanism resulting from the lower incisors occluding on the maxillary incisor bracket bite planes, which permits eruption of the molars and bicuspids[13]; and (ii) a bite opening mechanism that intrudes the lower incisors until space is available for placement of upper anterior lingual brackets without interference using a reverse curve mushroom archwire[14].

The present study proposes an original mechanism for lower incisor intrusion using the i-TTя© self-ligating lingual bracket system on adult patients and evaluates dental and skeletal changes after treatment using cephalometric assessment.

MATERIALS AND METHODS

Population and study design

This study followed a prospective longitudinal design and enrolled subjects seeking orthodontic treatment. As a routine procedure, a signed informed consent for releasing diagnostic records for scientific purposes was obtained from patients prior to entry into treatment. The protocol was reviewed and approved by the university ethics committee (approval no. 7236) and the procedures followed adhered to the World Medical Association Declaration of Helsinki. Briefly, the following criteria were applied: (i) patients had to be in good general health according to medical history and clinical judgment; (ii) adult patients seeking orthodontic treatment had to be specifically enrolled for lingual orthodontics; (iii) class I malocclusion had to be identified on pre-treatment lateral x-ray; and (vi) the overbite had to be >4 mm. Patients presenting severe crowding and extraction cases were excluded from the study.

Thirty patients (14 women, 16 men) were initially enrolled according to the selection criteria. As six patients dropped out of the study because final radiographs were lacking, 24 patients (11 women, 13 men) formed the final study sample. At the beginning of treatment, mean overbite and mean age were 5.35±1.52 mm and 30.96±5.28 years, respectively.

Appliance design

For all patients, i-TTя© lingual brackets (Rocky Mountain Orthodontics, Denver, USA)[15] were bonded from the lower right second premolar to the lower left second premolar. The i-TTя© is a self-ligating non-edgewise bracket. It has three slots with no moving parts *(Fig. 1)*: gingival and occlusal rounded slots (0.016") with vertical insertion of the archwire, and a central rectangular slot (0.022"×0.018") for auxiliaries with horizontal insertion of the archwire. The archwires consisted of nickel-titanium 0.012" and 0.014" archwire with nickel-titanium 0.010" and 0.012" auxiliaries. Archwire insertion in the gingival and occlusal slots is possible due to the flexibility and shape recovery of the nickel-titanium which is forced into the slot with a spatula *(Fig. 2)*. The archwires were selected according to the archform of the patient (small, medium or large) from a sample of straight preformed archwires and then modelled using the correct mushroom archform *(Fig. 3)*.

The archwire is usually modelled with two permanent bends per side when it is not inserted in the bracket slots: (i) a 1st order compensation bend between the

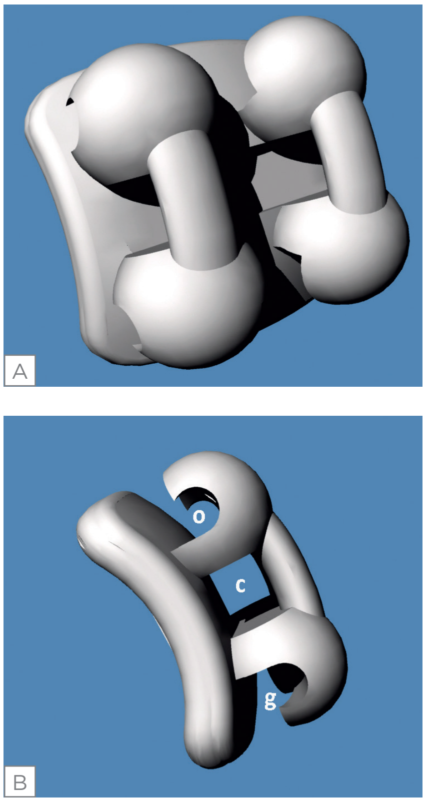

Figure 1: i-TTя© self-ligating bracket. (A) Perspective view. (B) Lateral view. 'o' indicates occlusal slot, 'c' indicates central tube, and 'g' indicates gingival slot.

