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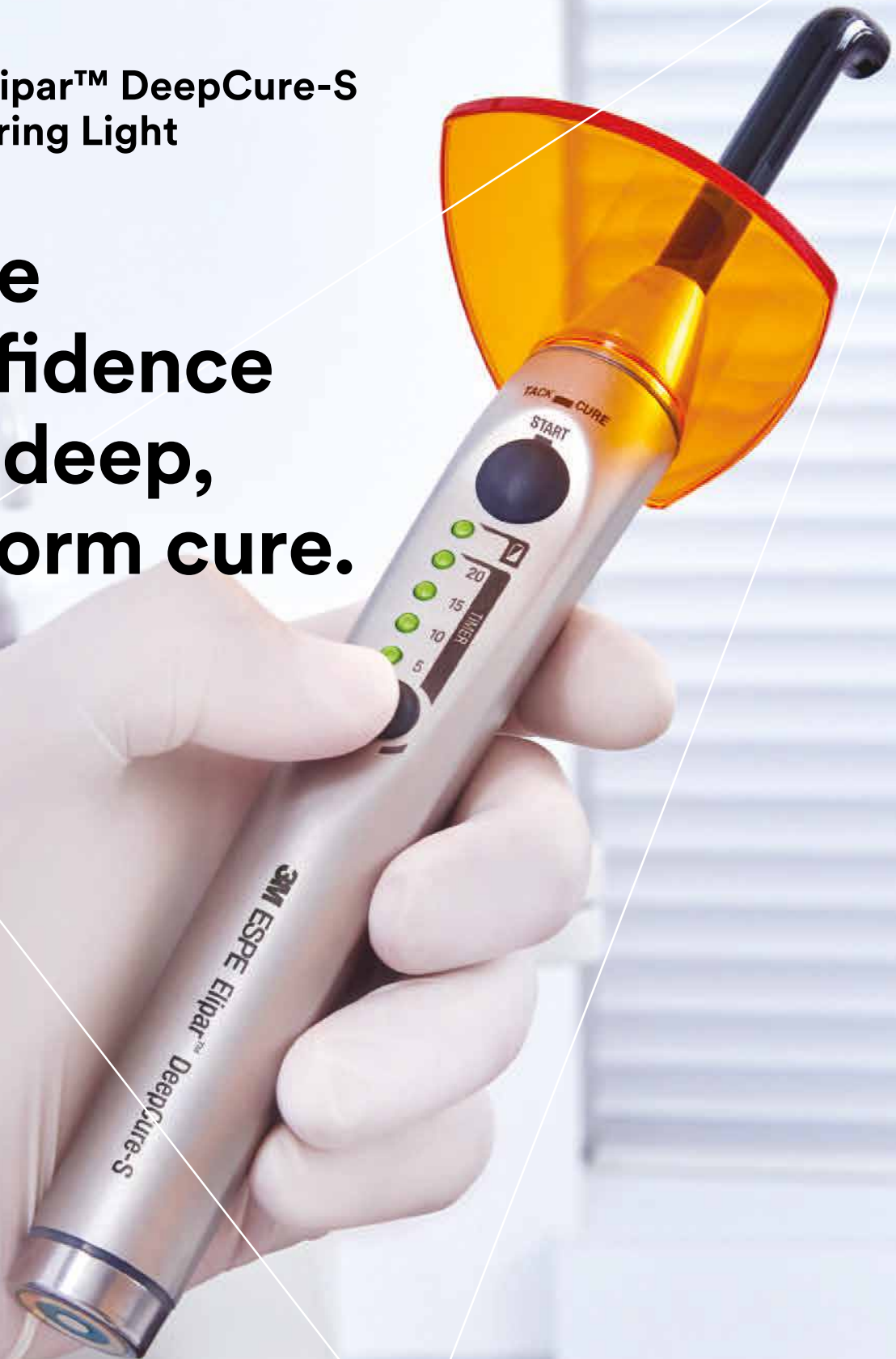
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President's Message

Sri Lanka Orthodontic Society.

It is my pleasure and privilege to pen this message for the inaugural Sri Lankan Journal of Orthodontics (SLJO) launched at the Sri Lanka Orthodontic Conference 2018, organized by the Sri Lanka Orthodontic Society (SLOS), the apex professional body of Orthodontists in Sri Lanka. It is a milestone indeed, to accomplish this arduous task of publishing a journal to showcase contemporary research findings and concepts in the dignified specialty of Orthodontics.

We are privileged to receive unique contributions from a galaxy of eminent academics, clinicians and multidisciplinary researchers of international repute as well as from Sri Lanka. This venture is a way forward to invest on knowledge economy and knowledge transfer in Orthodontics which is the art, science and the discipline in enhancing facial appearance of people while striking the balance among aesthetics, stability and occlusion. Gone are the days, clinicians dominated in providing health care to people exclusively based on normative assessments leaving patient concerns aside. Patient-centred health care is gaining recognition as an integral component of quality health care provision not only in developed countries but in developing countries as well. The specialty of Orthodontic care provision is not immune from such global concerns of best practice, while providing evidence- based quality care to its recipients.

The SLJO is aimed at making fruitful contributions in this regard while reinforcing our overarching theme of 'Enriching Orthodontics by evidence-based practice'. Against this backdrop, while gratefully appreciating the valuable contributions of authors of inaugural SLJO, let me wish all the success to revolutionize landscape of evidence-based, patient-centred practice in Orthodontics.

Dr W.M. Senadeera

President

Sri Lanka Orthodontic Society.



President's Message

World Federation of Orthodontists

It is a great pleasure for me to be given the opportunity to congratulate the Sri-Lankan Orthodontic Society on the publication of their first journal.

Such new ventures should be applauded for the work and dedication required.

A national journal gives society members the opportunity to read peer reviewed articles from both International and local national colleagues.

We owe it to our patients to treat from evidenced based modalities and what better way to keep up to date than through one's own society journal.

Journals are "living documents" allowing a regular interchange of ideas and opinion through articles and letters. But journals are only as good as the material submitted.

I am sure that members of the Sri-Lankan Orthodontic Society will embrace their journal and make it the success it deserves.

All good wishes and congratulations.

Allan R Thom

A handwritten signature in black ink that reads "Allan R. Thom". The signature is fluid and cursive, with the first name "Allan" and last name "Thom" clearly distinguishable.

President

World Federation of Orthodontists





President's Message

Asian Pacific Orthodontic Society

It gives me great pleasure to write this short message for the inaugural edition of the Sri Lanka Journal of Orthodontics.

I know that launching an academic journal is no mean task as I have seen the development of the Asian Pacific Orthodontic Society's own JOURNAL from its inception till it is today. I therefore congratulate the members of the Sri Lanka Orthodontic Society for undertaking this monumental project and finally seeing the fruits of your labour.

I also wish to take this opportunity to acknowledge the contributions of the SLOS towards the APOS. Your Society has been a stalwart over the last years as the APOS has grown and developed. Your past committee members, Dr Senadeera, Dr Wettasinghe and Dr Basnayake and have been very active and valued members in the APOS.

I congratulate the SLOS and its members once again for this momentous occasion and I wish you every success in all your future endeavours.

Well done!!

Bryce Lee

President

Asian Pacific Orthodontic Society

Sri Lankan Journal of Orthodontics

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It is an exciting time for the Sri Lankan Orthodontic Society (SLOS) and a time to reflect as well as congratulate the Society on achieving some extraordinary milestones. This first publication of the Sri Lankan Journal of Orthodontics represents the recognition that the SLOS has developed and matured into a robust group that has been recognised by the international community. The editorial board and group of reviewers have been selected from all corners of the world and articles attracted from the region. We will be actively sourcing articles from our international colleagues but must not lose sight that this Journal is the centrepiece of the specialty in Sri Lanka and will play a role in defining the course of the clinical practice and research in the region. At a time when evidence based clinical care is paramount for any developed environment, it is even more important in developing countries as the primary aim of any educator or clinician is to promote excellence in clinical practice that has a sound scientific base.

Over the last 3 decades I have witnessed the Society grow from a small group of clinicians who had a passion for orthodontics to a more formal professional group that commands the respect of all dental and medical practitioners across Sri Lanka. The extraordinary efforts of the of these early pioneers often goes unrecognised but I wish to acknowledge their active participation in setting the foundations for development. There is a long way still to go and we look forward to a bright future as the breadth of articles will explore many and varied topics of technology, ethics and practice management in addition to the necessary clinical and research areas relevant to orthodontics.

I am personally honoured by the Society to be asked to take the helm for this initial period and I will endeavour to see this Journal become a valuable resource within and outside the shores of Sri Lanka.

Mithran S Goonewardene

Editor-in-Chief

SLJO

The practice of evidence-based Orthodontics: An analysis paper of its underlying principles and current evidence for the management of skeletal malocclusions

Priti Subhash Mulimani¹

M.D.S., M.Orth.R.C.S.Ed, FDS RCSEd, Associate Professor Et Head, Department of Orthodontics, Faculty of Dentistry, Melaka Manipal Medical College

Abstract:

Present day orthodontic practitioners are more aware and have a greater understanding regarding the importance of integrating evidence-based research findings with their clinical practice. However when it comes to implementing these findings in reality, most important barriers are stated to be either a poor understanding of evidence-based practice or ambiguous and conflicting research. The numerous systematic reviews and meta-analysis that are regularly conducted, often times conclude that there is insufficient data in orthodontic literature to get clear answers. These issues in orthodontic research often create a perception of lack of clarity and information for practical implementation of Evidence-based Orthodontics (EBO).

With an objective to facilitate better understanding and application of EBO in day-to-day clinical routine, this commentary presents an elaborate elucidation of the underlying principles of an evidence-based practice. It will provide insights into the different types of orthodontic study designs, with particular emphasis on systematic reviews (SRs) and meta-analysis. A section on Cochrane systematic reviews, considered to be the most rigorous types producing the most reliable evidence, is also included along with the current Cochrane evidence on the management of skeletal malocclusion in Orthodontics. The often encountered issues, which inhibit clinicians from adopting EBP are also addressed and suggestions to overcome the barriers are also provided.

Key words: Evidence based orthodontics, Evidence based practice, Cochrane, Systematic reviews, Meta-analysis

Introduction:

Evidence-based practice (EBP) was defined by Sackett¹ as the conscientious, explicit, and judicious use of current best evidence when making decisions about the care of a patient. Thus, evidence-based care is a triad of 3 domains - clinical expertise, best research evidence and patient preferences or values (Figure 1). Clinical expertise is not merely possessing an educational qualification but deepening and applying learnt knowledge further to acquire greater proficiency and acumen in diagnostic skills and treatment modalities through clinical practice and experience. Clinical expertise and research evidence are said to complement each other, one being incomplete without the other. To quote Sackett "without clinical expertise, practice risks becoming tyrannised by evidence, for even excellent external evidence may be inapplicable to or inappropriate for an individual patient. Without current best evidence, practice risks becoming rapidly out of date, to the detriment of patients." Factors determining adoption of EBP by practitioners have been described in the "EPIC" framework as Environment (which includes the social, cultural and professional background of the practitioner), Personality of practitioner, Identity of practice, and Cognitive abilities².



Figure 1: Triad of Evidence Based Practice

How to find answers to the clinical questions? Research questions and study designs:

To obtain pertinent answers to clinical problems, clinicians and researchers should adopt the PICO format of questioning where P stands for participants or patients, I for Intervention, C for Comparisons and O for Outcome. For example, to investigate best treatment options for missing lateral incisors the PICO question would be – In patients undergoing orthodontic treatment for agenesis of lateral incisors, will space closure and substitution with canines produce a better aesthetic and functional result as opposed to space opening and replacement with prosthesis? In this scenario, the Participants are patients with congenitally missing lateral incisors, Intervention is orthodontic treatment, Comparison is between the two methods viz space closure and substitution with canines Vs. space opening and replacement with prosthesis and Outcomes are aesthetic results and functional efficiency. Articulation of clinical problem in PICO format generates the closest, most relevant and best matches while searching the literature for evidence³.

The second aspect of EBP is to find the best research evidence, which is depicted by the pyramid of hierarchy of evidence (Figure 2). The evidence pyramid grades studies according to their design, indicating the extent to which they are susceptible to bias thus reflecting their internal validity or trustworthiness of the findings of the study as being close to reality. The higher the position of a research design in the pyramid, greater are its validity, reliability, objectivity and lesser are the biases. The broad base of the pyramid is reflective of the availability of larger number of studies or sources at lower levels of evidence as opposed to its tip indicating much lesser studies or sources available at higher levels of evidence.

Evidence-based sources can be primary or secondary. Primary sources, mostly forming the base of the pyramid, consist of original research articles or individual studies which can be quantitative or qualitative. Quantitative research studies are the ones which test a hypothesis and can be of two types – 1. Experimental – where the researcher controls or manipulates variables to study the corresponding effects like in a Randomized Controlled Trial (RCT) and Controlled Clinical Trial (CCT) to establish a cause-and-effect relationship or 2. Non-experimental or Observational – wherein the researcher does not give a treatment, intervention, or provide an exposure, instead they just study or observe the events that exist or have taken place (Case control studies or Case reports) or are about to take place in certain populations (Cohort studies). On the other hand, qualitative research explores questions in depth

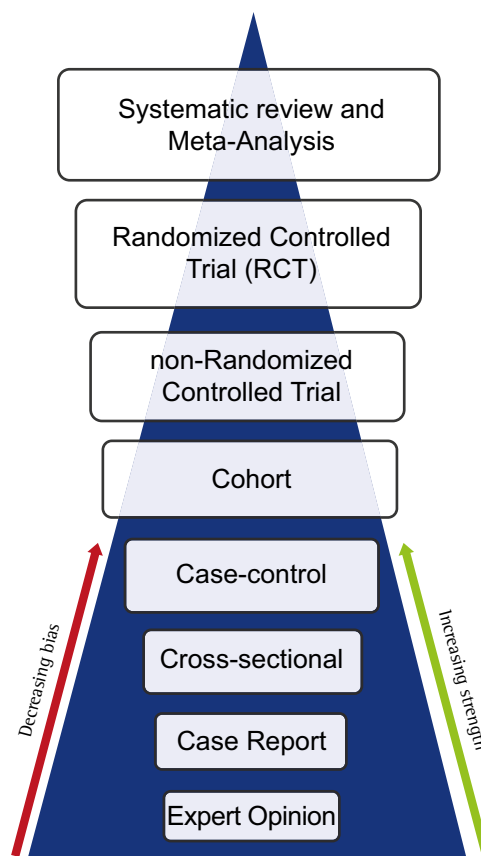


Figure 2: Hierarchy of Evidence

with respect to their hows and whys and may result in generation of new theories. To investigate what are the patients' perceptions regarding risks or benefits of orthodontic treatment is an example of qualitative research whereas to measure how many had an improvement in malocclusion or how many experienced an adverse event is a quantitative study.

Systematic reviews and Meta-analysis: what are they and why do we need them?

This body of research and scientific literature is ever expanding and cumulative. As more and more studies are conducted and research data piles up, the research questions often get entangled in the complex web of varied and contradictory findings from several different studies, which defy simple summarization or deductions and are more prone to being misinterpreted. As evidence based practice started to gain prominence in 1990s and clinicians turned to scientific literature for evidence it would often be the case that the basic question was still unanswered or had ambiguous or confusing answers to be put into use for simple clinical application. This created an important role for secondary research sources which essentially filter, integrate and synthesize data already generated by primary research and these occupy the tip of the evidence pyramid. Examples of secondary research sources are reviews, meta-analyses

or evidence-based practice guidelines⁴. To 'review' has been defined as: 'To view, inspect, or examine a second time or again'⁵. In the healthcare domain 14 types of reviews have been identified⁵. The classical literature review or narrative review also called as traditional reviews are of the nature of descriptive reporting of the findings of individual studies supporting or refuting the research question under investigation. Although they may provide a good overview of the studies existing in literature on a certain topic, these reviews have been criticized for lacking rigorous methodology, pre-stated objectives or data analysis which makes them prone to bias by not objectively investigating, questioning or critically evaluating the validity of the statements or observations made in included studies. The validity of these reviews may also have been affected by selective reporting as authors would have cherry-picked only those studies that support their hypothesis thus drawing up a biased or misleading picture⁵.

These limitations of traditional reviews have led to the rise and increased popularity of more systematic, objective, pre-specified and standardized methods for reviewing the literature namely the Systematic reviews (SR), which are considered to be the "gold standard" in evidence pyramid. Chalmers defines SR as a review that has been prepared using a systematic approach to minimizing biases and random errors which is documented in the Materials and methods section⁶. SRs have gained wide acceptance as reliable instruments of evidence detection due to their objective, meticulous, unbiased and transparent approach in conducting and reporting the methodology so that the same process can be replicated by anyone. SRs synthesize research evidence by following pre-specified guidelines laid down by international organizations like Cochrane Collaboration or the NHS Centre for Reviews and Dissemination. Thus there are said to be two types of SRs – Cochrane reviews and non-Cochrane reviews. The key steps in conducting any SR are – formulating the review question, defining the criteria for inclusion of studies, identifying all relevant studies by a meticulous search process, including studies which meet pre-defined criteria and finally analysis and interpretation of collective findings from included individual studies.

The data from individual studies included in a systematic review may or may not be combined together. If they are pooled together and subjected to statistical analysis, then it becomes a Meta-analysis. For example, consider that an SR assessing the effects of face mask on maxillary protraction and correction of Skeletal Class III malocclusion has 2 included studies and study no. 1 has 60 participants and study no. 2 has 40. If all these participants are combined together to obtain a sample size of 100 and then statistical analysis is carried out to detect the overall amount of maxillary protraction in

all these 100 participants, then this becomes a meta-analysis. However it is not possible to carry out a meta-analysis all the time because in order to do so there has to be some uniformity in the methodology, interventions used (appliances), comparisons made and outcomes measured (Change in SNA or ANB or Witts appraisal – outcomes indicating change in skeletal Class III) in the same way at the same time intervals. In other words, a meta-analysis can be done if studies are comparing one type of apple with another type of apple but not an apple with a pineapple. For example, in the above illustration if one study is using pre and post-treatment SNA values to detect maxillary protraction and another is measuring change in ANB to detect skeletal Class III correction then these studies cannot be combined. Similarly, even if both studies are measuring ANB but one has presented values at the end of 6 months and another at the end of 1 year then these cannot be combined. Thus, Meta-analysis which is referred to as the statistical pooling of the results of included studies in a systematic review, if carried out leads to an increase in the overall sample size thus increasing the statistical power of the analysis and the precision to assess the treatment effects, and are therefore said to produce "the highest quality of evidence available in medical science"⁷.