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canines and first premolars (mushroom bend); and (ii) a 2nd order terminal bend which is obtained by bending the distal end of the archwire towards gingival (distal bend) *(Fig. 4a)*.
When the archwire is inserted in the occlusal slots of the brackets from the second premolars to the canines and incisors, the archwire is twisted between the first premolars and the canines due to the different bracket heights, since the canines and incisors are usually more extruded in deep-bite patients. The twisting moment allows the mushroom bend to produce vertical forces expressed as an intrusive force on the anterior teeth and an extrusive force on the posterior teeth. The application point of the force on the anterior teeth is close to the centre of resistance, thus provoking negligible moment. In contrast, a moment towards buccal occurs on the posterior teeth. Nevertheless, the twisting moment on the archwire produces clinically negligible forces on the teeth since the archwire is free to rotate posteriorly if the distal bend is not inserted in the slot bracket *(Fig. 4b)*.
When the distal bend is inserted in the bracket central slot, the twisting moment on the archwire produces higher forces on the teeth since it is no longer free to rotate. The intrusive force on the anterior teeth due to the twisting moment of the archwire, and similarly the extrusive force and the moment toward buccal, are both increased, especially on the second premolar where the distal bend is inserted *(Fig. 4c)*.
The collateral extrusive movements of the premolars do not occur in the clinical situation because the forces exerted by the rounded 0.012" or 0.014" nickel-titanium archwires are very light and do not overcome the occlusal forces exerted by the fossa–cuspid relationships on the premolars. Consequently intrusion of the anterior teeth generally takes place in this situation *(Fig. 4d)*.
Figure 5 shows a clinical case where intrusion mechanics were applied and lower incisor intrusion was successfully accomplished.

Cephalometric analysis

Lateral cephalograms were taken before treatment (T0) and at the end of treatment (T1). Mean treatment time was 19.21±6.43 months and mean intrusion time, measured as the interval time between T0 and bracket placement on the upper incisors, was 6.42±1.50 months.
Tracings were performed using eight linear and seven angular measurements (*Fig. 6* and *Table 1*) to the nearest 0.1 mm and 0.5 degrees, respectively. Correction for linear enlargement was performed. The cephalometric analysis employed for the assessment of lower incisor intrusion was according to Hong et al.[12] *(Table 1)*. All tracings and measurements were performed twice by the same trained observer (EC). For the final evaluation, the mean value of the double measurements was used. Measurements were taken from a midpoint 'I' between the incisal edge and the root apex of the lower incisor[8]. This was done on the T0 radiograph and the marker was then relocated on the T1 radiograph using a template so that best fit anatomical registration could be performed on the incisal edge of the lower incisor in order to have comparable measurements between the two time points. All bilateral structures were located midway between the two images.

Statistical analysis

A pilot study was performed with five patients (3 men, 2 women) where the distance from lower incisor intrusion point I to MP *(Table 1)* was measured for power analysis. According to this analysis, 10 subjects were required to obtain a

Figure 2: Insertion of the archwire. The flexibility and shape recovery of the archwire allow it to be inserted in the slot.

Figure 3: Mushroom archform. Intraoral occlusal picture of the individual mushroom archform.

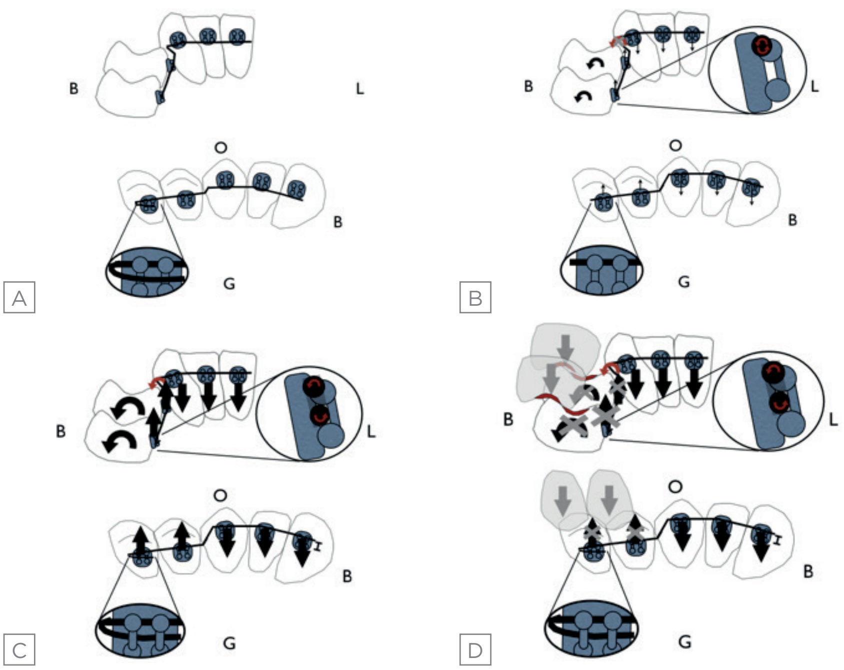

Figure 4: Intrusion mechanics. Coronal and sagittal views are shown for each step. B, buccal; G, gingival; L, lingual; O, occlusal. Description in the text.