Patient preferences: The part of EBP set to become increasingly important in current era

The final aspect of EBP is patients' preferences or values which involves informing them about all available treatment options, helping them understand these options, the outcomes, risks, benefits, cost and time associated with each and allowing them to express their preference based on the consequences which matter the most to them. Even if the patient leaves it up to the orthodontist to make the choice or is unable to fully comprehend to make a decision, informed consent, explanation of treatment procedures with their probable pros, cons and consequent outcomes and executing the plan which is in the best interest of the patient are crucial in building trust and providing ethical treatment to the patient. Needless to say when patients are children, parental consent and involvement in the treatment decision-making process is paramount not only in terms of ethics but also for medicolegal reasons. With the abundance of information available at fingertips courtesy the internet, treatment options research by patients themselves has become greater than ever, thanks in large part to Google. However, an overabundance of information might not always be the most credible. A great disparity exists between freely available, unauthenticated information on the internet and scientifically validated, research-based facts.

Cochrane systematic reviews attempt to bridge this gap for both clinicians and patients. For clinicians the Cochrane network provides a platform to seek

evidence at its highest level and for patients, lay-people or care-givers it provides plain language summaries, encourages participation in review groups or forums and makes information about healthcare evidence easier to access, use and understand for all. Cochrane was founded as an international, independent, not-for-profit collaboration of researchers, professionals, patients, care-givers, and people interested in health by Iain Chalmers in 1993 in honour of Archie Cochrane, a British medical researcher who had first envisioned and highlighted the necessity of collecting and publishing critical reviews of knowledge from randomised controlled trials. Its objective itself is to gather and summarize the best evidence from research to help make informed choices about treatment. To fulfill this objective Cochrane maintains an online library of which the Cochrane Database of Systematic Reviews (CDSR) is the most important part and it consists of high quality Cochrane reviews on various important health topics^{8,9}.

Cochrane systematic reviews & current evidence on skeletal malocclusion management:

Cochrane reviews not only summarize evidence but they also critically appraise the findings of included study, the quality of evidence and consequent recommendations based on this evidence. Grading of Recommendations Assessment, Development and Evaluation (GRADE) tool used in Cochrane reviews, rates quality of evidence as high, moderate, low or very low quality and strength of recommendations as strong and weak. This assessment takes into account the risk of bias of the included studies, the directness of the evidence, the inconsistency of the results, the precision

of the estimates and the risk of publication bias¹⁰. After peer-review and correction cycle of the prepared review and passing the quality control check it is published on the Cochrane library. Published reviews are a life-long commitment and a top-up search and updating of the review has to be done every two years.

Our specialty of Orthodontics, is not only the first specialty created in the field of dentistry but also a pioneer in research and evidence-based practice. The name of the specialty was changed to "Orthodontics and dentofacial orthopaedics" to reflect the role of our field, in being able to influence or change not only the position of teeth but also of the underlying bone structure and jaw morphology. The extent of this influence has always been a topic of hot debate in orthodontics. Randomized controlled trials in the 90s and systematic reviews in recent years have found little influence of growth modification techniques on jaw growth¹¹⁻¹⁵. Cochrane reviews by the Cochrane Oral Health Group have stepped in to investigate the role of orthodontics in treatment of skeletal malocclusions in both children and adults. As of October 2016, two hundred and six reviews (in different stages of title registered, protocol and review) were found in Cochrane Oral Health Group (COHG) on all topics related to dentistry, out of which 25 were on Orthodontic treatment. Of these 25, twenty-two were full reviews, two were protocols and one was a registered title. Treatment modalities for skeletal deformities in various malocclusions in adults and children were analysed in six of these 22 full reviews, the summary of which is provided in Tables 1 -4.

Table 1: Treatment of Class II Division 1 Malocclusion in Children
Summary of Evidence from a Cochrane Systematic Review

Participants	Interventions	No. of RCTs included in Review	Comparisons	Outcomes	Results	Conclusion
Orthodontic Treatment for Prominent Upper Front Teeth (Class II malocclusion) in Children ¹⁶						
Children or adolescents (age 16 years or less) or both receiving orthodontic treatment to correct Class II malocclusion.	Early treatment (either one or two-phase) with any type of removable, fixed or functional appliances or head-gear compared with late treatment with any type of removable, fixed or functional appliances or head-gear. Early treatments were defined as those commencing in children aged between seven and 11 years of age.	17	a. Early (two-phase) intervention with adolescent (one-phase) treatment b. Functional appliance (Bionator, FR II) Vs Headgear for early treatment c. Functional appliances Vs. no treatment in adolescents d. Different types of functional appliances in adolescents like - Twin Block with other types of appliances (R-appliance, Bass, Bionator, Dynamax) or modifications to twin blocks (incremental Vs. single-step advancement and with or without labial bow), R-appliance with Anterior Inclined Bite Plate and a fixed functional appliance with a functional appliance (Activator Vs. Forsus)	Primary - Overjet Secondary - Relationship between upper and lower jaws - ANB, PAR index etc self-esteem, patient satisfaction,	a. When headgear (two-phase treatment) was compared with adolescent treatment (one phase) or headgear and functional appliances in phase one treatment were compared with each other - at the end of the first phase of treatment statistically significant differences, in favour of functional appliances, were shown with respect to final overjet only. At the end of phase two, there was no evidence of a difference between appliances with regard to overjet b. Late orthodontic treatment for adolescents with functional appliances showed a statistically significant reduction in overjet compared to no treatment (very low quality evidence). c. There was no evidence of a difference in overjet when Twin Block was compared to other appliances but, a statistically significant reduction in ANB was shown in favour of Twin Block. There was no evidence of a difference between Twin Block and its modifications d. There was insufficient evidence to determine the effects of Activator, FORSUS FRD EZ appliances, R-appliance or AIBP.	The evidence suggests that providing early orthodontic treatment for children with prominent upper front teeth is more effective in reducing the incidence of incisal trauma than providing one course of orthodontic treatment when the child is in early adolescence. There appears to be no other advantages for providing treatment early when compared to treatment in adolescence.

Table 2: Treatment of Class II Division 2 Malocclusion and Anterior Open Bite in Children
Summary of Evidence from a Cochrane Systematic Review

Participants	Interventions	No. of RCTs included in Review	Comparisons	Outcomes	Results	Conclusion
Orthodontic Treatment for Prominent Lower Front Teeth (Class III malocclusion) in Children¹⁹						
Children or adolescents or both (age 16 years or less) receiving treatment for Class II division 2 malocclusion	Orthodontic braces (removable, fixed, functional) or headgear with or without extraction of permanent teeth.	0	None	None measured (Primary- PAR Index Secondary- Number of visits required to complete treatment and the duration of treatment, ANB, teeth inclination changes, Patient discomfort etc)	No RCTs or CCTs were identified that assessed the treatment of Class II division 2 malocclusion in children.	It is not possible to provide any evidence-based guidance to recommend or discourage any type of orthodontic treatment to correct Class II division 2 malocclusion in children.
Treatments for Adults with Prominent Lower Front Teeth²⁰						
Children and adolescents 16 years old or younger at the start of treatment, with anterior open bite.	Non-surgical modalities of correcting anterior open bite like functional orthopaedic appliances, fixed and removable orthodontic appliances		a. Frankel's function regulator-4 (FR-4) with lip-seal training versus no treatment; b. Repelling-magnet splints versus bite-blocks; c. Palatal crib associated with high-pull chincup versus no treatment.	Primary - Correction of the anterior open bite Secondary- Incisors position and inclination, alteration of hyper divergent growth pattern, mandibular ramus growth, expansion of the upper and lower jaw – inter-canine and molar width	a. FR-4 associated with lip-seal and removable palatal crib associated with high-pull chincup were able to correct anterior open bite. b. The study comparing repelling-magnet splints versus bite-blocks could not be analysed because the authors interrupted the treatment earlier than planned due to side effects in patients.	There is weak evidence that the interventions FR-4 with lip-seal training and palatal crib associated with high-pull chincup are able to correct anterior open bite. Given that the trials included have potential bias, these results must be viewed with caution.

Table 3: Treatment of Class III Malocclusion in Children & Adults
Summary of Evidence from a Cochrane Systematic Review

Participants	Interventions	No. of RCTs included in Review	Comparisons	Outcomes	Results	Conclusion
Orthodontic Treatment for Prominent Lower Front Teeth (Class III malocclusion) in Children¹⁹						
Children or adolescents or both (age 16 years or less) receiving treatment for Class III malocclusion	Orthodontic braces (removable, fixed, functional), chin cups, facemasks, reverse headgear, bone-anchored appliances, or any other intra or extra-oral appliance aimed at correcting Class III malocclusion	7	a. Facemask versus untreated control b. Facemask with expansion versus facemask only c. Nanda facemask versus conventional facemask d. A 600 g chin cup versus 300 g chin cup versus untreated e. Tandem traction bow appliance versus untreated control Mandibular headgear versus chin cup versus untreated control	Primary – Overjet Secondary – ANB, Wits appraisal, self-concept, Oral Aesthetic Subjective Impact Score (OASIS)	a. Change in overjet and ANB favouring the face mask as opposed to untreated controls was found b. Improvements in overjet and ANB were still present three years post-treatment with face mask when compared with untreated controls (low quality evidence) c. Chin cup compared with an untreated control showed a statistically significant improvement in ANB (low quality evidence) Tandem traction bow appliance compared to untreated control (very low quality evidence) showed a statistically significant difference in both overjet and ANB favouring the intervention group.	There is some evidence that the use of a facemask to correct Class III malocclusion in children is effective when compared to no treatment on a short-term basis. However, in view of the general poor quality of the included studies, these results should be viewed with caution. Further randomised controlled trials with long follow-up are required.
Treatments for Adults with Prominent Lower Front Teeth²⁰						
CAadults with Class III malocclusion	Orthodontic or surgical treatment or both, to correct Angle Class III malocclusion	2	a. Bilateral Vertical Ramus Osteotomy (VRO) by extraoral approach with or without osteosynthesis b. Intraoral Vertical Ramus Osteotomy (IVRO) versus Sagittal Split Ramus Osteotomy (SSRO).	Secondary – Changes in condyle position, Stability of correction (Primary outcome of overjet, canine and molar relationship were not reported by included studies)	between the two treatments. The trials did not provide adequate data for assessing effectiveness of the techniques described.	included trials, to conclude that one procedure is better or worse than another. Further high quality randomized controlled trials with long term follow-up are required.

Table 4: Treatment for Posterior Crossbites
Summary of Evidence from a Cochrane Systematic Review

Participants	Interventions	No. of RCTs included in Review	Comparisons	Outcomes	Results	Conclusion
Orthodontic Treatment for Posterior Crossbites ²¹						
Although this study intended to include non-surgical interventions for correction of posterior crossbite, without a Class III skeletal relationship, in both children and adults, all 14 included studies were on children and no studies on adults with crossbites were found.	Any orthodontic or dentofacial orthopaedic (not surgical) treatment used to correct posterior crossbites	15	a. Rapid expansion like banded versus bonded Hyrax or Minne, b. Different rates of expansion – slow and sem-rapid against rapid c. Fixed versus removable like Quad-helix versus expansion plate d. Grinding – occlusal grinding in the primary dentition (aged five years old) with/without an upper removable expansion appliance in the mixed dentition versus no treatment e. Quad-helix plus multi-bracket versus expansion arch plus multi-bracket f. Conventional mid-line expansion screw versus springloaded expansion screw	Primary- Correction of the posterior crossbite. Secondary-Stability of crossbite correction and changes in inter-canine or molar width	a. Fixed quad-helix appliances may be 20% more likely to correct crossbites than removable expansion plates (low-quality evidence). b. Quad-helix appliances may achieve 1.15 mm more molar expansion than expansion plates (moderate-quality evidence). c. Fixed quad-helix appliances and removable expansion plates are superior to composite onlays for crossbite correction, molar expansion and canine expansion (Very low quality evidence). d. Both tooth grinding, with or without an expansion plate and fixed bonded Hyrax followed by U-bow activator are superior to no treatment for the outcomes crossbite correction and molar/canine correction (Very low quality evidence). e. No evidence was found for other comparisons	There is a very small body of low- to moderate-quality evidence to suggest that the quad-helix appliance may be more successful than removable expansion plates at correcting posterior crossbites and expanding the inter-molar width for children in the early mixed dentition (aged eight to 10 years). The remaining evidence found was of very low quality and was insufficient to allow the conclusion that any one intervention is better than another.

The often encountered barriers in EBP and measures to overcome them:

Despite EBP gaining more ground, there are certain issues in applying it clinically and also in generating evidence in the field of orthodontics for the following reasons –

1. Etiology of malocclusion is complex, multi-factorial and ambiguous, which means there can be different treatment plans for the same malocclusion in different patients based on age, severity, compliance, patient response and several other factors. This makes hypothesis testing in the field of Orthodontics non-linear unlike the disease-drug testing in medical field.
2. There are rapid advances in Orthodontic products and new products are released in the market with laboratory values, company claims and figures being used for advertisement which are often untested or authenticated by independent research. In this void of evidence there exists a lag between availability of reliable evidence & clinical usage of products.
3. Clinicians have cited the following barriers for their failure to practice evidence-based orthodontics in practice²² –
 - a. “No evidence is available and there is conflicting data from different studies. Even systematic reviews fail to provide answers and conclude that there is lack of evidence to make recommendations”

b. “Practice pressure, patient workload, time constraints”

c. “EBO devalues clinicians’ experience & skill”

To each of the issues mentioned above, following are the respective solutions –

1. Refinement of Orthodontic research methodology to generate new evidence or improve existing evidence:

It is a common grouse that systematic reviews don’t reach any conclusion and cite that there is insufficient evidence or there are no good studies. Grant and Booth⁵ have mentioned that a meta-analysis cannot be better than its included studies allow. Similarly, a systematic review can only provide the answers that its included studies allow. It cannot generate any new data on its own unless the primary research has detected it. Hence the onus is on improving the quality of primary research and not just increase the quantity, build on existing literature and add new information.

Implementing the following guidelines can greatly improve quality of research –

- a) Using standardized measures for diagnostic criteria and outcome assessment – COMET (Core Outcome Measures in Effectiveness Trials) is an Initiative which is working on developing core outcomes in orthodontics which can subsequently be the

minimum set of outcomes that are measured in all clinical trials and systematic reviews.

- b) Designing RCTs with adequate sample size based on power calculations, adequate sequence of randomisation with allocation concealment, blind outcome assessment, and completeness of follow up.
- c) Conforming to the Consolidated Standards of Reporting Trials (CONSORT) statement while reporting the methodology of RCTs, which will enable appraisal and interpretation of results, and accurate judgements to be made about the risk of bias and the overall quality of the evidence.

The intention of standardization of outcomes, study designs, reporting or methodology is so that, no matter which corner of the world a study is conducted in, the results of the study can be compared or added to findings of other similar studies, thus making them more comparable, useful, relevant and additive to existing knowledge. It also helps in reducing resource and research wastage and adding valuable new outputs to the work in progress of building a sound and sensible Orthodontic evidence base.

2. Learn to practice Evidence Based Orthodontics with the currently available evidence and even in the absence of it: To do this one has to read and be up to date with the latest scientific and research findings, acquaint oneself with research methodology to be able to evaluate evidence, develop critical appraisal skills and objectively assess treatment claims or findings. Look at what works and also at what “does not” work. Do not ignore negative findings or findings of no differences. Apply evidence where it exists and where it does not exist, use clinical expertise to select the best option and explain to the patient regarding the same, since EBO is not only about research it is also about clinical expertise and patient’s opinion²³. In the June 2016 issue of AJODO, Rolf Behrents the Editor-in-Chief mentions the writing of a 14th Century French Philosopher, Buridan in the editorial piece of “Buridan’s Paradox”. Applying the principle of this paradox to Orthodontics implies suspending judgment as to the best course of action until more is known. In our specialty, for new products or techniques or even old techniques with lack of evidence, when more and better research is conducted, then we will know more. Until that time our treatment choice should not be determined by our biases but instead should be guided by what is the best treatment for the patient at that time and be based on sound scientific principles²⁴. Newer evidence as, when and if it becomes available can then be incorporated into practice if one remains in constant touch with the latest developments in the scientific literature.

3. Finally, the response to the resistance to EBP put up by certain practitioners saying it is too theoretical, idealistic, imperfect for practical situations and a denial of their clinical experience, is embodied in the words of Robert Kiem, editor of JCO that EBP is not a division or debate between “evidence-based” and “experience based” practice, but rather a mutually beneficial continuum between the two philosophies²⁵. Continuing professional development, life-long learning and keeping oneself updated with latest findings are an integral part of being able to deliver the best orthodontic treatment to our patients, instead of stagnating and relying only on what was taught in dental colleges, since Orthodontics is continuously evolving. Various options like systematic reviews, clinical summaries, guidelines or Cochrane reviews exist to considerably reduce the volume of clinical reading thus saving time and facilitating easy availability of evidence summary for clinical application.

The tradition of looking up to respected, well-established and prominent authorities in other words known as “key opinion leaders” for showing the path still continues in the field of Orthodontics. While expert opinions form the foundation and provide the strong base for the pyramid of evidence and is much valuable in many instances, independent thinking and critical appraisal faculties should be maintained by clinicians to make an informed choice instead of becoming dogmatic followers of a certain philosophy without objective evaluation like during the Angle era. Orthodontics is not only an art but also a science, and the key to practicing it likewise lies with implementing evidence-based orthodontics.

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Figure legends:

Figure 1: Triad of Evidence Based Practice

Figure 2: Hierarchy of Evidence

Transverse expansion with self-ligating system: A systematic review

Prabhakar Veginadu¹, Siva Subramanian Chitravelu², Sridevi Padmanabhan³

1. Department of Orthodontics, Sri Ramachandra University

2. Department of Orthodontics–Sri Ramachandra University

3. Department of Orthodontics–Sri Ramachandra University

ABSTRACT

Objective: The purpose of this systematic review is to identify and review the literary evidence on the efficiency of self-ligating bracket (SLB) system in bringing about transverse arch dimension changes when treated either extraction or non-extraction, as compared to conventional system.

Methods: An online search was conducted through 4 electronic data bases from their inception to September 2014. Randomized controlled trials (RCTs) and Controlled clinical trials (CCTs) comparing SLB and conventional systems for transverse arch dimensional changes were included. Quality assessment of the included articles was performed.

Results: Seven studies were identified, including 4 RCTs with low risk of bias, 3 prospective CCTs with high risk of bias. Of the seven studies, 5 studies investigated mandibular dental arch changes alone, while 2 studies investigated changes in both maxillary and mandibular arches.

Conclusion: Four of the seven studies reported no statistically significant difference in transverse arch dimensional changes between SLB and conventional systems, while three studies reported a greater increase with self-ligating system.

Introduction

The “swinging pendulum” of extraction versus non-extraction treatment began with the Dewey – Case debates of 1911¹, and remains unresolved to this day. E. H. Angle (1905), initially provided extraction treatment for his patients, but modified his approach to non-extraction therapy based upon the philosophy that ‘a full complement of teeth’ can be maintained by modifying the environment surrounding the dentition.² Opposed to this non-extraction mode of therapy were several of his pupils, including Tweed and Begg (1963), who advocated that more stable results could be achieved through treatment with extraction.

In order to arrive at a decision on the preferred modality of treatment, either extraction or non-extraction, aspects such as stability of occlusion, characteristics of dental arches- arch width and arch perimeter, facial and smile esthetics, must be considered and their effects on the dentofacial complex need to be clarified.⁴

Extraction is believed to have a negative effect on profile, smile esthetics and final occlusion.⁵ However evidence states the contrary. Investigations showed that extraction treatment had an affirmative effect on the profile, resulted in a better occlusion as compared to non-extraction and the results obtained were stable over a long term.^{6,7,8,9,10} Considering this present state of evidence, one would expect a higher percentage of extraction cases. But studies have shown that “the pendulum” has swung back towards the non-extraction mode of treatment over the past decennia (26.8% of cases treated with extraction in the last decade compared to 50% in 1980s).¹¹

Fixed appliance treatment of Class I malocclusions without extraction inevitably results in an increase in the arch perimeter. This is achieved by generalized expansion at the inter-canine region and the buccal segments, along with advancement of the incisors irrespective of the treatment modalities used.¹² The expansion is usually greater at the premolar region. However, the magnitude and the nature of arch dimensional changes have an influence on long-term stability: inter-canine dimension and excessive proclination of mandibular incisors are regarded as considerably unstable.¹³

Self-ligating brackets are ligatureless bracket systems that have a mechanical device built into the bracket to close off the edgewise slot.¹⁴ There are three types of self-ligating bracket systems being used in contemporary orthodontic practice; described depending on the mode in which they interact with the archwire: Passive, Active and Interactive. Since the advent of the concept of self-ligation, manufacturers and advocates have proposed many advantages of self-ligating brackets over conventional brackets. Some of these include more certain engagement of the archwire, less friction between the bracket and the archwire, minimal chairside assistance, faster archwire ligation and removal.¹⁵ In addition, the proponents of passive self-ligating system claim that more stable transverse arch expansion with minimal incisor proclination can be achieved with self-ligating system, as the alteration of archform with this system, is “physiologically determined.”¹⁶ These claims render a paradigm shift in treatment that warrants fewer extractions and more arch expansion. However, it subsequently raised questions about the stability of results and the feasibility of long-term retention provided by this

technique.¹⁷ Also, studies have shown that the increase in arch length achieved with self-ligating system is by the buccal tipping of premolars and molars, contradicting the original claims by the proponents.¹⁸

The proposed advantages of self-ligating brackets challenge several aspects of conventional orthodontic approach. The recent widespread use of self-ligating brackets indicates that this technique is likely a viable alternative to conventional methods.¹⁹ However several conflicting studies comparing conventional and self-ligating brackets have caused controversy regarding the clinical outcome. In addition, development of several self-ligating bracket designs, in the recent years, has augmented the controversy. As a result, there is uncertainty of the claimed advantages or disadvantages of self-ligating system over conventional system.¹⁵

Therefore, the aim of this systematic review is to compare the transverse dimension changes achieved with self ligating and conventional bracket systems, after orthodontic treatment.

Materials and Methods:

Search Strategy

The first step of this systematic review involved formulation of a research question and subsequently a specific protocol based on Population Intervention Control Outcome Study Design (PICOS) format (Table 1). Based on these criteria, the systematic review should be able to answer the question: 'Does the self-ligating bracket system bring about more transverse arch expansion than conventional system?'

Population	Angle's Class I subjects with mild to moderate crowding treated with fixed appliance
Intervention	Complete arch fixed appliance therapy treated with SLBs or Conventional brackets (CBs), with or without premolar extractions, and without adjunct treatment modalities
Comparison	Conventional PEA bracket systems
Outcome	Transverse arch dimension changes after orthodontic alignment
Study design	Randomized clinical trial, Prospective cohort studies

Table 1. PICOS format and research question

The studies included in this systematic review were identified through a literature search carried out through the following electronic databases: PubMed (1960- September 2014), Google Scholar (1960-2014), and the Cochrane Library from inception to September 2014. Detailed search strategy for PubMed database is given in Appendix 2.

Two reviewers (P.V) and (S.S.C), who were not blinded to the authors or the results of the research, participated in the selection process. Firstly, titles and abstracts of potential articles for inclusion were examined. Full texts of articles that met the inclusion criteria^{21,22,23,24,25,26,27} were then obtained from the published journals and reference lists of the included studies were manually screened for relevant research. Disagreements, if any, were resolved by discussion between the reviewers and a third reviewer (S.P) to reach a consensus.

Eligibility Criteria

The inclusion and exclusion criteria formulated for selection of the studies are listed in Table 2. The studies retrieved had to be either randomized controlled trials (RCTs) or either prospective or retrospective controlled clinical trials (CCTs), comparing transverse arch dimension changes for extraction or non-extraction treatment with the self-ligating or conventional bracket systems. No restrictions were set on the:

- type of self-ligating or conventional systems used
- parameters selected
- mode of quantifying or measuring the changes
- stage of fixed appliance treatment

Inclusion Criteria	Exclusion Criteria
• Randomized controlled trials (RCTs), Prospective Controlled clinical trials (CCTs) • Studies comparing self-ligating and conventional systems for transverse arch dimensional changes • Angle's Class I malocclusion with mild to moderate crowding in the anteriors • All age groups and genders • Articles in English • All stages of treatment	• In-vitro studies, ex-vivo studies, Animal studies, Retrospective studies, Case reports, Case series, Cross-sectional studies, Descriptive studies, Reviews, Opinions and Editorials • Studies with no control group • Adjunct therapy for expansion of arch before fixed appliance • Severe crowding, Angle's Class II and Class III malocclusion

Table 2. Inclusion and Exclusion Criteria

Quality Assessment of Included Studies

The quality assessment of the included studies was performed according to the Cochrane Collaboration's tool for assessing risk of bias.²⁸ The following criteria were used for assessment (Table 3):

- Sample size calculation
- Randomized sequence generation
- Allocation concealment reported

- Blinding of participants, personnel and outcome assessors
- Reporting of withdrawals
- Intention to treat analysis

An overall assessment of risk of bias (high, unclear, low) was also made for each included trial using the Cochrane Collaboration risk of bias tool. Studies with one or more criterion adjudged to be at high risk of bias were considered to be at high risk of bias overall.

outcome assessors and data analysts were blinded in four studies.^{23,24,25,26}

The four RCTs identified, had low risk of bias, and the three CCTs had high risk of bias.

Table 3. Quality Assessment of Included studies

Study	Design	Sample size Calculation	Random Sequence generation	Allocation Concealment	Blinding of measurement	Reporting of withdrawals	Intention to treat analysis	Risk of Bias
Pandis (2007)	CCT	No	Unclear	No	No	None	No	High
Scott (2008)	RCT	Yes	Yes	Yes	Yes	Yes	No	Low
Fleming (2009)	RCT	Yes	Yes	Yes	No	Yes	No	Low
Tecco (2009)	CCT	No	Unclear	No	No	No	No	High
Pandis (2010)	RCT	No	Unclear	No	No	Yes	No	High
Pandis (2011)	RCT	Yes	Yes	Yes	Yes	Yes	No	Low
Fleming (2013)	RCT	Yes	Yes	Yes	Yes	Yes	No	Low

Results:

Study Search

The electronic database search (Appendix 1) identified 153 titles and abstracts, of which 13 deemed potentially relevant to the present systematic review. Following the review of full articles, 8 satisfied the inclusion criteria. However one article was excluded as the data presented was republished from earlier trials. Eventually seven articles^{21,22,23,24,25,26,27} were suitable for final analysis. Details of the electronic search is provided in Appendix 2.

The seven studies included four randomized controlled trials,^{23,24,25,26} three prospective controlled clinical trials.^{21,22,27}

Assessment for Risk of Bias

Seven studies investigating the self-ligating system with the conventional system for transverse arch dimension changes were identified. The outcomes assessed included changes in intercanine, interpremolar, intermolar width and incisor proclination, following either extraction or non-extraction treatment.

All the studies except two,^{24,27} investigated only mandibular dental arch changes. Study casts and lateral cephalometric radiographs for quantitative analysis of the results. A priori sample calculation was carried out in only four studies.^{23,24,25,26} Generation of random-number sequence was undertaken in three studies^{23,24,26} using electronically generated random allocation. One study²⁵ achieved randomization using random permuted blocks. Four trials had acceptable allocation concealment.^{23,24,25,26} Blinding of participants and personnel was not done in any of the studies, but

Discussion

A definitive conclusion should not be drawn from this systematic review, considering very few high quality evidence were available in relation to transverse expansion of dental arches following treatment with self-ligating system. Insufficient trials of low or medium risk of bias in homogenous groups precludes a meta-analysis of the outcome of interest.

The description of studies included in this review is given in Table 4. These studies showed conflicting results, the reason for which could be attributed to the difference in sample selection, the stages of treatment, the type of brackets used. Archwire sequence in all the four high quality studies^{23,24,25,26} were same in the two bracket groups, while they were different in the rest of the studies.^{21,22,27}

The following parameters were evaluated in the studies (Table 5):

- Intercanine dimension
- Interpremolar dimension
- Intermolar dimension
- Incisor proclination

Table 4. Description of included studies

Study	Design	Participants	Intervention		Archwire Sequence		Outcomes
			SLB	Conventional	SLB	Conventional	
Fleming (2009)	RCT	66	SmartClip	Victory	0.016" round, rectangular, 0.019"x0.025" rectangular martensitic active NiTi, 0.019"x0.025" SS	0.017"x0.025"	IC*, IPM*, IM*, Mand Incisor Incl
Pandis (2011)	RCT	50	Damon MX	Microarch (Roth Px)	0.014" CuNiTi, 0.016"x0.025" CuNiTi, 0.019"x0.025" beta-titanium, 0.019"x0.25" SS		IC, IM
Fleming (2013)	RCT	96 (87 analyzed)	Damon Q InOvation	Ovation	0.013"/0.014" round CuNiTi, 0.014"x0.025", 0.018"x0.025" CuNiTi, 0.019"x0.025" SS		IC, IPM, IM, Molar Incl, Max Incisor Incl
Pandis (2007)	CCT	54	Damon 2	Microarch	0.014" CuNiTi Damon TM 0.014"x0.025" CuNiTi Damon TM	0.016" CuNiTi (Ormco)+elastics, 0.020" Sentalloy archwire+elastics	IC, IPM, IM, Mand Incisor Incl
Tecco (2009)	CCT	40	Damon 3 MX	Victory	0.014" and 0.016", 0.016"x0.025" CuNiTi	0.016" and 0.019"x0.025" Ni-Ti form II	IC, IPM, IM
Pandis (2010)	CCT	56 (54 analyzed)	Damon 2	Microarch	0.014" CuNiTi 0.014"x0.025" CuNiTi 0.016"x0.025" SS	0.016" CuNiTi+elastics, 0.020" Sentalloy archwire+elastics	IC, IM, Mand Incisor Incl
Scott (2008)	RCT	62 (60 analyzed)	Damon 3	Synthesis	0.014"x0.025", 0.018"x0.025" NiTi, 0.019" x 0.025" SS		IC, IM, Mand Incisor Incl

*IC-Intercanine, #IPM-Interpremolar, ^IM-Intermolar

Table 5. Quantitative results of included studies

Study	Intercanine changes		Interpremolar changes		Intermolar changes		Incisor inclination		Authors' Conclusion
	SLB	Conventional	SLB	Conventional	SLB	Conventional	SLB	Conventional	
Fleming (2009)	0.85 (1.52)	1.17 (1.77)	0.73 (2.06)	1.46 (1.55)	0.5 (1.44)	1.41 (1.7)	1.46 (0.93)	1.36 (1.35)	SLB shows greater increase in IM width
Pandis (2011)	1.9 (1.3)	1.5 (0.9)	-	-	1.40 (0.8)	2.1 (1.2)	-	-	No significant difference between two groups
Fleming (2013)	1.97 (2.16)	0.88 (2.18)	4.51 (2.68)	3.7 (3.19)	1.22 (2.26)	1.41 (2.08)	1.12 (3.88)	2.84 (5.68)	No significant difference between two groups
Pandis (2007)	1.92 (1.36)	1.75 (1.32)	-	-	2.60 (1.30)	2.54 (1.49)	-	-	SLB shows greater increase in IM width
Tecco (2009)	3.3 (2.6)	2.6 (2.4)	4.4 (2.5)	4.3 (2.1)	2.3 (1.5)	2.4 (2.0)	-	-	No significant difference between two groups
Pandis (2010)	1 (0.85)	1.8 (1.2)	-	-	2.4 (1.9)	1.5 (1.7)	-	-	SLB shows greater increase in IM width, No difference in intercanine width
Scott (2008)	2.55 (2.27)	2.66 (2.33)	-	-	0.09 (2.40)	0.63 (2.12)	1.73 (4.06)	2.34 (3.72)	No increase in the intermolar width reported with either systems

Intercanine dimension

All the studies included in this review evaluated the changes in intercanine dimensions, and have reported an increase in intercanine dimension, irrespective of the bracket design. But only Fleming et al (2013)²⁴ identified slightly greater increase in passive self-ligating group (Damon Q) with a mean of 1.97 and SD of 2.16. Canine is considered the most stable structure in the arch and any significant change in its position would result in relapse; lesser the change in its position, the more stable is the treatment.^{12,29}

Interpremolar dimension

Only three studies included interpremolar dimension changes.^{23,24,27} These studies found no statistically significant difference between the two bracket groups. The greatest amount of increase was reported by Fleming et al (2013)²⁴ and Tecco et al (2009),²⁷ at around 4.5 mm of expansion with the self-ligating in the first premolar region. In another study, Fleming et al (2009)²³ suggested that the increase in inter-second premolar dimensions contributed to a great extent in relieving the crowding (1.8mm of total 2.65mm of crowding relieved).

Intermolar dimension

Three studies,^{24,25,27} reported increase in the intermolar dimension, but the increase with self-ligating system was not statistically significant as compared to conventional system. Scott et al (2008)²⁶ in a study on treatment with self-ligating system in patients with extraction, reported no increase in the intermolar width. This was attributed to the forward sliding of the molars into the extraction spaces, in the narrower part of the arch. However, other three studies^{21,22,23} did show a significant increase in intermolar width in self-ligating groups as compared to conventional groups. Pandis et al (2007)²¹ showed intermolar width increase in the self-ligating group was 1.5 times greater than in the conventional appliance group. They suggested that this difference could reflect unidentified confounding variables or systematic error in the measuring process.

Incisor inclination

Proponents of passive self-ligating system claim that significant increase in arch perimeter can be achieved without the labial movement of incisors.¹⁶ However the studies in this review point the contrary. Three of the four high quality studies^{24,25,26} concluded that, use of self-ligating brackets do bring about significant incisor proclination. But there was no difference reported in the amount of proclination between the two bracket groups in all the three studies. Scott et al (2008)²⁶ related this to the identical tip and torque prescription values between the bracket systems used. Fleming et al

(2009),²³ suggested the association between amount of crowding resolved, age, and duration of treatment, to the incisor proclination.

The greatest amount of transverse expansion in treatment with self-ligating system occurs at the interpremolar region followed by intercanine and the least expansion occurs at the intermolar region. And statistically significant changes in arch dimensions were found to be occurring between baseline (insertion of .014") and removal of .018"x .025" Cu NiTi.²⁰

The findings of Fleming et al (2013)²⁴ confirmed that the intermolar width increase was by buccal tipping of molars, and not by translation of buccal segment and buccal bone remodeling, as claimed by Damon(1998).¹⁶ Further studies describing the pattern of buccal bone changes following transverse arch expansion with self-ligating system, are required to corroborate the efficiency of these systems over the conventional approach.

Conclusion:

This study was undertaken to answer the question: Does the self-ligating system bring about more transverse arch expansion than conventional system?

Of the seven retrieved articles:

- All seven studies^{21,22,23,24,25,26,27} found that self-ligating bracket system brings about transverse expansion of dental arches.
- Four studies^{24,25,26,27} reported no statistically significant difference in transverse arch dimensional changes between self-ligating and conventional bracket systems, while three studies^{21,22,23} reported a greater increase with self-ligating system.
- Two studies^{24,27} in maxillary arch, and one study²⁵ in mandibular arch, reported no significant difference in the arch width changes at the intercanine and the intermolar regions, between the two bracket systems. Fleming et al (2013)²⁴ and Tecco et al (2009)²⁷ also reported no difference at the interpremolar region. Scott et al (2008)²⁶ evaluating extraction patients, reported that the intercanine width increased, while the intermolar width did not show an increase, with self-ligating bracket. According to the authors, this was related to the forward sliding of the molars into a narrower part of the arch.
- Fleming et al (2009)²³, Pandis et al (2010)²² and Pandis et al (2007)²¹ reported that, self-ligating bracket system produced greater expansion in the intercanine, interpremolar and intermolar regions as compared to the conventional system which was statistically significant.

- Five studies^{21,22,23,24,27} confirmed that transverse arch expansion, irrespective of the bracket systems used, resulted in incisor proclination.

More evidence through larger and higher quality studies is required to support the efficiency of self-ligating system in transverse arch expansion.