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1. Overbite (mm)	Vertical overlap of the upper and lower central incisors perpendicular to the occlusal plane[a]
2. MP to FH (degrees)	The angle formed by the mandibular plane[b] and the Frankfort horizontal plane
3. LAFH (mm)	The distance between the anterior nasal spine and Menton
4. U1 to FH (degrees)	The angle formed by the long axis of the upper central incisor and the Frankfort horizontal plane
5. Length of L1 (mm)	Length of the lower central incisor
6. L1 to NPg (mm)	The perpendicular distance between the incisal edge of the lower central incisor and the nasion-pogonion line
7. L1 to MP (degrees)	The angle formed by the long axis of the lower central incisor and the mandibular plane
8. Point I to MP (mm)	The perpendicular distance between the internal reference point I and the mandibular plane. Point I was standardized as a midpoint between the incisal edge and the root apex of the lower central incisor
9. L6 tip to MP (mm)	The perpendicular distance between the mesio-buccal cusp tip of the lower first molar and the mandibular plane
10. L6 axis to MP (degrees)	The angle formed by the long axis of the lower first molar and the mandibular plane
11. OP to FH (degrees)	The angle formed by the occlusal plane and the Frankfort horizontal plane
12. L5 tip to MP (mm)	The perpendicular distance between the tip of the lower second premolar and the mandibular plane
13. L5 axis to MP (degrees)	The angle formed by the long axis of the lower second premolar and the mandibular plane
14. L4 tip to MP (mm)	The perpendicular distance between the tip of the lower first premolar and the mandibular plane
15. L4 axis to MP (degrees)	The angle formed by the long axis of the lower first premolar and the mandibular plane

[a] The occlusal plane is formed by a line bisecting the overlapping cusps of the first molars and the incisal overbite.
[b] The mandibular plane is formed by a line through Menton, tangent to the lower border of the angle of the mandible.
Eight linear and seven angular measurements are defined and described.
[c] Refer to *Fig. 1*.

Table 1: Cephalometric variables[c].

power of 0.80 for the present study.

SPSS software, version 22.0 (SPSS, Chicago, IL, USA) was used to perform the statistical analyses. The Shapiro-Wilk test and Levene test confirmed the normal distributions and equal variances between T0 and T1, respectively. Means and standard deviations (SD) were computed for all investigated cephalometric variables.

A paired sample t-test was employed to assess the significance of the difference in each parameter between the time points.

A p value of <0.05 was used to reject the null hypothesis.

Method error

The same trained operator performed and repeated all measurements 1 month later. Systematic and random errors were calculated, and the first and second measurements were compared using paired t tests and Dahlberg's formula[16], at a significance level of $p<0.05$. All measurement error coefficients were found to be adequate for appropriate reproducibility of the study.

RESULTS

Means and SDs were calculated for all tested cephalometric variables *(Table 2)*. The mean differences between T0 and T1 were also computed; the paired t-test values are given in *Table 2*.

Dental parameters

The overbite significantly decreased by 3.34±0.85 mm ($p<0.05$) and the final mean overbite was 2.0131.24 mm. Intrusion of the lower incisors as measured from point I to MP was 2.22±1.22 mm and was statistically significant ($p<0.001$). The buccal inclination of the lower incisors was 1.15±0.91 degrees (L1 to MP) but was not statistically significant, nor were changes in the lower incisor edges (L1 to NPg) significant. No significant changes were seen for inclination of the upper incisors. No significant extrusion of the first molars was measured.

The first and second lower premolars showed significant mesial tipping of 4.14±4.50 and 3.98±4.28 degrees, respectively. The mesial tipping was associated with non-significant slight intrusion of 1.15±4.52 and 1.30±4.52 mm, respectively.