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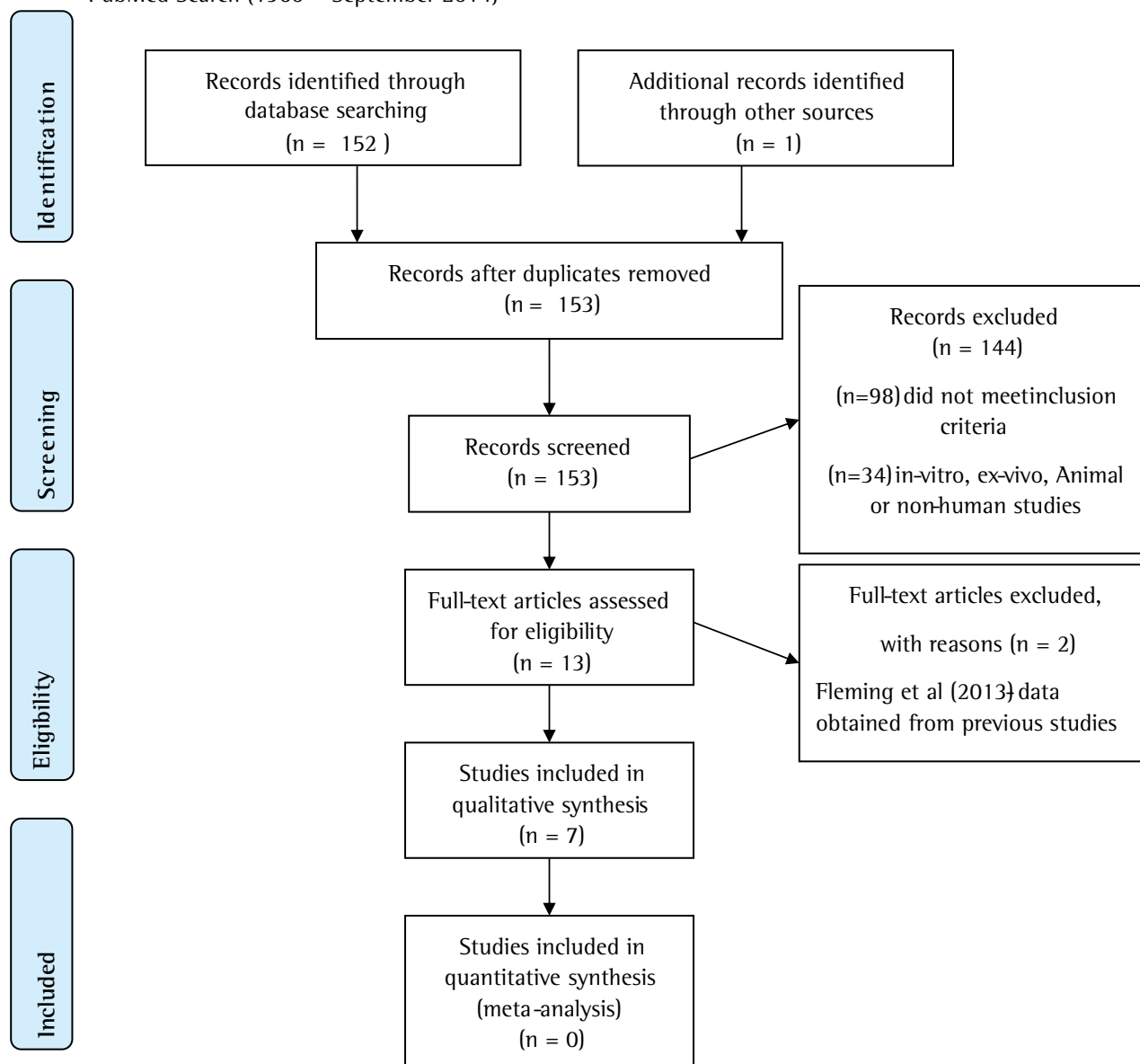
Appendix 1:

Database search strategies

PubMed: self-ligat* AND conventional AND (transverse OR arch OR dental OR dimension OR changes)

Appendix 2:

PubMed Search (1960 - September 2014)



Growth Modification of the Face: A Review

Dr V.S.N.Vithanaarachchi

Senior Lecturer, Consultant Orthodontist, Faculty of Dental Sciences, University of Peradeniya, Sri Lanka

ABSTRACT

Multiple theories have been applied in the past to explain the mechanism of growth modification of the craniofacial complex. However from among these various theories, the functional matrix theory is considered to be more acceptable in relation to the growth modification. Most clinicians use growth modification devices for wide variety of skeletal discrepancies. The use of headgears is mainly considered to control the maxillary growth in class II malocclusions. Furthermore functional appliances are also indicated to correct class II skeletal problems aiming to enhance forward and downward growth of the mandible. Face mask therapy has been more popular among clinicians as it is known to enhance the downward and forward growth of the maxilla. However, clinicians have alternative views regarding the chin cup therapy. Transverse growth modification is practiced by the expansion of mid palatal sutures with narrow maxilla. Vertical growth modification is mainly aimed at the correction of deep bite and for patients with long faces. With all these methods, the ultimate goal of growth modification depends on timing of treatment, length of treatment, working mechanism of appliance, skeletal and dental condition of the patient and compliance of patient towards orthodontic treatment. This article reviews the literature on growth modification in relation to the class II, class III malocclusions and vertical as well as transverse discrepancies.

Introduction

Historically the aim of the specialty of orthodontics has been primarily aimed at the correction of malocclusion by means of controlled movement of the developing and mature dentition to a desirable level. However orthodontics is based on the two major considerations which are orthodontic bio- mechanics and craniofacial biology. Proper knowledge on of these areas is essential for successful treatment outcomes for developing malocclusion and dentofacial deformities.

In late 19th and early 20th centuries, growth modification was widely accepted as it was assumed that it was largely controlled by environmental factors. Later, with the evidence of cephalometric studies, the concept of growth modification was less popular as most of the changes that take place with orthodontic treatment were produced by tooth movement and less due to modified growth (1). The American view was that growth modification was impossible due to genetic control over the growth of the craniofacial structures. However, the concept of the growth modification is still popular among orthodontists especially those in Europe.

In order to understand craniofacial growth a series of competing theories can be used with regard to skeletal growth in general as well as craniofacial growth in particular. Each of these theories attempts to explain the key elements of craniofacial growth focusing the primary mechanism which determined the growth (2). In this article, it is hoped to provide an overview of growth modification with their possibilities and limitations focusing on different malocclusions.

Historical Review:

Studies by Sir John Hunter in eighteenth century on the growth of the jaws are widely accepted as first scientific research on craniofacial growth. Further experimental researches on craniofacial growth were continued by Thoma (1848) and Humphrey (1864) in the nineteenth century and Brash and Scott in early twentieth century (3). The first general theory of craniofacial growth was the “remodeling theory” which highlights significance of the distinction between appositional and interstitial bone growth. Weismann’s concept of the germ plasm was most influential on growth modification in late nineteenth century (4). With the identification of the relationship between genes and chromosomes, genetic correlation was highlighted in relation to the cranio- facial growth. With advanced studies, it was

identified that the remodeling theory was focused on the surface deposition and resorption in bone growth in general. An alternative view highlighted the passive secondary role of the periosteum and bone surfaces in skeletal growth. In 1940s, the sutural theory was identified with the work done by Weinmanm and Sicher in association with the craniofacial growth (5).

In 1960 Moss published a classic paper on a new theory of craniofacial growth referred to as “functional matrix” hypothesis with regards to the skeletal growth (6). According to the concept of Moss, the class triad of craniofacial growth which includes sutures, bone surfaces and the cephalic cartilages are the primary growth centers of craniofacial skeleton. According to the functional matrix theory, the craniofacial skeleton develops initially and grows in direct responses to its

extrinsic and epigenetic environment. With further experimental results, the servo system theory was introduced and it attempts to explain the complex number of interrelated factors in the growth of the craniofacial complex (7).

Class II Growth Modification

Skeletal, soft tissue, and dental factors and habits are considered to contribute etiologically to the development of class II malocclusion. Skeletal class II malocclusions are due to protrusion of the maxilla, retrusion of the mandible or combination of both. The modalities available for skeletal correction include growth modification, orthodontic camouflage and orthognathic surgery (8). Many works in the literature have reported the different devices of growth modification for class II skeletal correction. Growth modification of moderate to severe skeletal class II malocclusion can be done with headgears and functional appliances. Headgear is mainly used to deliver posteriorly directed extra oral forces to the maxilla (9) and it compresses the maxillary sutures altering the growth and apposition of bone at sutures. Therefore, it restricts the normal downward and forward maxillary growth while the mandible grows normally, it “catches up” thereby correcting the maxillary skeletal discrepancy (8).

With the experimental data, it was shown that, an improvement in the antero – posterior position of maxilla relative to the mandible was greater than 5mm when introduce the maximum growth (10). Further, supportive evidence from randomized controlled clinical trials has shown that the effect of the headgear is not limited to the maxilla and it also enhanced mandibular growth (9). Tulloch et al reported an average reduction of SNA angle by 0.92° per year in a group allocated early correction of class II skeletal problem with headgear therapy (11). In addition to the skeletal effect, the typical response for the headgear wear is to prevent the downward and forward eruption of maxillary first molars. This dento – alveolar effect indirectly enhances the forward direction of mandibular growth. Intrusive effect of the maxillary molars with headgear treatment is more desirable in class II skeletal problems in maximizing the antero- posterior skeletal correction. Further inter molar and inter canine widths are increased with headgear treatment and as a result of such increased arch width and length, an appreciable reduction of over jet can be obtained with headgears.

Clinicians have identified different functional appliances such as bionator, activator, twin block, Herbst appliance and Frankel II regulator for growth modification of moderate to severe class II skeletal discrepancies. Functional appliances are indicated to class II skeletal

correction with the aim of stimulating downward and forward growth of the mandible. In addition it causes restriction of maxillary growth although the effect is less. However, greater dento- alveolar effects are observed with functional appliances although there is no mechanism to align irregular arches. (8, 9)

With animal studies, McNamara demonstrated 5–6 mm of growth enhancement of mandible with in juvenile rhesus monkeys with protrusive appliances (12). To assess the outcome of the functional appliances, several prospective randomized clinical trials were conducted with human study samples. Tulloch et al compared the effect of bionator with headgear appliances (13). The outcome comparison was done by Keeling et al with regards to the bionator and headgear and Ghafari et al also compared Frankel appliance with straight pull cervical headgear (14). All these studies clearly showed that correction of molar relationship was not due to the enhanced mandibular growth alone and mandibular protraction appliance may enhance small magnitude of the mandibular growth.

Successful outcome is also possible in class II correction with functional appliances in combination with headgears. Ozturk and Tankuter conducted comparative study with activator and activator high pull headgear combination appliances and compared with untreated children and showed greater reduction and better control of lower incisors (15).

Class III Growth modification:

Until the 1970s, skeletal class III malocclusions were mainly considered as result of a large and /or protrusive mandible. However currently it is considered to be the result of various factors such as prognathic mandible, retrognathic maxilla or combination of both. According to the studies of Ellis and McNamara and Guyer, 40% – 60% of skeletal class III malocclusions are associated with maxillary deficiencies (16). Therefore it is important to recognize maxillary protraction as an appropriate treatment modality for growing patients with class III malocclusion. During the past few decades, many clinicians have practiced protraction face mask therapy as the most popular method of protracting the maxilla. Many primate experiments have shown that dramatic skeletal changes can be obtained with maxillary protraction (17). In human studies Delaire was most interested in maxillary protraction and was the pioneer of the face mask therapy in young children (18). Later, Petit modified the basic concepts of Delaire by increasing the amount of generated force by the face mask, which decreases the overall treatment time. Many clinical studies have revealed that maxillary protraction was enhanced when used in conjunction with a palatal

expander (19). De Clerck advanced the method of distraction of the maxillary sutures with rapid palatal expansion or an alternating expansion – constriction of the mid palatal suture before traction (20). However in a randomized prospective clinical trial, it was found that the amount of protraction of the mid face was not affected by rapid palatal expansion (21). Therefore application of rapid palatal expansion in face mask is important for patients with severe constriction of the maxilla (20).

A review of the early days of orthodontics reveals that restraining mandibular growth was attempted with a cup or cap on the chin which was attached to the back of the head. Much supportive and unsupportive research evidence is found in the literature regarding chin cup therapy. In 1977, Graber conducted a comparative study with class III Caucasian children and showed a posterior rotation of the mandible, a decreased gonial angle, a restriction in vertical condylar growth and a clockwise rotation of the maxilla (22). Mitani and Fukazawa evaluated the effects of chin cup treatment in more elaborate way in 3 stages of age range and concluded that complete inhibition of mandibular growth is difficult to achieve and individual reactions to the chin cup force varied (23). Ritucci and Nanda focused on the effect of chin cup therapy on the maxilla and cranial base and reported a clockwise rotation of the maxilla with minimal downward vertical growth (24). In 1990 Sugawara also obtained similar results with a group of class III patients and reported that the chin cup had no effect on the antero – posterior growth of the mid face and proclination of upper incisors was common which might be due to occlusal interferences (24). In 2015 De Clark and Proffit highlighted that chin cup treatment would be more effective for a patient with a large mandible with short face. Therefore, chin cup therapy would be more effective in patients of Asian than European or African descent due to short face height being more common in Asian class III patients (20).

The use of class III elastic to bone plates is relatively new method and has not been thoroughly examined as other treatment procedures in growth modification. However, employment of skeletal anchorage in class III orthopedic has two main benefits such as minimizing dento alveolar changes both downward and backward mandibular rotation and the feasibility of application of continuous light force from class III elastics. In this process, miniplates are inserted on the infrazygomatic crest and in mandibular canine regions and both these plates are connected with elastics (20). The success rate of the miniplate depends mainly on the surgical procedure and thickness and quality of the bone.

Although it is believed that, higher forces are needed for moving bones than for moving teeth, better clinical results are obtained with light bone – anchored inter maxillary traction than heavy extra oral forces from protraction headgears. This successful outcome might be due to better compliance of patients with wearing intra oral elastics than an extra oral face mask.

Transverse Growth Modification:

Maxillary arches with less than the average trans palatal width may be crowded and need to indicate orthopedic expansion in growing children. Transverse growth modification is practiced by maxillary expansion opening the mid palatal suture. Light force is needed to achieve mid palatal expansion of children of 8-9 years and there is a risk of injury to the nose as a result of displacement of the vomer bone with rapid palatal expansion during this age period (20). However, heavier force is needed for sutural expansion of 9-10 years children, due to inter digitation of bone spicules on the edges of the mid palatal suture. As mid palatal expansion in the late mixed dentition requires a relatively heavy force, it is important to include as many teeth as possible in the unit of anchorage. One disadvantage in late mixed dentition is the reduced resistance from the primary teeth due to the resorption of their roots. Therefore it is better to resort to sutural expansion after the eruption of 1st premolars (8).

Unfortunately true orthopedic expansion of the lower arch is not possible except by distraction osteogenesis. Further, excessive transverse growth is a problem in the mandible due to the influence of tongue size and posture.

Vertical Growth Modification:

The ideal over bite in a normal occlusion may vary between 2-4mm or 5%- 20% overlap between upper and lower incisors. When the incisors overlap more than 40%, it is considered as deep bite with deleterious effects on dental health and Temporomandibular Joint (9). However, deep bite is not considered a disease entity but it is considered as clinical manifestation of an underlying skeletal or dental discrepancy. Usually skeletal deep bite is associated with horizontal growth pattern and characterized by maxillary and mandibular jaw growth discrepancy, convergent rotation of the jaw bones and deficiency in mandibular ramus height, highlighting the reduced lower face height relative to the other facial thirds. The most severe form of the excessive overbite is mainly associated with class II Division 2 malocclusion and it is needed to improve downward growth of the mandible and accepting some downward rotation of the mandible to increase anterior face height. However, while rotating the mandible

downwards would improve the face height, it would also move the chin back and worsen the mandibular deficiency (20). Therefore, the most favourable method of growth modification for short face height patients is the use of activator or bionator type appliance which facilitates the eruption of mandibular posterior teeth following trimming of the acrylic.

The primary feature of the long face is a large anterior face height characterized with elongation of the lower third of the face. As a result of the increased face height, maxillary palatal plane and posterior teeth are more inferior and mandible tends to rotate downward and back ward (26). Lip incompetence, tendency for anterior open bite, mandibular deficiency with class II malocclusion, lower incisor crowding and narrow maxilla with posterior cross bite are more associated with long face problems(26). There are two traditional methods to address the long face pattern of growth in children namely high pull headgear with maxillary fixed appliance and functional appliances incorporating bite blocks between teeth. The headgear applies a direct external force to oppose vertical maxillary development while functional appliances indirectly involve in that mechanism by stretching the muscular and other facial soft tissue to create a reactive force exerted on the occlusal surfaces of teeth through the bite blocks (8).

Discussion:

Functional appliances have become part of contemporary orthodontics practice but their mode of action is still controversial. However, if advantage is not taken of growth modification, dental camouflage or orthognathic surgery are the other treatment options available for the correction. There are many controversies about the optimal time of growth modification treatment. Some clinicians believe that early intervention with growth modification improves facial harmony and simplifies and reduces the time involved in the second phase of orthodontic treatment. However, others believe that it is a waste of time and resources and all treatment goals could be achieved with one stage comprehensive orthodontic treatment in late mixed dentition (27). Nevertheless, most researchers recommend early intervention with orthodontic treatment for children suffering with psychological and social problems and as a preventive measure for traumatic malocclusion.

There is also much controversy about the most appropriate appliance indicated in a particular case and their efficacy in modifying the growth. Part of the problem could be due to most research predictions being based on the conventional cephalometric measurements which have some limitations leading to errors. The use of three dimensional cephalometry may

help the researchers to identify the effects of growth modification devices with minimum errors (28).

Proffit stated that functional appliances could just accelerate the growth (8). While considering the different devices indicated in growth modification, headgear will restrict the maxilla while functional appliances will enhance the growth of the mandible. Growth modification further can help to manage the open bite and deep bite associated with vertical skeletal discrepancies.

Conclusion:

The ultimate success of growth modification treatment mainly depends on treatment timing, length of treatment, mechanism of the appliance, patient's skeletal condition and compliance of the patient. Therefore, for any type of orthopedic approach in growing children, there should be defined indications and guidelines with better biomarkers to predict the outcome of treatment.

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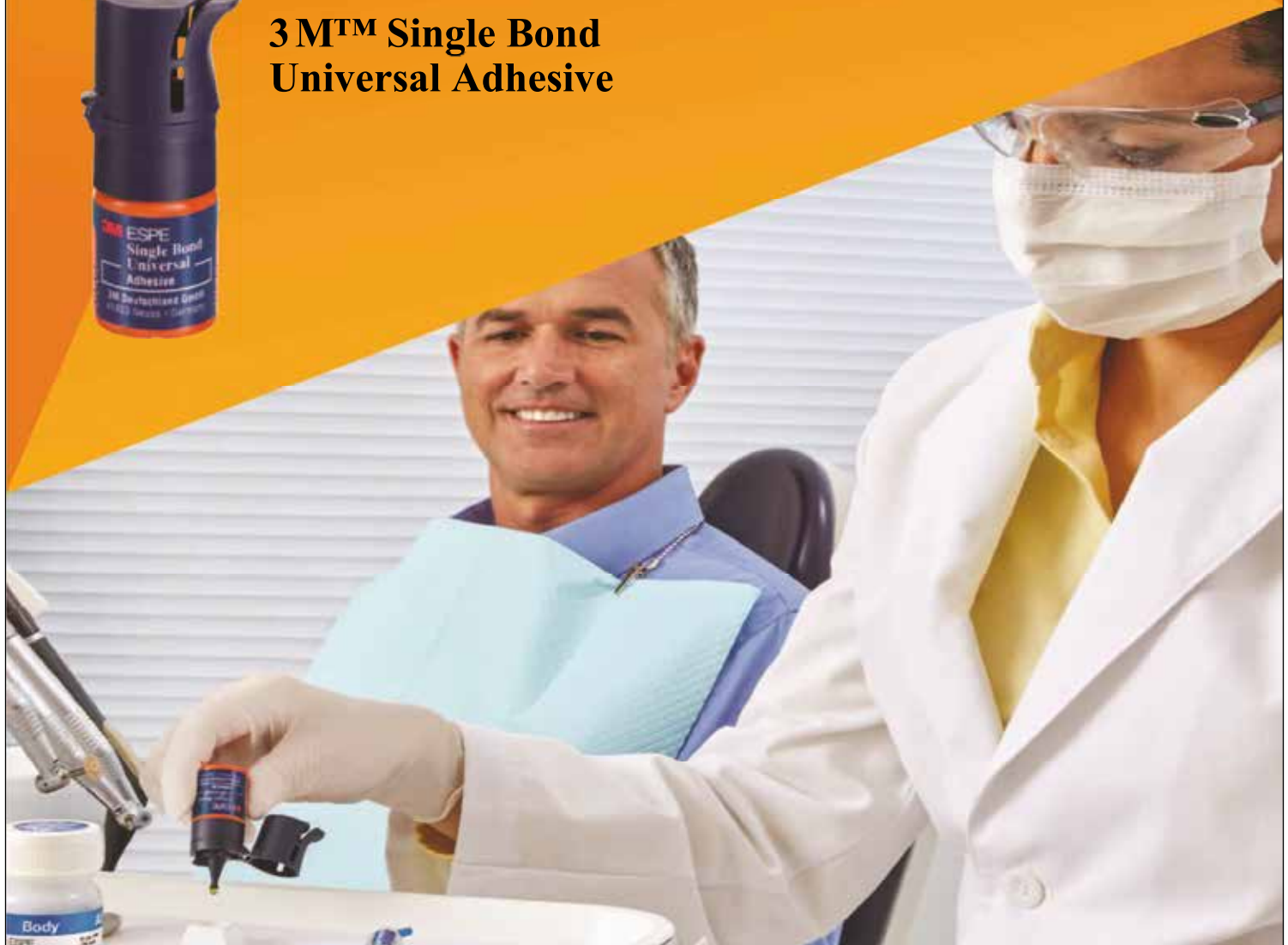
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Orthodontic Loading and SOST/Sclerostin Expression in Rat Alveolar Osteocytes

S. Premaraj¹, T. Premaraj¹

Orthodontic Section, Department of Growth and Development, University of Nebraska Medical Center College of Dentistry, Lincoln, NE, USA

ABSTRACT

Objective: To investigate whether orthodontic loading modulates SOST/sclerostin expression in alveolar bone.

Methods: Twenty-five 16-week old rats were divided into 3 groups. A NiTi coil spring was inserted between upper left first molar and incisor. Spring was adjusted to deliver 10-gram force. Upper right molar was used as control. Eight, 24 and 48 hours after loading, SOST and sclerostin expression were determined by real time RT-PCR and immunohistochemistry, respectively.

Results: SOST expression in the alveolar bone surrounding the tooth subjected to orthodontic loading was significantly higher than control. SOST in the tension site of the maxillary left first molar was upregulated by 4.53, 7.2, and 14.4, folds on 8, 24 and 48 hours after placement of the spring, respectively. SOST in the compression site was upregulated by 1.8, 6.14 and 5.3 folds on 8, 24 and 48 hours after spring placement, respectively. Orthodontic loading induced a significant increase in the number of sclerostin-positive osteocytes in the alveolar bone.

Conclusion: Orthodontic loading induced upregulation of SOST/sclerostin expression in the alveolar bone

INTRODUCTION

Modeling and remodeling of alveolar bone surrounding a tooth exposed to orthodontic force is essential for orthodontic tooth movement (OTM)¹. Cellular activity which results in resorption and formation of alveolar bone and OTM in response to orthodontic loading is well characterized². However, the mechanisms by which mechanosensors present in the periodontium transduce the orthodontic forces into biological responses that lead to OTM yet to be studied in detail.

Osteocytes are mechanosensors in the bone tissue³ and capable of sensing mechanical loads applied to the skeleton and transform these forces into biological reactions.. Recent studies on mice with diphtheria toxin receptor mediated cell knockout (TRECK) have demonstrated that osteocyte is required for the bone resorption response to orthodontic loading⁴. However, the molecular mechanisms of osteocyte-mediated regulation of osteoclastogenesis and bone resorption during OTM are yet to be elucidated in detail.

Sclerostin is a SOST encoded glycoprotein expressed in osteocytes, odontoblasts, cementocytes and periodontal ligament cells⁵⁻⁷. In skeletal tissue, sclerostin diffuse through the abundant network of osteocyte canaliculi to reach the bone surface⁸. Sclerostin promotes osteoclastogenesis and bone resorptive activity by a RANKL-dependent pathway⁹. Modulation of sclerostin levels is a finely regulated mechanism by which osteocytes regulate bone modeling/remodeling in response to mechanical loading^{10,11}.

The purpose of the current study was to investigate whether expression of SOST/sclerostin is modulated by orthodontic forces in rat alveolar bone osteocytes. In a mouse model of tooth movement, orthodontic loading has been shown to induce spatial changes in the distribution and level of the sclerostin expression in the osteocytic lacuna-canalicular system¹². In this paper, we report the orthodontic loading-induced temporal changes in the levels of SOST transcripts and sclerostin expression in the rat alveolar osteocytes.

MATERIALS AND METHODS

Animals

Twenty-five (16-week old) Sprague-Dawley rats (Harlan, Indianapolis, IN) were used in this experiment. Animals were housed under optimal light, temperature and humidity controlled conditions. Food and water were provided ad libitum. All of the procedures performed were in accordance with the Institutional Animal Care and Use Committee (IACUC) guidelines. Animals were divided into 3 groups consisting 5, 10 and 10 rats.

Orthodontic tooth movement

Animals were acclimatized for one week prior to appliance placement. Animals were anesthetized and an ultra-light NiTi coil spring (GAC international, Bohemia, NY) was attached between upper left first molar and upper incisors by .004 inch stainless steel ligature and orthodontic adhesive (TransbondTM XT, 3M Oral care, St. Paul, MN) (Figure 1). Spring was adjusted to deliver 10 gram-force. The right upper first molar with only a ligature wire tied around the tooth was used as control.

Eight, 24 and 48 hours after placement of orthodontic appliances, 5 animals from each group were used to analyze SOST mRNA expression by real time RT-PCR, as described below. Remaining five animals each from 24 and 48 hours group were used for immunolocalization of sclerostin, as described below.

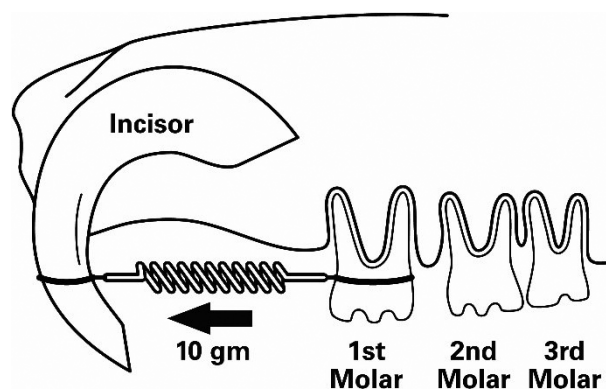


Figure 1. Schematic of the experimental tooth movement. The NiTi coil spring is attached to the maxillary first molar and maxillary incisors by stainless steel ligature.

SOST gene expression

Animals were sacrificed by CO₂ narcosis. Maxilla was divided into two halves and snap frozen in liquid N₂. Maxillary halves were carefully dissected under a dissecting microscope to remove the alveolar bone within the tension and compression areas in the orthodontic loading group and within similar areas in the control group (Figure 2). Harvested alveolar bone were pulverized in liquid N₂ using mortar and pestle. Bone powder was suspended in TRIzol (Invitrogen, Carlsbad, CA) and centrifuged for 5 minutes at 4°C to pellet the bone grit. From the supernatant, RNA was isolated and reverse transcribed by RT-PCR using Moloney Murine Leukemia Virus (M-MLV) reverse transcriptase (Invitrogen, Carlsbad, CA). Gene expression was determined by SYBR Green quantitative Real-time RT-PCR. Beta-actin mRNA levels from each sample will be used as internal control to normalize the mRNA levels. Primer sets are shown in Table 1. SOST gene expression was calculated using $\Delta\Delta C_t$ method and presented as ratio to beta-actin.

Table 1. Primer design for real time reverse transcriptase polymerase chain reaction (RT-PCR)

Target	Forward	Reverse
SOST	GGAATGATGCCACAGAGGTCAT	CCCGGTTTCATGGTCTGGTT
Beta-actin	GAAATCGTGCGTGACATCAAA	TGTAGTTTCATGGATGCCACAG

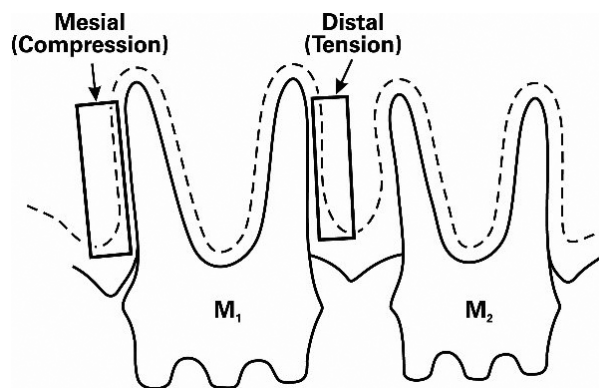


Figure 2. Schematic of the longitudinal section of the maxillary molar region showing the region interests for the immunohistochemical analysis of sclerostin expression

Immunolocalization of Sclerostin

Harvested maxillary halves were prepared for decalcified histological sections. Five-micrometer thick sections of mesio-distal sagittal plane of the maxillary first molar tooth were collected on glass slides. An indirect immunoperoxidase method (Cell and tissue staining kit -CTS008, R&D System, Minneapolis, MN) was used to detect reactivity of polyclonal antibodies specific for sclerostin (AF 1589, R&D Systems) using diaminobenzidine (DAB) staining. Number of sclerostin positive-osteocytes (osteocyte cell bodies exhibiting brown staining), and the numbers of sclerostin-negative osteocytes (osteocyte bodies exhibiting blue staining) (Fig. 3), were counted on each section in the tension and compression areas of alveolar bone. Percentage of sclerostin-positive cells in the compression and tension areas of the control and orthodontic loading side were calculated as the number of sclerostin-positive cells divided by the total number of cells (sclerostin-positive plus sclerostin-negative cells).

Statistical Analysis

Differences in SOST expression between tension and compression areas within control and orthodontic loading sides at different time points were assessed for statistical significance using analysis of variance (ANOVA). Unpaired t test was performed to identify statistically significant difference in sclerostin expression between tension and compression areas within control or orthodontic loading sites at each time point

RESULTS

A rat model of experimental tooth movement was used to characterize the changes in the mRNA levels of SOST and sclerostin expression in the alveolar osteocytes induced by 8, 24, and 48 hours of orthodontic loading.

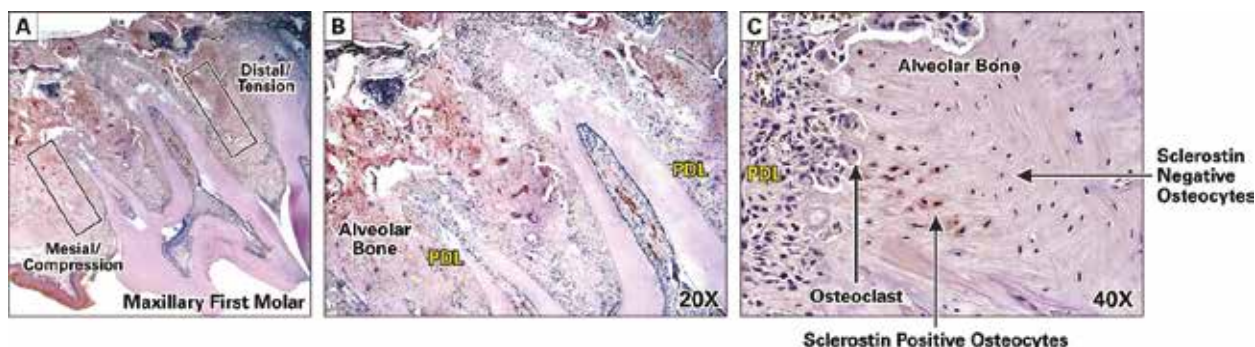


Figure 3. Expression of sclerostin in alveolar osteocytes on the tension and compression sites in alveolar bone. A. longitudinal section of the maxillary molar region showing the region interests for the immunohistochemical analysis of sclerostin expression (original magnification: 10X) B. Longitudinal section of the maxillary molar region showing the region interests for the immunohistochemical analysis of sclerostin expression (original magnification: 20X) C. Immunohistochemistry for sclerostin, which can be visualized by the brown staining of the osteocyte cell bodies and cell processes within the lacuna. Note the lack of sclerostin staining in all tissues shown (marrow, vessels, and periodontal ligament) except for the osteocytes embedded in the bone matrix (original magnification: 40X).

SOST expression in alveolar bone

SOST transcript levels in the alveolar bone surrounding a tooth subjected to orthodontic loading was significantly higher than that of control tooth. SOST expression in the compression site of alveolar bone was upregulated by 1.8, 6.14 and 5.3 fold 8, 24 and 48 hours after spring placement, respectively (Figure 4A). SOST levels in the tension site of alveolar bone of the maxillary left first molar were upregulated by 4.53, 7.2, 14.4 folds on 8, 24 and 48 hours after placement of the spring, respectively (Figure 4B). There was no significant difference in the levels of SOST expression between the compression and tension sites of the alveolar bone of an orthodontically loaded tooth (Figure 4C).

Sclerostin expression in osteocytes

To investigate the effect of orthodontic loading on sclerostin expression, the percentage of sclerostin-positive osteocytes was calculated for the alveolar bone in the compression (mesial) and tension (distal) sites of the control and orthodontic loading sides. The alveolar bone surrounding a tooth subjected to orthodontic loading demonstrated a statistically significant increase in the number of sclerostin-positive osteocytes when compared to the control side ($p < 0.05$). There was no difference in the percentage of sclerostin-positive osteocytes between the mesial and distal sites of control side. The differences in the percentage of sclerostin-positive osteocytes between compression and tension sites at 24 and 48 hours after orthodontic loading were not statistically significant (Figure 5).

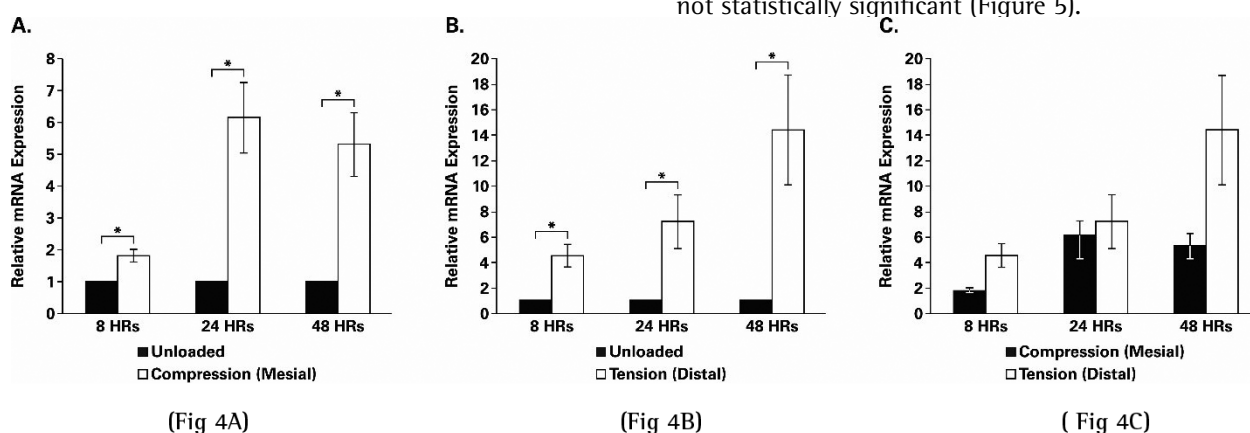


Figure 4. SOST expression in the alveolar bone in the control and tooth movement side. A. Relative SOST mRNA expression in the mesial and compression sites after 8, 24 and 48 hours. B. Relative SOST mRNA expression in the distal and tension sites after 8, 24 and 48 hours. C. SOST expression in the alveolar bone in the tooth movement side. Relative SOST mRNA expression in the tension and compression sites after 8, 24 and 48 hours. Mean $\pm$ SEM ($n=5$). * $p < 0.05$.

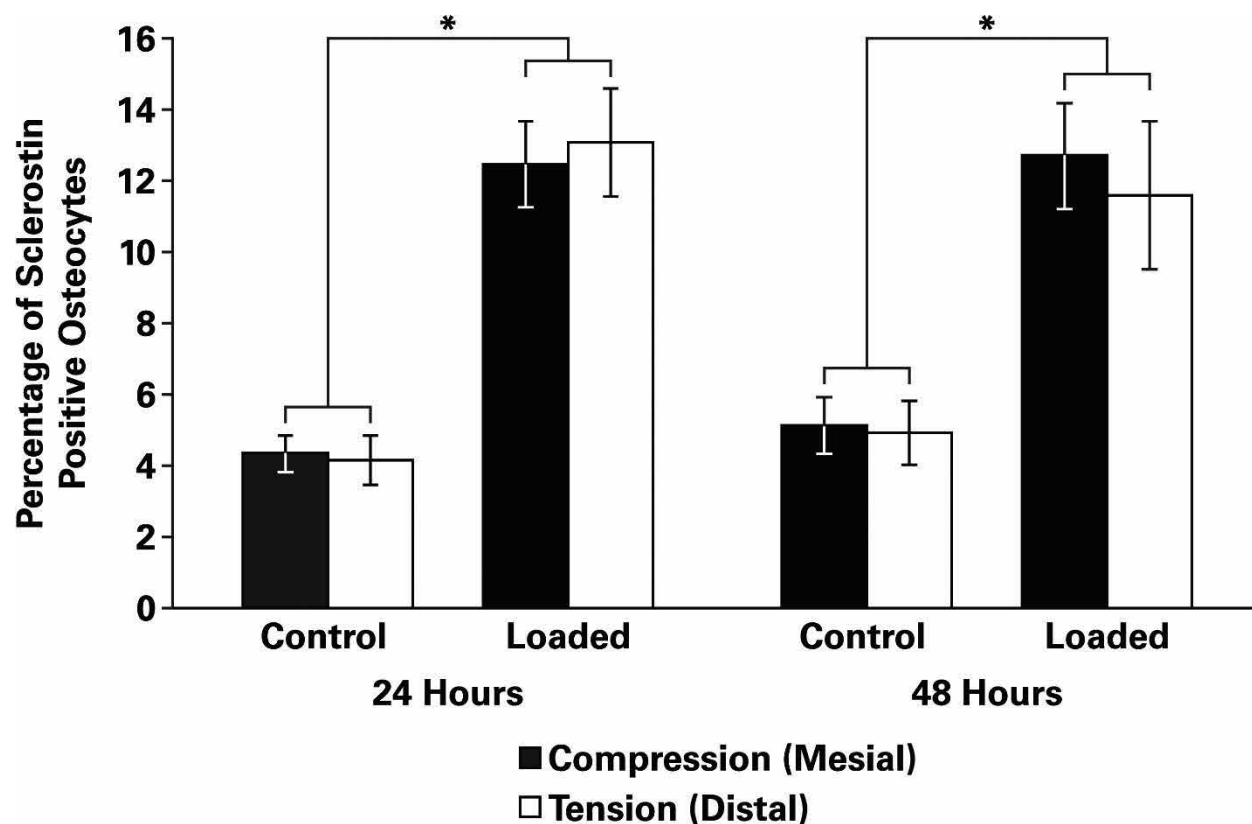


Figure 5. Osteocyte sclerostin expression in the alveolar bone in the control and tooth movement side. Percentage of sclerostin-positive osteocytes in the tension (distal) and compression (mesial) sites after 24 and 48 hours, after loading. Mean percentage are shown $\pm$ SEM ($n=5$). * $p<0.05$

DISCUSSION

Orthodontic tooth movement occurs due to bone modeling/remodeling sequence that is induced by therapeutic mechanical loading. Currently there is no consensus on the underlying molecular mechanisms that transduce the orthodontic load to biological responses.