Inclination of the occlusal plane was rotated counterclockwise but was not significant.

Skeletal parameters

The lower facial height and the inclination of the mandibular plane were not significantly altered.

DISCUSSION

The aim of the present study was to evaluate the efficacy of a mechanism for lower incisor intrusion using the i-TTя© lingual appliance and a continuous archwire.

The overbite significantly decreased by 3.34±0.85 mm in the present sample and reached normal values *(Table 2)*. Hong et al.[12] evaluated overbite decrease and lower incisor intrusion with lingual appliances and found a mean decrease of 1.9 mm in overbite. The differences in the reported results might be mainly due to differences in the examined samples. Moreover, the present study evaluated lower incisor intrusion and overbite at the end of fixed orthodontic treatment, while the previous study performed an evaluation immediately after the intrusion phase; this difference in timing

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	T0		T1		T1-T0		
	Mean	SD	Mean	SD	Mean	SD	*p*
Overbite	5.35	1.52	2.01	1.24	-3.34	0.85	0.01*
MP to FH	24.34	4.55	23.32	3.35	-1.02	0.54	0.17
LAFH	68.59	8.04	66.55	5.93	-2.04	1.54	0.26
U1 to FH	115.85	7.14	116.28	6.12	0.43	0.22	0.82
Length of L1	25.38	3.07	25.1	2.51	-0.28	0.36	0.08
L1 to NPg	4.53	3.68	3.43	2.93	-1.10	0.61	0.15
L1 to MP	93.88	8.07	95.03	7.3	1.15	0.91	0.48
Point I to MP	27.65	3.45	25.43	3.31	-2.22	1.22	0.00**
L6 tip to MP	30.35	4.7	29.73	3.81	-0.62	0.23	0.32
L6 axis to MP	83.05	6.4	80.95	7.07	-2.11	1.01	0.15
OP to FH	5.82	3.81	6	3.31	0.19	0.14	0.82
L5 tip to MP	34.64	4.77	33.35	3.20	-1.30	4.52	0.17
L5 axis to MP	88.64	3.68	92.52	2.92	3.98	4.28	0.00**
L4 tip to MP	35.92	4.64	34.77	3.32	-1.15	4.52	0.22
L4 axis to MP	87.39	3.82	91.39	2.99	4.14	4.50	0.00**

Data are shown as the mean and SD. Cephalometric values are shown at T0 and T1, and the differences between T0 and T1 were calculated. Results of the paired t-test are indicated.
* $p<0.05$
** $p<0.001$.

Table 2: Comparison of cephalometric variables between T0 and T1.