Evidence from recent studies in long bone indicates that osteocytes control local bone remodeling by modulating sclerostin levels in response to mechanical loading^{10,13}. Osteocytes are sensitive to orthodontic-load induced strains within the alveolar bone¹⁴. In a mouse model of disuse mechanotransduction, hind limb unloading was found to upregulate SOST transcript levels in tibia¹⁵. Based on these studies, it is apparent that unloading of long bones induces inhibition of Wnt/ β -catenin signaling and expression of RANKL via upregulation of sclerostin levels, thereby leading to reduced bone formation and increased bone resorption⁹.

Although the work cited above provides relatively convincing evidence for the role of osteocytes and sclerostin in the bone loss associated with the unloading of long bones, whether a similar mechanism is at play in alveolar bone subjected to orthodontic forces remains

to be established. To examine this question, in this study we performed experiments designed to identify the interactions between sclerostin and orthodontic loading that will eventually allow identification of underlying mechanisms of orthodontic loading-induced modeling/remodeling of alveolar bone.

The present study is the first in vivo experiment to characterize the temporal changes in the SOST transcript levels in the alveolar bone during the initial phase of OTM. In our study, SOST transcript levels were upregulated by orthodontic loading, however we did not find a statistically significant difference in SOST gene expression between compression and tension sites. Our data is in agreement with the findings of a recent in vitro study using MLO-Y4 osteocyte-like cells¹⁶. Specimens of alveolar bone harvested to extract RNA in the present study did contain periodontal ligament cells (PDL) as well. Since PDL cells do upregulate expression of SOST when subjected to mechanical loading¹⁷⁻¹⁹, SOST transcript levels measured in the present study includes that derived from PDL cells in addition to osteocytes. It would be ideal if the RNA used in the real time RT-PCR derived solely from the osteocytes/alveolar bone. Since it would be difficult to harvest alveolar bone completely free of PDL cells, in-

situ hybridization would be most appropriate technique to quantify the SOST expression in the alveolar bone.

The effect of orthodontic loading on sclerostin protein expression in the alveolar osteocytes was determined by immunohistochemistry. Orthodontic loading did increase the sclerostin expression in the osteocytes located in the alveolar bone subjected to orthodontic loading for 24 or 48 hours. We did not find any significant difference in the sclerostin expression between compression and tension sites at both time points. Our results are in agreement with the findings of two mice studies in which orthodontic loading has been shown to upregulate sclerostin expression in the alveolar osteocytes present on the compression and tension sites on 7 and 14 days after force application^{20,21}. In contrast, Rangiani et al. demonstrated that expression of osteocyte sclerostin on the compression site was more than that was seen on the tension site, after 8 days of orthodontic loading²². More recently, Shu et al reported differential expression of sclerostin in the compression and tension sites of the alveolar bone around a rat molar tooth that was subjected to orthodontic loading for a period of 28 days¹⁶. They hypothesized this difference in expression is the result of changes in microenvironment such as hypoxia but not due to the difference between compression and tension¹⁶.

In long bones, sclerostin expression is upregulated by unloading¹⁵. Sclerostin could induce bone loss by decreased bone formation by inhibiting Wnt/beta-catenin signaling and increased bone resorption via upregulation of RANKL-mediated osteoclastogenesis^{9,15}. Therefore, the question is whether different regions of alveolar bone are unloaded or loaded during the application of orthodontic forces and the pattern of sclerostin expression correlate with the strain levels. Melsen hypothesized that bone resorption in front of roots in the direction of tooth movement occurs as a result of hypo-physiological loading (unloading) below the minimum effective strain^{23,24}. The central theme of this tooth movement model is that bone apposition is induced by the load exerted by the stretched fibers of PDL and bone resorption by unloading of the alveolar bone²⁵. Finite element model (FEM) analysis of stress and strain levels in the alveolar bone subjected to orthodontic load have shown that the transfer mechanism of orthodontic loads through the alveolar bone cannot be explained in simple terms of compression and tension²⁵. In addition, tension in the alveolar bone found to be far more predominant than compression²⁵. The above findings could explain our findings that there were no significant differences in the expression of SOST and sclerostin between compression and tension sites.

Data from our study clearly indicate orthodontic loading modulates sclerostin expression in osteocytes. Further in vitro mechanistic studies and in vivo experiments are warranted to illustrate the function of sclerostin in orthodontic mechanotransduction.

CONCLUSIONS

1. SOST levels were upregulated in the alveolar bone surrounding an orthodontically loaded tooth.
2. There was no significant difference in SOST mRNA levels between compression and tension sites of the orthodontically loaded alveolar bone.
3. Orthodontic loading upregulated the sclerostin expression in the osteocytes located in the alveolar bone subjected to orthodontic loading.
4. There was no significant difference in the sclerostin expression of the osteocytes located in the compression and tension sites of the orthodontically loaded alveolar bone.

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FIGURE LEGENDS

Figure 1. Schematic of the experimental tooth movement. The NiTi coil spring is attached to the maxillary first molar and maxillary incisors by stainless steel ligature.

Figure 2. Schematic of the longitudinal section of the maxillary molar region showing the region interests for the immunohistochemical analysis of sclerostin expression

Figure 3. Expression of sclerostin in alveolar osteocytes on the tension and compression sites in alveolar bone. A. longitudinal section of the maxillary molar region showing the region interests for the immunohistochemical analysis of sclerostin expression (original magnification: 10X) B. Longitudinal section of the maxillary molar region showing the region interests for the immunohistochemical analysis of sclerostin expression (original magnification: 20X) C. Immunohistochemistry for sclerostin, which can be visualized by the brown staining of the osteocyte cell bodies and cell processes within the lacuna. Note the lack of sclerostin staining in all tissues shown (marrow, vessels, and periodontal ligament) except for the osteocytes embedded in the bone matrix (original magnification: 40X).

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Figure 5. Osteocyte sclerostin expression in the alveolar bone in the control and tooth movement side. Percentage of sclerostin-positive osteocytes in the tension (distal) and compression (mesial) sites after 24 and 48 hours, after loading. Mean percentage are shown ± SEM (n=5). * p<0.05.

The socio-demographic profile, treatment expectations and factors influencing perceived oral health status among Sri Lankan orthodontic patients: Short Report

Wickramasinghe Mudiyanse Senadeera¹, Irosha Rukmali Perera², Thilini Shereen Rajapakshe¹, Rasika Dissanayake², Cecillia Elisabeth Kohl³, Sandy Yen Paulina Lantz³

1. Orthodontic Unit, National Dental Hospital (Teaching) Sri Lanka, Ward Place, Colombo 7, Sri Lanka

2. Preventive Oral Health Unit, National Dental Hospital (Teaching) Sri Lanka, Ward Place, Colombo 7, Sri Lanka

3. Dental School, Malmö University, Sweden

ABSTRACT

Objective: Achieving pleasing facial aesthetics is fundamental to providing orthodontic treatment. Moreover, perceived oral health status of orthodontic patients could influence their final treatment outcome. Present short report is aimed at exploring such important aspects among patients in Sri Lanka. **Materials & Methods:** The sample comprised of 100 patients who sought orthodontic care from National Dental Hospital (Teaching) Sri Lanka (NDHTSL) included into a novel data base. Data were entered and analysed using SPSS-21 Statistical Soft Ware Package. Descriptive statistics were used to present data and Fisher's exact test of statistical significance was used to compare groups. **Results:** The majority of orthodontic patients attended the orthodontic unit, NDHTSL were females (73.3%) and 89.0% belonged to low and middle socio-economic groups. By age distribution, 49.3% belonged to ≥ 20 -year-age group while 32% belonged to 12-15-year-age group. Improvement in appearance was the expectation of the overwhelming majority (89.0%) of the patients. Schooling orthodontic patients felt their oral health status to be poor compared to orthodontic patients who were university students. Moreover, orthodontic patients with significant orthodontic treatment need due to severe forms of malocclusion felt poor oral health status compared to no/little or borderline treatment need groups with minor forms of malocclusion based on the dental health component of IOTN index.

These differences were statistically significant ($p < 0.05$). **Conclusions:** Treatment expectations and factors affecting perceived oral health status of orthodontic patients' need Orthodontist's attention. The perceived oral health status of orthodontic patients was influenced by their educational status as revealed by the present findings. Further assessments with large sample sizes warranted.

Key words: socio-demographic profile, treatment expectations, perceived oral health status,

Introduction

Striking the balance between aesthetics, functions and stability is the overarching goal of contemporary orthodontic treatment while improving an individual's facial appearance is the main goal within the paradigm shift of growing demand for treatment modalities based on aesthetic principles. 1. Orthodontic treatment is a category of care predominantly accessed by adolescents and young adults, influenced by parental care givers and peers with a great need of long-term compliance for the final treatment outcome compared to other specialties of health care 2. Moreover, the demand for orthodontic treatment is predominantly driven by personal concerns about appearance and other psychosocial and economic factors 3.

In order to gain long-term compliance of young orthodontic patients for successful and sustainable treatment outcomes it is crucial to provide a patient centred-care throughout 4. An insight into treatment expectations, perceived oral health status and related factors provides core-components of comprehensive patient-centred orthodontic care. Nevertheless, due to dominance of normative assessments and judgments, patient-centred assessments are not being routinely and sufficiently explored in comprehensive management of orthodontic patients. Expectation has been identified as an important psychological factor to influence patients' evaluation of the quality of treatment or the final treatment outcome 2. Patients' perceived expectation as the benefit from treatment could influence an array of subsequent factors such as treatment outcome, patient and parent satisfaction, patient's corporation as well as compliance 2. On the contrary, if a gap being created between patient expectation and actual experience it could be hypothesized that patients and parents will be dissatisfied and that may interfere with compliance.

Nevertheless, there is an information gap with regard to patient centered outcomes such as treatment expectations and perceived oral health status of orthodontic patients in routine clinical records. Against this backdrop, this short report is aimed at exploring the socio-demographic profile, treatment related expectations, perceived oral health status and related factors among a group orthodontic patients attended the orthodontic unit of National Dental Hospital (Teaching) Sri Lanka.

Materials and Methods

Present short report was based on a novel and comprehensive data base established at the orthodontic unit. It is aimed at complimenting existing clinical record at the National Dental Hospital (Teaching) Sri Lanka which is the premier, tertiary care, multi-specialty public dental hospital in Sri Lanka. This data base included an array of patient-based indicators such as educational/occupational status, socio-economic category, perceived oral health status, oral hygiene practices, oral hygiene status assessed by Simplified Debris-Index 5 and treatment expectations.

Orthodontic treatment need was assessed by a modified version of dental component of Index of Orthodontic Treatment Need (IOTN) 6 by taking spacing between teeth into consideration. Spacing is not included into the original version but it is a common orthodontic concern among Sri Lankan patients. The IOTN dental component is categorized into 5 grades based on the severity of malocclusion needing orthodontic treatment. For example Grade 1 (No treatment need due to extremely minor malocclusions including contact point displacement <1 mm), Grade 2 (Little treatment need based on 7 criteria of minor malocclusions), Grade 3 (Borderline Treatment Need based 6 criteria of malocclusion more severe than that of Grade 2), Grade 4 categorized as Treatment Need based on 10 criteria of severe malocclusion such as partially erupted teeth, increased and complete overbite with gingival and palatal trauma, extreme lateral open bit >4 mm, anterior or posterior cross bites with > 2 mm discrepancy, severe contact point displacement > 4 mm, increased over jet >6 mm but ≤ 9 mm etc.) and Grade 5 Treatment Need comprised of 6 criteria of severe malocclusion, more severe than that of Grade 4 category

Data were collected using a specially designed, pre-tested, interviewer administered data collection form followed by the initial consultation for first visit patients and post treatment session for those who were already undergoing treatment.

Each patient was assigned to a socio-economic category as upper, middle and lower based on parental socioeconomic status assessed by level of education and occupational status and ownership of a vehicle. An operational classification was computed by combining these variables. As almost all patients were adolescents and young adults it was deemed rational to classify them based on parental socio-economic status as recommended 7.

100 patient-data records in the data base were randomly selected to be included into this short report. Data were entered and analysed using SPSS-21. Descriptive statistics were used to present data and Fisher's exact and Chi-Square Test of statistical significance with the significance level set at $p < 0.05$.

Results

Table 1: Socio-demographic profile, treatment category and treatment expectations of orthodontic patients seeking treatment at the orthodontic unit, NDHTSL

Variable	N	%
Gender		
Male	27	27.0
Female	73	73.0
Total	100	100.0
Age Category		
12-15 years	38	38.0
16-19 years	22	22.0
≥ 20 years	40	40.0
Total	100	100.0
Educational Status		
Schooling	59	59.0
University Undergraduates	41	41.0
Total	100	100.0
Socio-economic status(SES)		
Low	38	38.0
Middle	51	51.0
Upper	11	11.0
Total	100	100.0
Treatment Category		
1st Visit	40	40.0
Ongoing treatment	60	60.0
Total	100	100.0
Treatment Expectations		
Improving appearance	89	89.0
Improving functions	11	11.0
Total	100	100.0

As shown in Table 1, the majority (73.0%) of orthodontic patients were females and 60% were receiving treatment. By age distribution 40% were aged ≥ 20 years, 22% were aged 16-19 years and 38% were aged 12-15 years. Moreover, 59.0% were schooling and the rest were university undergraduates. Obviously, 89% belonged to low and middle socio-economic group.

* assessed by modified dental health component of Index of Orthodontic Treatment Need (IOTN)

As illustrated in Figure 1, 77% of orthodontic patients were categorized as in need of treatment according to modified dental health component of Index of Orthodontic Treatment Need (IOTN) Grade 4 and 5.

% Distribution of orthodontic patients by orthodontic treatment need

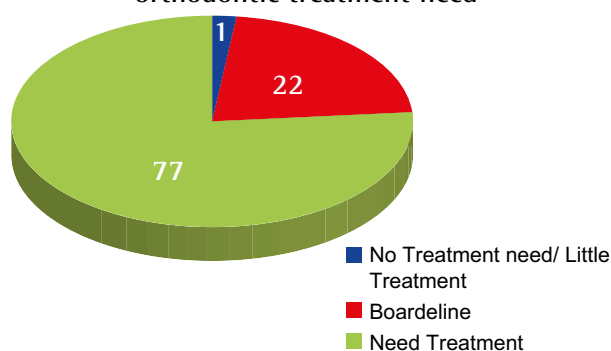


Figure 1: Distribution of orthodontic patients by orthodontic treatment need*

Out of the array of socio-demographic and orthodontic treatment related factors educational status and dental health component of IOTN category were significantly associated with perceived oral health status of orthodontic patients categorized as good, average and poor ($p < 0.05$) (Table, 2). Accordingly, school going children and those who belonged to modified dental health component of IOTN grades 4 & 5 perceived their oral health status to be poor compared to university undergraduates and IOTN grades 1,2 and 3 respectively (Table,2).

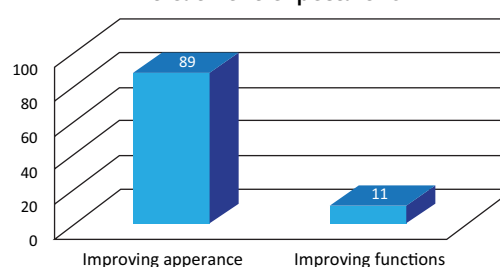
Discussion

Present short report showcases patient-centred indicators such as the socio-demographic profile, treatment expectations and perceived oral health related factors among orthodontic patients in the Sri Lankan socio-cultural context. Nevertheless, the findings should be interpreted cautiously due to inherent limitations such as small sample size. Previous studies have reported many parent and or patient perceived expectations such as to improve existing facial and or dental appearance, oral health and functions 2,4. Improvement of social confidence, social acceptance and attractiveness as well as psychological confidence could be considered as other perceived expectations in obtaining orthodontic treatment. Furthermore, expectation is regarded to be a catalyst for improving success of treatment 2,4,8.

Patients and dental professionals differ in their evaluation of oral health and the perception of oral diseases 8. Nevertheless, the conventional mode practiced to this date for assessing orthodontic treatment need or evaluating treatment outcomes is based on normative assessment of occlusal indices and cephalometric measures. This practice needs complimenting with patient-centred assessments for to optimize outcomes of orthodontic treatment 2,4.

As emerged from the findings, young adults and adolescents from low and middle socio-economic groups accessed the orthodontic care from the premier tertiary care dental public health hospital in Sri Lanka (Table,1). Sri Lanka is a lower-middle-income developing country but provides orthodontic care free of charge for the end user as a component of

% Distribution of orthodontic patients by treatment expectations



The overwhelming majority (89.0%) of orthodontic patients stated that improving appearance as their treatment expectations (Figure, 2).

Figure 2: Distribution of orthodontic patients by treatment expectations

public dental care services. This could be considered as a commendable service as health resources are scarce and orthodontic treatment is costly.

Moreover, the overwhelming majority (89.0%) of orthodontic care seekers expected improvements in their appearance. This is a common expectation for adolescents and young adults with malocclusion 2,4,8.

Perceived oral health status is an important patient-based indicator that reflects how malocclusion status and related oral health problems affect an individual prior to starting orthodontic treatment. On the contrary, perceived oral health status of an adolescent or adult already receiving orthodontic treatment could be affected by various issues related to treatment affecting basic functions such as eating, speaking, brushing teeth and social contact. Moreover, it could be a proxy for perceived orthodontic treatment need. As revealed by the findings school going adolescents and those who were having orthodontic treatment need (Grade 4, 5 by the dental component of IOTN index) reported their oral health status to be poor compared to University Undergraduates and IOTN grades 1,2 & 3 indicating no, little or borderline treatment. This could be due to differences in perceptions on impact of malocclusion among adolescents compared to young adults. Moreover, higher orthodontic treatment need indicated a higher burden of malocclusion which could impact on perceived oral health status of the affected individual. This finding was in agreement with previous studies 9,10 highlights the importance of complimenting normative indicators of orthodontic treatment need by perceived indicators for better appraisal of the disease burden, treatment need and treatment outcome.

Furthermore, the findings supported the notion that age group, gender and socio-economic status and treatment status were not significantly associated with perceived oral health status of orthodontic patients despite more adolescents and adults belonging to low and middle socio-economic groups perceived their oral health to be good compared to better-off counterpart. On the contrary, previous studies conducted among Sri Lankan adolescents reported that lower

socio-economic status was associated with poor perceived oral health 11.

In conclusion, present brief report unraveled important yet lesser known aspects of patient-centred indicators of orthodontic patients in Sri Lankan socio-cultural context

needing attention of Orthodontists. As these indicators could critically influence the final treatment outcome, it is planned to conduct a research with a large sample size and refined methodology.

Table 3: Factors associated with perceived oral health status of orthodontic patients

Factor	Perceived Oral Health Status				χ^2/f - value	p-value
	Good n %	Average n %	Poor n %	Total n %		
Gender					5.507	0.236 (p>0.05)
Male	12 (31.6)	11 (24.4)	4 (23.5)	27 (27.0)		
Female	26 (68.4)	34 (75.6)	13 (76.5)	73 (73.0)		
Total	38 (100.0)	45 (100.0)	17 (100.0)	100 (100.0)		
Age Group	Good n %	Average n %	Poor n %	Total n %		
12-15 years	10 (26.3)	21 (46.7)	7 (41.2)	38 (38.0)	4.537	0.103(p>0.05)
16-19 years	6 (21.1)	11 (24.4)	3 (17.6)	22 (22.0)		
≥ 20 years	20 (52.6)	13 (28.9)	7 (41.2)	40 (40.0)		
Total	38 (100.0)	45 (100.0)	17 (100.0)	100 (100.0)		
Educational Status	Good n %	Average n %	Poor n %	Total n %	7.441	0.024 (p<0.05)
Schooling	16 (42.1)	32 (71.1)	11 (64.7)	59 (59.0)		
University	22 (57.9)	13 (28.9)	6 (35.3)	41 (41.0)		
Undergraduates						
Total	38 (100.0)	45 (100.0)	17 (100.0)	100 (100.0)		
SES status	Good n %	Average n %	Poor n %	Total n %		
Low	19 (50.0)	15 (33.3)	4 (23.5)	38 (38.0)	5.185	0.255 (p>0.05)
Middle	15 (39.5)	26 (57.8)	10 (58.8)	51 (51.0)		
Upper	4 (10.5)	4 (8.9)	3 (17.7)	11 (11.0)		
Total	38 (100.0)	45 (100.0)	17 (100.0)	100 (100.0)		
Treatment Category	Good n %	Average n %	Poor n %	Total n %	5.507	0.236 (p>0.05)
1 st visit	11 (28.9)	19 (42.2)	10 (58.8)	40 (40.0)		
Ongoing treatment	27 (71.1)	26 (57.8)	7 (41.2)	60 (60.0)		
Total	38 (100.0)	45 (100.0)	17 (100.0)	100 (100.0)		
Dental component of IOTN category	Good	Average	Poor	Total		
None, little or borderline (Grade 1,2,3)	5 (13.2)	16 (35.6)	2 (11.8)	23 (23.0)	6.782	0.036 (p<0.05)
Need treatment (Grade 4,5)	33 (86.8)	29 (64.4)	15 (88.2)	77 (77.0)		
Total	38 (100.0)	45 (100.0)	17 (100.0)	100 (100.0)		

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Value Addition of CBCT in Orthodontic Treatment Planning of Impacted Canines and Considerations for Dental Implants

Eric Strouse¹, Meenakshi Vishwanath¹, Jonathan Feldman¹, Sunil Mutalik¹, Melissa Landin¹, Aditya Tadinada¹

University of Connecticut School of Dental Medicine, University of Nebraska Medical Center, College of Dentistry, University of Connecticut School of Dental Medicine, University of Connecticut School of Dental Medicine, University of Connecticut School of Dental Medicine, University of Connecticut School of Dental Medicine

Abstract

Objectives: The aim of this study was to assess the value addition of cone-beam computed tomography (CBCT) in the orthodontic treatment planning of impacted canines and considerations for dental implants based on the diagnosis and treatment plan.

Materials and Methods: 35 impacted canines from 17 treated patients were evaluated. The first set of simulated images consisted of traditional 2-dimensional peri-apical radiographs generated on the Clark's tube shift technique. The second set consisted of CBCT scans, with the evaluators being able to manipulate the scans in all three orthogonal planes. Four orthodontists with varying experience and one oral maxillofacial radiologist completed questionnaires for each impacted canine and the radiographic modality.

Results: The data showed that the evaluators produced varying diagnosis and treatment plans depending on the radiological modality used. The impacted canine was correctly localized with 2D radiography 46% of the time, while evaluators were unsure or incorrect 54% of the time. In identifying root resorption there was 63% uncertainty or disagreement between the methods. There was 25% disagreement or uncertainty in regards to the decision on whether the impacted canine could be brought into occlusion using orthodontic methods. There was 21% disagreement or uncertainty on whether the impacted canine would be treatment planned for extraction.

Conclusions: CBCT may provide a value addition over 2D radiography in more accurate diagnosis and more confident treatment planning, leading to improved patient outcomes.

Keywords: Cone-beam computed tomography, cuspid, impacted, teeth

Introduction:

Impacted canines are not an uncommon problem in dental patients. Other than the third molars, maxillary canines are the second most frequently impacted teeth with a prevalence between 1% to 3%, with mandibular canines encountering impactions seen between 1% and 2%. (1, 2, 3, 4, 5). Due to this relatively common occurrence, managing impacted canines has become a regular task in orthodontic practices. Treatment of impacted canines can be both extended and difficult, and due to the high esthetic demands and functional considerations both surgical and orthodontic intervention is often necessary (6). Impacted canines can also lead to resorption of neighboring permanent teeth, especially the lateral incisor (7, 8).

Accurate diagnosis and fundamentally sound treatment planning are the cornerstone of successful orthodontic treatment (9). Precise localization of the impacted canine in all three planes of space, and its surrounding structures is essential in the orthodontic-surgical management of presenting patients. Traditionally, the use of two-dimensional (2D) radiographic images (panoramic, periapical, occlusal, and cephalograms) have been used in orthodontics. With 2D imaging comes distortions, superimpositions and other inherent issues. Diagnosis and treatment planning can become difficult with conventional radiography due to these reasons. With its lower cost, high spatial resolution and reduced radiation dose compared to medical computed tomography (CT), the development of Cone Beam Computed Tomography (CBCT) is emerging as the imaging modality of choice in clinical cases requiring extensive 3D views.

Should orthodontic traction not be feasible, or the patient does not desire the treatment, surgical removal of the impacted canine is the only solution available (10,11). Due to the resultant poor esthetics and occlusal asymmetry, implant placement is a common subsequent step (12). If adequate residual bone remain after the extraction of the canines, an immediate implant is an option for the patient (13). These clinical scenarios require knowledge of bone quantity, quality and proximity to critical anatomical structures (14).

In considering impacted canines, CBCT has been previously shown to be useful for their diagnosis, as well as for the identification of associated sequelae (15), such as root resorption in adjacent incisors. This study was conducted in order to assess the diagnosis and treatment planning of impacted maxillary and mandibular canines as well as considerations for dental implant placement, should the tooth be extracted. We hypothesize that three-dimensional imaging will provide detailed information on the location, presence of PDL space, diagnosis of root resorption and offer superior information in orthodontic treatment planning.

Materials and Methods:

Cone beam images were collected from 24 consecutive patients, who were referred for localization of either unilateral or bilateral impacted or ectopically erupting canines (all the images were collected from multiple private orthodontic practices that have been de-identified and archived at the University of Connecticut School of Dental Medicine. The patients were of mixed dentition, aged 11–14 and all identifying characteristics including age, gender or race were removed for purposes of the study. A total of 35 impacted or ectopically erupting canines were studied, including 30 maxillary impactions, 5 mandibular impactions, 8 bilateral impactions, 7 unilateral right impactions, 12 unilateral left impactions. Digital imaging and communications in medicine (DICOM) format of the traditional 2D diagnostic radiographs and CBCT scans were utilized for each patient.

The traditional 2D radiographs included two simulated periapical images using the Clark's Method of tube shift technique. For each impacted canine, one standard periapical and one employing a distal shift was provided (Figure 1). Volumetric images of the patient's dentition were obtained from the CBCT scan (Figure 2). Images were viewed on HP Pavillion ZE 2000 computer and 20-inch dual monitor display with a 1600 x 900-pixel resolution. All patient identifiers including name, age, sex and race were removed. The institutional review board of the University of Connecticut approved this study.

Four orthodontists and one oral and maxillofacial radiologist participated in the study. One orthodontist with over 25 years' clinical experience, two with 5–10 years' clinical experience and one in the final year of orthodontic residency. The radiologist had 5 years' clinical experience. The impacted canines were evaluated over the course of two sessions. Prior to beginning, all evaluators reviewed the questionnaire as a calibration.

The impacted canine cases were ordered randomly. The periapical radiographs using simulated Clark's tube shift Technique were assembled onto a PowerPoint slide presentation showing the two periapicals for each impacted canine, a standard periapical along with a periapical utilizing a distal shift were presented. The CBCT scans were ordered randomly and evaluators were able to freely manipulate the scans using the InVivo software to simulate actual radiological clinical practices. The viewing conditions (room lighting and display monitor settings) were standardized. Clinicians analyzed the images and completed the questionnaires independently. A total of 70 questionnaires were completed by each evaluator, one for the 2D radiographs

and one for the CBCT scan for each impacted canine. A board-certified Oral and Maxillofacial Radiologist with extensive clinical experience scored the 35 CBCT cases for the following three variables: location of the impacted canine, is the impacted canine being blocked by any adjacent teeth or anatomic structures and whether the PDL space of the impacted canine can be visualized.

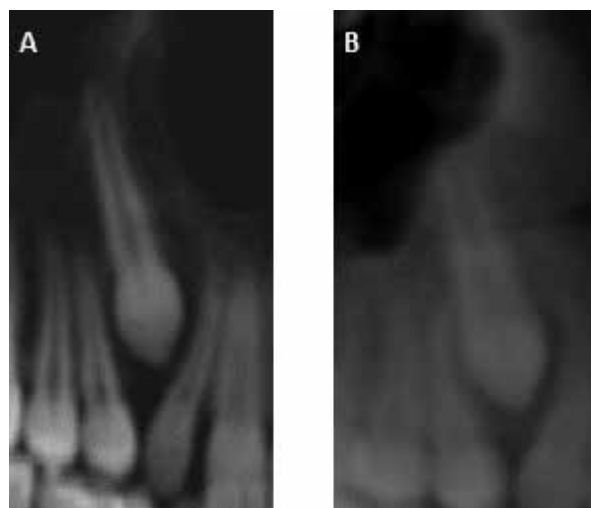


Figure 1. Periapical radiographs using Clark's Method. A, PA of #6; B, Distal shift PA of #6. C, PA of #11; D, Distal shift of #11

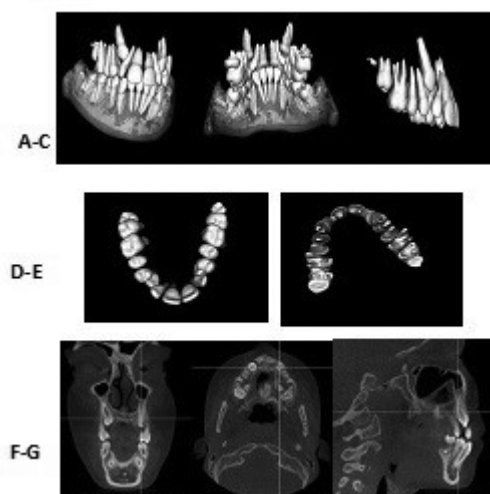


Figure 2. A-E, Reconstructed models of #6 and #11 from InVivo CBCT software; G-H, Section views in coronal, axial and sagittal views.

Statistical Analysis

The data was analyzed after collected using IBM SPSS Statistics software version-22. Interrater reliability was performed with an Alpha Cronbach's test for each variable (Table 1). Descriptive statistics with counts of agreement and ability to diagnose and treatment plan

for each imaging modality were calculated. These were used as a measure of difference between CBCT and 2D imaging.

Variable	CBCT	2D
Location of the impacted canine	0.951	0.609
Is the impacted canine being blocked	0.813	0.112
Can you visualize the PDL space	0.066	-0.2
Relationship to adjacent incisor	0.861	0.566
Root development	0.946	0.794
Root resorption	0.528	-0.065
Erupt unassisted	0.757	-0.03
Orthodontic treatment plan	0.611	0.755
Extraction	0.75	-0.043
Image quality	0.49	0.488
Case difficulty	0.893	0.769

Table 1. Cronbach alpha scores for CBCT and 2D for each variable between the five evaluators.

Results

For identify the location of the impacted canine, the crown of the impacted tooth was used to make the diagnosis of its buccal/lingual location. The five evaluators were able to correctly identify the location 46% of the time for the 35 impacted canines (175 total responses), with a range of 28.6% to 62.8% (Figure 3) Evaluators were unable to make a diagnosis using 2D radiography 24% of the time, and produced an incorrect diagnosis 30% of the time.

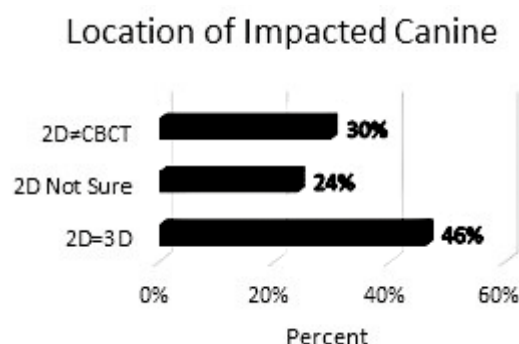


Figure 3. Percentages of agreement and differences for the location of the impacted canine (buccal, lingual/palatal, mid-alveolar, Not Sure) between the 2D traditional radiographs and the 3D CBCT

Is the Impacted Canine Being Blocked by any adjacent Teeth/Anatomic Structures

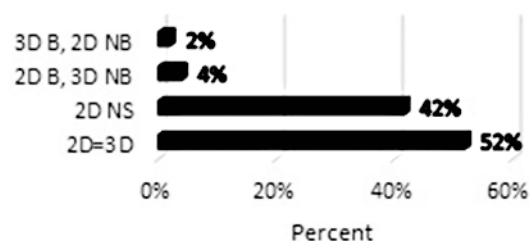


Figure 4. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on whether or not the impacted canine is being blocked by any adjacent teeth or anatomic structures (B, blocked; NB, not blocked; NS, not sure).

In diagnosing whether the impacted canine was being blocked by any adjacent teeth or anatomic structures, the five evaluators were in agreement with their diagnosis between the two imaging modalities 52% of the time (Figure 4) 42% were unable to make a diagnosis using 2D radiography. In diagnosing whether the PDL space of the impacted canine could be visualized, the five evaluators were in agreement 42% of the time (Figure 5). 32% of the time, evaluators were unable to make a determination when viewing only the 2D radiography. There were differences in diagnosis between the ability to visualize the PDL space for the two modalities 19% of the time.

Can you Visualize the PDL Space of the Impacted Canine

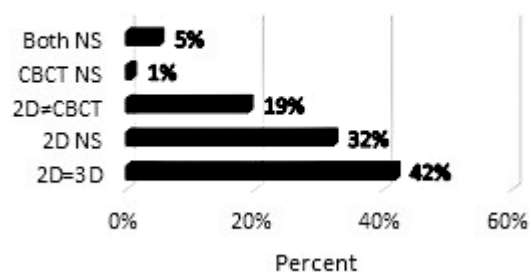


Figure 5. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on whether or not the PDL space of the impacted canine can be visualized (NS, not sure).

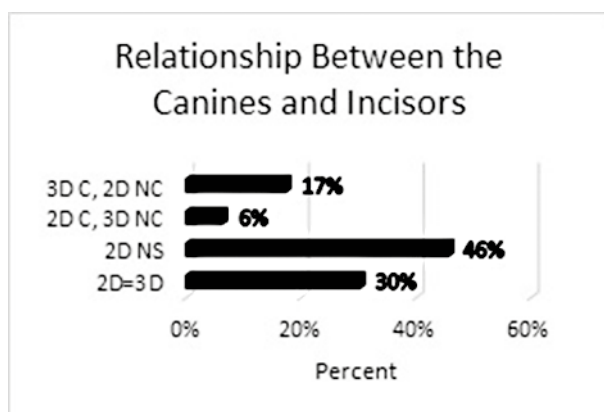


Figure 6. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on the contact between the impacted canine and the adjacent incisors. Contact was defined as distance from the crown of the impacted canine and the adjacent incisor being less than 1mm (C, contact; NC, no contact; NS, not sure).

In diagnosing whether the crown of the impacted was in contact with the adjacent incisor a cutoff of less than 1mm was used. There was a 30% agreement in diagnosis between the two modalities (Figure 6). The evaluators were unable to make a diagnosis using 2D radiography 46% of the time. Assessing the state of root development produced the same diagnosis between modalities among the five evaluators 57% of the time (Figure 7). Evaluators were unsure of a diagnosis using 2D radiography 8% of the time, and 45% of the time produced differing diagnosis.