might be considered a limitation of the present study and might reduce the comparability of results.
Lower incisor intrusion was 2.22±1.22 mm at the end of the fixed orthodontic treatment, which was statistically significant. Intrusion was assessed using point I, in accordance with previous evaluations[8], since measurement at the incisal edge might be affected by changes in incisor inclination towards buccal. Previous studies reported an average of 1–2 mm of true incisor intrusion[5,12,17,18] either with segmented or continuous mechanics. However, Kinzel et al.[18] reported 2.71 mm of lower incisor intrusion, comparable to the results of the present study.
The results showing decreased overbite and lower incisor intrusion might seem contradictory because the intrusion (2.22±1.22 mm) was slightly less than the decrease in overbite (3.34±0.85). In the present study sample, the T1 lateral x-ray was performed at the end of treatment and not immediately after lower incisor intrusion for ethical reasons since another lateral x-ray after the lower incisor intrusion phase was not clinically required or justified. However, the changes in the upper incisors might have slightly influenced the overbite. Nevertheless, no significant changes were seen regarding inclination of the upper incisors (U1 to FH, *Table 2*).
Limited buccal inclination of the lower incisors of 1.15±0.91 degrees (L1 to MP) was seen in the present study, which was not statistically significant. The result was confirmed by no significant changes in the incisor edges (L1 to NPg, *Table 2*). As consequence of lower incisor intrusion with labial appliances, buccal inclination often occurs because of the greater distance between the point of force application and the centre of resistance of the tooth. Lingual appliances allow the point of force application to be moved closer to the centre of resistance of the tooth, thus reducing rotational moment and accordingly the undesired flaring of lower incisors during intrusion *(Fig. 7)*.
The first and second lower premolars showed significant mesial tipping with no significant extrusion even though they were included in the appliance, unlike the first molars. The mesial tipping was associated with slight pseudo-intrusion which was neither statistically nor clinically significant and might be considered a side effect of the levelling and aligning phase. The distal bend was modelled in contact with the more distal bracket and good sagittal control was achieved on the anterior teeth with moderate mesial tipping of the premolar crowns.
No significant extrusion of the first molars or premolars was seen in the present study. The intrusion mechanism used a continuous archwire which can produce unexpected forces, thus making force levels and force vectors difficult to control or determine[19-21].
Furthermore, specific differentiation of the vertical patterns of the patients was not performed, which might be considered a limitation of the present study. In fact, mesofacial and brachyfacial patients were reported to have higher bite forces than dolichofacial subjects[22,23], who also seem to more often have undesirable extrusion of posterior teeth due to weaker musculature that fails to withstand extrusive forces during orthodontic treatment[24].
As suggested by Bench et al.[25], teeth would be controlled by natural anchorage in a brachyfacial pattern, where the musculature is strong. However, dolichofacial subjects would be less able to overcome the teeth-extruding and bite-opening effects of orthodontic treatment and incisor intrusion with continuous archwire.
According to the results of the present study, the inclination of the mandibular plane was not significantly altered and no clockwise rotation of the mandible occurred, thus confirming there was no significant loss of posterior vertical anchorage or molar extrusion. Growing patients might also be able to maintain a stable mandibular plane when undesired molar extrusion occurs due to mandibular compensating growth, unlike non-growing patients where control of the vertical dimension might be more difficult. The subjects selected for the present study were non-growing patients who showed stable mandibular plane inclination and lower facial height, thus proving good vertical control of the intrusion mechanism with negligible loss of posterior anchorage and posterior teeth extrusion.
Perhaps the use of the light forces produced by nickel-titanium round archwires helped to control undesired extrusion of the posterior teeth since

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Figure 5: Clinical case showing lower incisor intrusion. (A) Pre-treatment intraoral pictures showing deep-bite malocclusion and a class 1 molar relationship. (B) The lingual bracket system was bonded on the lower arch to start the aligning and intrusion phase. Treatment progression up to the lower arch is completely aligned. The bracket system was also applied in the upper arch in this patient. (C-D) Pre-treatment and post-treatment intraoral photographs show correction of the deep bite with intrusion of the lower anterior teeth which were not visible in the frontal view in pre-treatment records. A vertical step between the canines and premolars showing canine and incisor intrusion can be seen in the lateral view of post-treatment pictures.

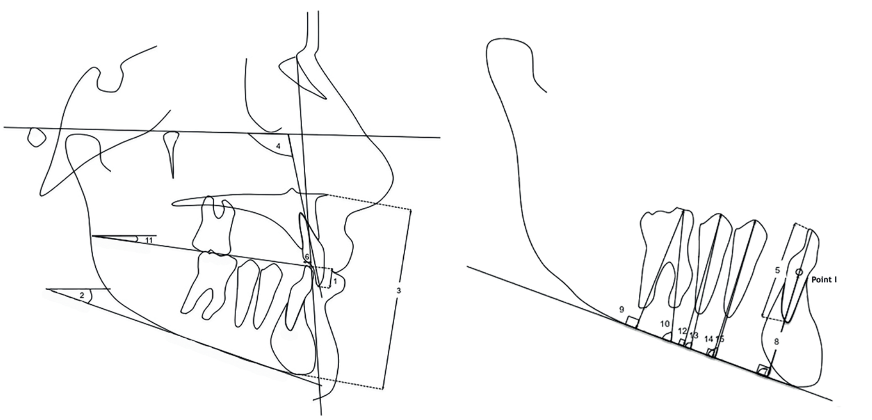

Figure 6: Cephalometric analysis. Refer to Table 1.

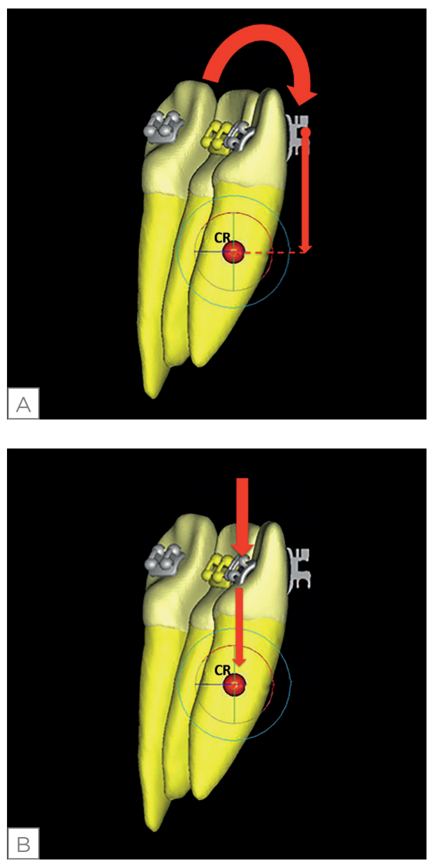

Figure 7: Analysis of forces. (A) Vestibular appliance performing intrusion on the lower incisors. (B) Lingual appliance performing intrusion on the lower incisors. CR, centre of resistance.

the archwire forces may not be strong enough to overcome occlusal forces. The results of the present study support the previously mentioned hypothesis.

CONCLUSIONS

- Intrusion of the lower incisors by 2.22±1.22 mm was accomplished using i-TTя© lingual bracket system on a sample of adult patients.
- Undesired extrusion of premolars employed as anchorage teeth for incisor intrusion was negligible, with stable mandibular plane inclination and lower facial height.
- The results of the present study need to be confirmed by further research into the possibilities of muscular anchorage and by long term follow-up.

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MB and NC acquired the clinical data and treated all the patients; PZ, EC and RF processed all the images for the analyses and drafted the manuscript; AM supervised in acquiring clinical data and and revising the manuscript critically for important intellectual content; AC supervised in drafting the manuscript and revising it critically for important intellectual content. All authors read and approved the final manuscript.

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Vittorio Grenga
Private Practice of Orthodontics,
Rome, Italy

Correspondence:
Via Apuania, 3 • 00162 Rome • Italy
e-mail: vigrenga@tin.it

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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.

The Eagle's Syndrome

A 30-year-old woman was referred to a dental and maxillofacial clinic for recurrent orofacial pain particularly in the temporomandibular joints and in the area of the muscles of mastication.
Clinical examination revealed a good and stable occlusion; orthopantomography (OPG) showed no dental pathologies but revealed bilateral elongation of the styloid processes.
CT scanning with 3D reconstruction confirmed a diagnosis of Eagle's syndrome (ES) *(Figs. 1–3)*.

DISCUSSION

The elongation of the styloid process or the mineralization of the styloid ligament are signs of a rare clinical condition called ES. ES was first defined in 1937 and it is caused by elongation of the styloid process beyond 2.5 cm[1-3].
The styloid process is an elongated tapered projection that originates in the petrous portion of the temporal bone, lying medially and anteriorly to the stylomastoid foramen, between the internal and external carotid arteries, and lateral to the tonsillar fossa[4].
ES can occur unilaterally or bilaterally and frequently results in symptoms of dysphagia, recurrent throat pain and foreign object sensation, referred otalgia, headache, pain on rotation of the neck, dizziness, pain in mouth opening, discomfort during chewing, change in voice and a feeling of hypersalivation[5].
Styloid process elongation or stylohyoid ligament mineralization has been reported to be present in imaging studies in 19.4–52.1% of the general population and in up to 76% of patients with temporomandibular disorders (TMD)[5].
ES can be diagnosed with panoramic radiography (OPG) or with cone beam computerized tomography (CBCT) which can definitively measure the length of the styloid process.
Treatment of ES is primarily surgical through an intraoral or extraoral approach. Non-surgical treatment includes non-steroidal anti-inflammatory medications and local infiltration with steroids or anaesthetic agents.
ES is not familiar to dentists and can lead clinical manifestations similar to TMD.
Misdiagnosis hinders treatment success since TMD is treated with conservative and reversible therapy, while treatment for ES can involve surgical excision[6].

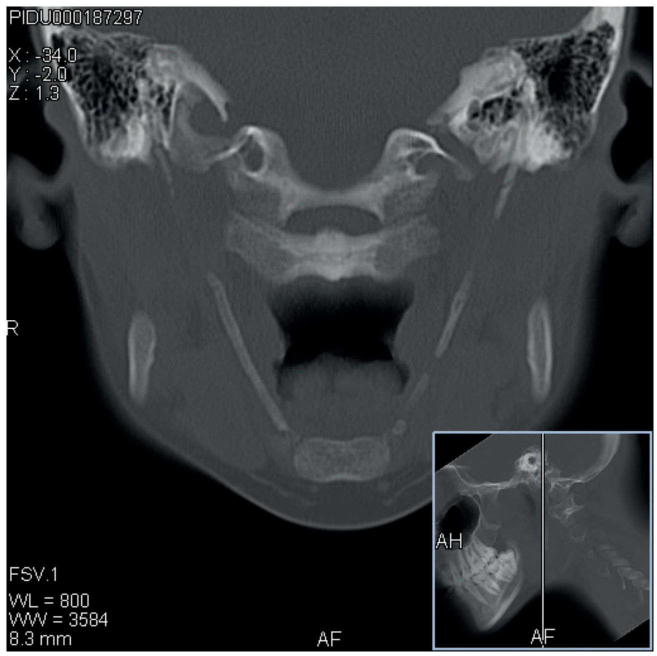

Figure 1: 2D CT image in coronal reconstruction showing elongation of both styloid processes.

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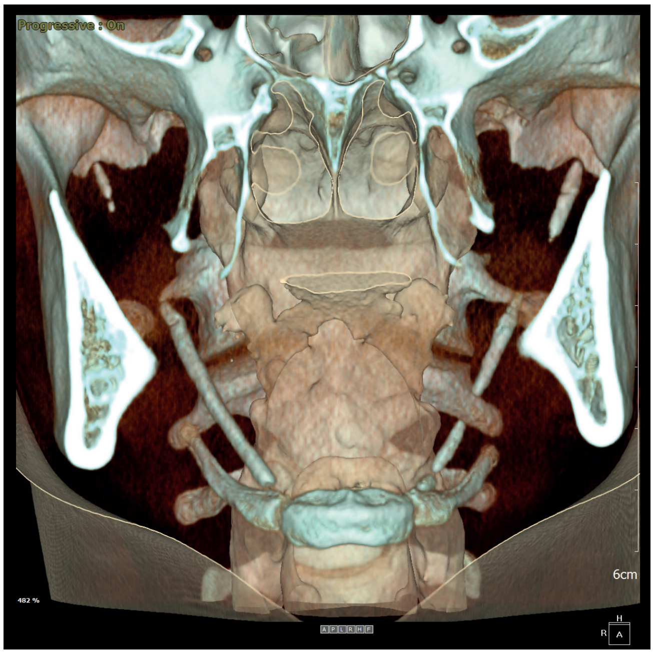

Figure 2: 3D CT image demonstrating bilateral elongation of the styloid process.

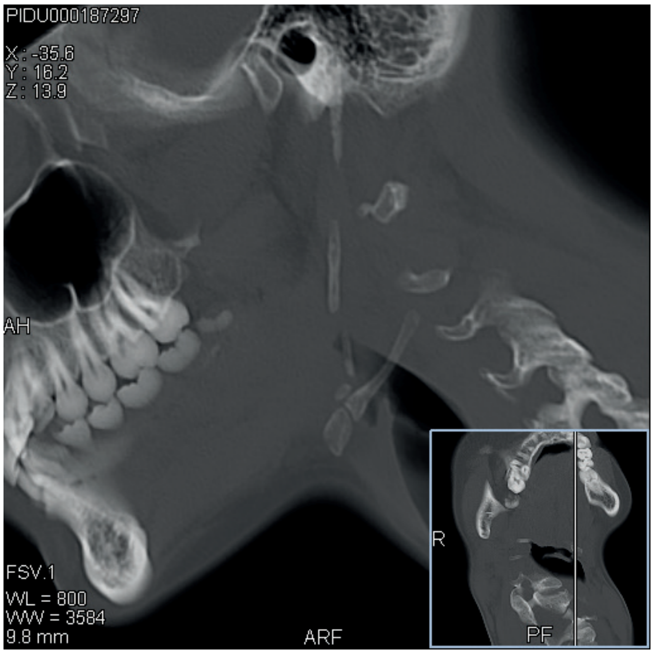

Figure 3: 2D CT in sagittal reconstruction showing elongation of both styloid processes.

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

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