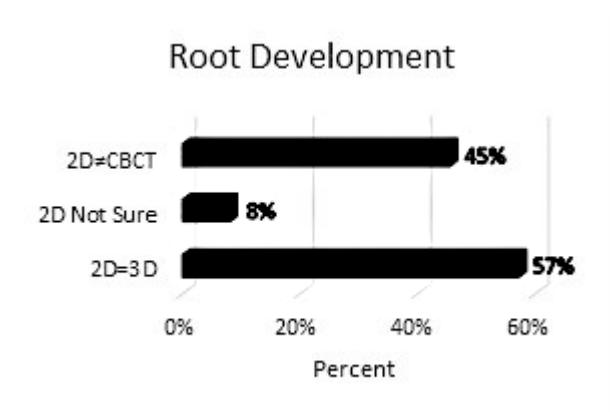


Figure 7. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on the root development of the impacted canine

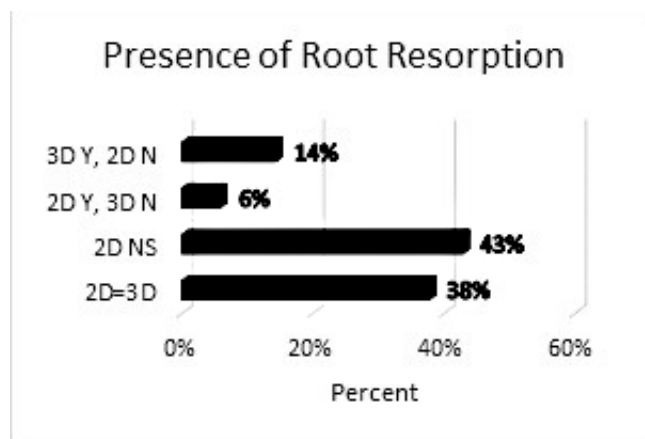


Figure 8. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on the ability to detect the presence of root resorption (Y, yes; N, no; NS, not sure).

In detecting root resorption, the five evaluators were in agreement on their diagnosis 38% of the time for the 35 canines (Figure 8). 43% were not sure in making a diagnosis using 2D radiography. For 14% of the cases, evaluators did not detect the presence of root resorption using 2D radiography, but were able to diagnose root resorption using CBCT. In 6% of the cases, evaluators diagnosed the presence of root resorption with 2D radiography, but did not with CBCT.

In predicting whether the impacted canine would erupt unassisted, evaluators were in agreement between 2D and CBCT 79% of the time for the 35 impacted canines (Figure 9). Evaluators were not sure in making a diagnosis using 2D radiography 15% of the time. The evaluators were asked if they would make the decision to bring the impacted canine into occlusion using orthodontics. In 75% of the cases, they were in agreement with their treatment plan between 2D and the CBCT (Figure 10). In 15% of the cases, they were not sure using 2D radiography, but did make a treatment planning decision using the CBCT.

The evaluators were prompted additionally if they would choose to extract the impacted canine from the radiographic imaging provided. For 79% of the cases, evaluators were in agreement for both the 2D and CBCT imaging (Figure 11). In 15% of the cases, they were not sure using 2D radiography, but did make a decision using the CBCT. There was one case for which three of the evaluators all noted that they would consider extracting the lateral incisor, and consider placing a dental implant in the edentulous zone. They all said they would request a CBCT for treatment planning purposes.

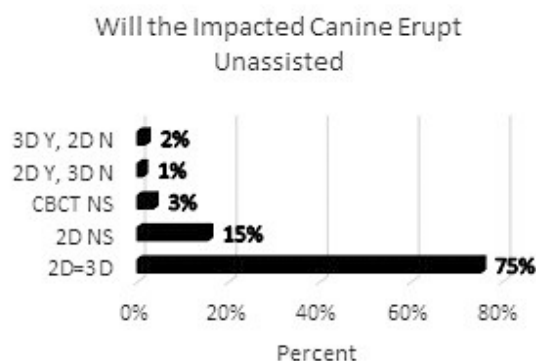


Figure 9. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on whether or the impacted canine will erupt unassisted (Y, yes; N, no; NS, not sure).

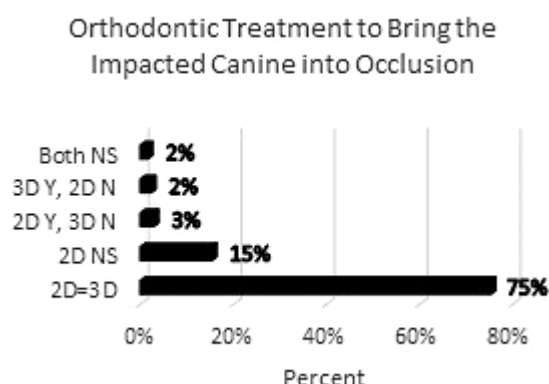


Figure 10. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on the decision to perform orthodontic treatment to bring the impacted canine into occlusion (Y, yes; N, no, NS, not sure).

Questions for dental implant considerations were answered if there was a possibility of implant placement (either “yes” or “not sure” for treatment planning extraction of the impacted canine). There were 20 total cases in which evaluators said they would not consider planning a dental implant from viewing the CBCT, but were “not sure” from the 2D radiographs (Figure 12). Furthermore, when dental implants were considered, evaluators were asked whether they could visualize various aspects of anatomy from the various radiographic modalities. In 100% of the cases, evaluators said they could visualize bone height, trabecular pattern and proximity to critical structures using both 2D and CBCT (Figure 13). In 100% of the cases, evaluators said they could visualize bone width, buccal and lingual cortical plates with CBCT, while 0% said they could visualize these qualities from the 2D radiography.

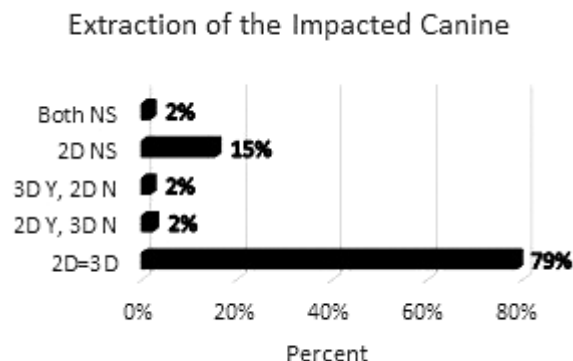


Figure 11. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on whether to extract the impacted canine (Y, yes; N, no, NS, not sure).

Discussion

Orthodontic treatment planning for impacted canines depends on a multitude of factors. Being able to accurately localize the impacted canine is very important in regards to treatment planning. Additionally, impacted canines can present other difficulties including root resorption of adjacent teeth which can have significant consequences. This study builds on some early research comparing various radiographic modalities in planning impacted canines. Periapical radiographs are traditionally a common choice as a means for locating objects buccal-lingually using two-dimensional imaging with the Clark’s shift technique.

Due to the complexity of impacted canines, accurate diagnosis is highly important for proper management. The ability to precisely locate an impacted canine in space makes for improved surgical and orthodontic planning. Clinicians need to visualize an impacted canine in relation to its neighboring teeth and other anatomic structures in order to plan for future treatment. Visualization of other variables, such as the presence of an intact PDL space and root development can also play important roles in diagnosing the eruption potential of these teeth. By possessing superior diagnostic information, clinicians can plan with more confidence, leading to fewer mismanaged cases. Our study had an overall findings suggesting a decreased ability to make confident diagnosis and treatment using 2D imaging alone. Uniformly across the variables in both diagnosis and treatment planning, there was a clear benefit in the use of CBCT.

To produce a true gold standard would have required an anatomical dissection. This was not a viable option, both practically and ethically. With its 1:1 anatomical accuracy, along with a lack of distortion or artifact,

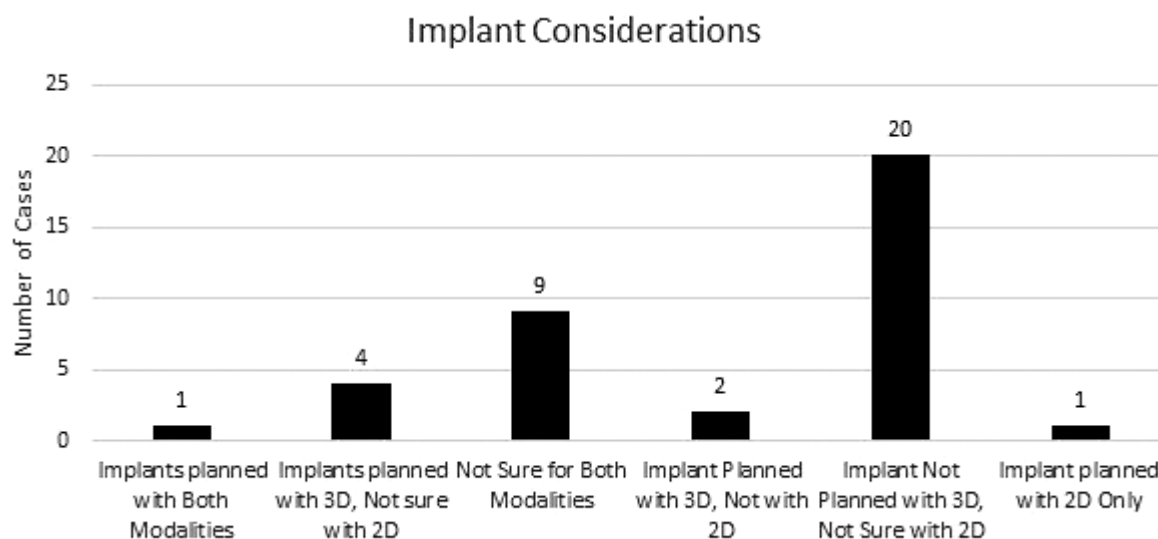


Figure 12. Description of cases in which implants were considered, with the number of cases show for each situation

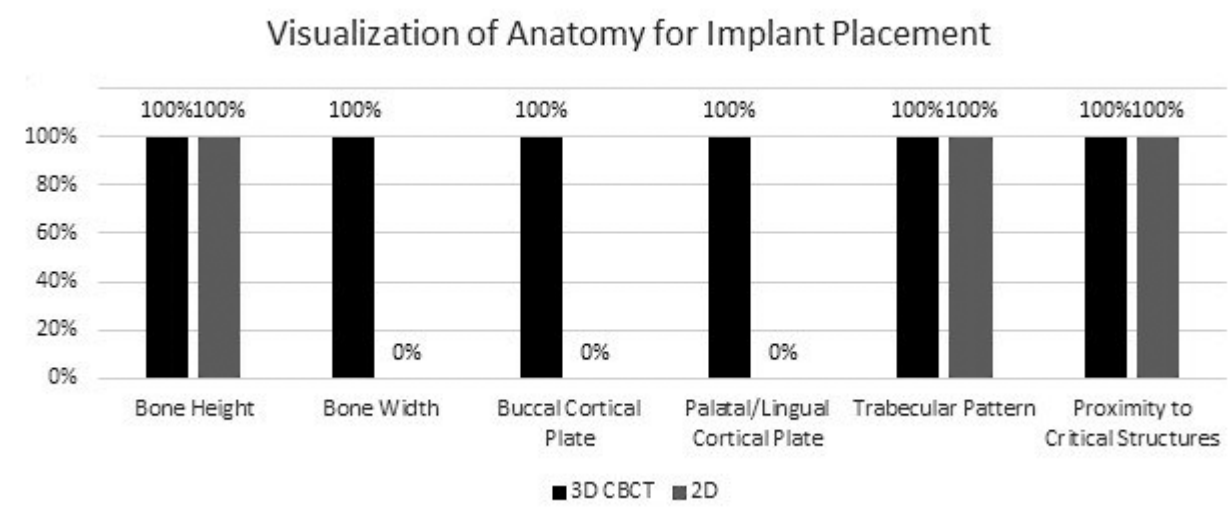


Figure 13. Percent of practitioner's ability to visualize anatomic variable considered in the placement of dental implants for both 2D and 3D CBCT imaging.

CBCT was used as the gold standard for the purposes of localization. This was confirmed by a very high interrater reliability score as evaluators diagnosed the location using the CBCT, the high agreement confirming the accuracy of the imaging. Surprisingly, the percentages of accurate diagnosis was lower than other studies comparing localization using periapical radiographs. Ericson and Kurol⁽¹⁶⁾ demonstrated only 8% of the impacted canines not being able to be accurately localized labiopalatally using periapical images. Despite the lack of a true gold standard, interrater agreement was high for each of the variables for the CBCT scans. The 2D imaging produced lower agreement. We attribute this to the true accuracy of CBCT. Evaluators

were able to make more consistent and true diagnoses, and therefore more appropriate treatment plans. The lower kappa scores for 2D images were indicative of a decreased ability to make orthodontic diagnoses using this imaging alone. Improper localization has a direct relationship to patient outcomes. One study analyzed the treatment of 37 impacted canines that were taken as "failed". Of the failures, 40.5% were due to mistaken localization

Additionally, although evaluators were standardized in regards to their understanding of the questionnaire, they all came from various backgrounds with different training and treatment philosophies. One orthodontist serving as an evaluator, with over 25 years of clinical

experience, was not trained with three-dimensional imaging and does not use it in his private practice. For this reason, he was less comfortable manipulating the three-dimensional software which may have impacted his responses to our survey. Other evaluators were trained in various countries, with different treatment philosophies and methods, taking away from the uniformity of the study. This variety of evaluators does, however, provide a wide mix of philosophies brought together and averaged for the purposes of this study. There will be inherent disagreement in many aspects of diagnosis and treatment planning in orthodontics. With improved diagnostic imaging, we found diagnosis and treatment planning to be more consistent. This was evident in our study, causing difficulty in producing detailed statistical measures.

Several authors have confirmed that when using three-dimensional imaging root resorption is more prevalent than it is assumed to be, and conventional radiographic imaging has been shown to be inadequate in detecting root resorption (Algerban et al. 2011). CBCT eliminates the problems with conventional imaging and allowing for an increased ability to detect root resorption. Our study had similar findings, in only 38% of the cases was the detection of root resorption similar between CBCT and 2D imaging. There was a large percentage of cases (43%) in which a presence or lack thereof root resorption was made with CBCT but evaluators were not sure when viewing 2D imaging. Haney et al. had similar findings, in which 64% of judges were in agreement between 2D and CBCT, with a wide range of 36% to 86% in the judge's agreement. This study builds on that by increasing the sample size from 25 to 35, surpassing the minimal sample size for a normal bell curve distribution. Early detection of root resorption is of great importance. If not detected early, the loss of an incisor is a possibility, making the increased diagnostic ability of CBCT to be very beneficial.

Due to their difficulty and possibility of various sequelae, impacted canines have been studied extensively in the literature. It is known that CBCT has the capability to produce more accurate diagnoses due to its inherent properties. Our study showed that there was a 79% agreement between the two imaging modalities in the decision to treatment plan orthodontic treatment. The remaining 21% produced varying treatment plans between the imaging types or an inability to make a plan using the 2D imaging alone, a large proportion of the cases. With such uncertainty in using 2D imaging alone and the potential difficulty of these cases, it may be a suggestion for use of CBCT in treatment planning of impacted canines. Other images that are traditionally taken, such as a panoramic, lateral cephalogram and

more are also able to be generated from a CBCT, aiding the provider in the treatment planning process. Further, with an assessment of the entire craniofacial complex, better assessing the airway, TMJ and other possible incidental findings, allowing for the best possible patient outcomes.

This is one of the first studies to look at the consideration of treatment planning dental implants in the situation of impacted canines. Some patients may not desire orthodontic treatment, and bringing an impacted canine into occlusion may sometimes not be feasible. A case study from Garcia et al. investigated immediate implants after the removal of impacted maxillary canines in nine patients. Practitioners will be interested in what situations implant placement is an option, and what radiographic modalities will be necessary. Our study found 20 cases in which the evaluator was not sure about placing an implant when viewing 2D imaging, but would not consider an implant when viewing the CBCT of the same case. In other cases practitioners made varying decisions between imaging modalities. The evaluators noted that they were considering placing an implant, they would request for a CBCT. This indicates that consideration of extraction and implant placement will have to be taken on a case by case basis. It is well known that CBCT provides superior diagnostic capabilities in the treatment planning and placement of dental implants (Tyndall et al. 2012). Our study supported this, with evaluators responding that they were able to visualize important variables for implant placement not visualized with 2D imaging. While evaluators did state they were able to view the proximity to critical structures using 2D imaging, it has been shown that in the placement of mini implants CBCT significantly reduces root perforation compared to other imaging, indicating that avoiding anatomical structures may require more accurate imaging⁽¹⁸⁾.

Although there is little in published literature regarding the financial cost of CBCT, the cost of low radiation three-dimensional imaging using CBCT is becoming more affordable. It is important for the benefits of this imaging modality to become available for practitioners. In addition to the technology becoming more affordable, radiation doses of three-dimensional CBCT are becoming lower. CBCT imaging for comprehensive orthodontic patients is approximately 65 μ Sv compared with about 26 μ Sv for a lateral cephalogram and a panoramic image taken with a digital machine with subsequent low-dose protocols for orthodontics 35–40 μ Sv. This amount is lower than a full-mouth series of intra-oral radiographs to assess periodontal status. This, combined with the superior diagnostic information provided by CBCT, may make this modality a valuable option for orthodontists in the diagnosis and

treatment planning of impacted canines. A randomized clinical trial to further analyze these same questions is not viable option, as it is unethical to expose patients randomly to additional radiation solely for the purpose of a research study, without a clinical or radiological basis.

Conclusions

These results suggest that three-dimensional CBCT may produce improved accuracy in the diagnosis of impacted canines. When compared with 2D imaging, inconclusive to erroneous treatment plans can be produced. Three-dimensional imaging may have the ability to offer advantages in proper diagnosis and treatment planning due to its superior information, allowing for improved overall outcomes and patient care.

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Table and Figure Legends

Table 1. Cronbach alpha scores for CBCT and 2D for each variable between the five evaluators.

Figure 1. Periapical radiographs using Clark's Method. A, PA of #6; B, Distal shift PA of #6. C, PA of #11; D, Distal shift of #11

Figure 2. A-E, Reconstructed models of #6 and #11 from InVivo CBCT software; G-H, Section views in coronal, axial and sagittal views.

Figure 3. Percentages of agreement and differences for the location of the impacted canine (buccal, lingual/palatal, mid-alveolar, Not Sure) between the 2D traditional radiographs and the 3D CBCT.

Figure 4. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on whether or not the impacted canine is being blocked by any adjacent teeth or anatomic structures (B, blocked; NB, not blocked; NS, not sure).

Figure 5. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on whether or not the PDL space of the impacted canine can be visualized (NS, not sure).

Figure 7. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on the root development of the impacted canine.

Figure 8. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on the ability to detect the presence of root resorption (Y, yes; N, no; NS, not sure).

Figure 9. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on whether or the impacted canine will erupt unassisted (Y, yes; N, no; NS, not sure).

Figure 10. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on the decision to perform orthodontic treatment to bring the impacted canine into occlusion (Y, yes; N, no; NS, not sure).

Figure 11. Percentages of agreement between the 2D traditional radiographs and the 3D CBCT on whether to extract the impacted canine (Y, yes; N, no; NS, not sure).

Figure 12. Description of cases in which implants were considered, with the number of cases show for each situation.

Figure 13. Percent of practitioner's ability to visualize anatomic variable considered in the placement of dental implants for both 2D and 3D CBCT imaging.

RETROSPECTIVE CLINICAL AUDIT: SUCCESS RATE OF ALVEOLAR BONE GRAFTS CARRIED OUT IN CLEFT PATIENTS

Basnayake S¹, Karunathilaka S², Rajaganesh A³, De Alwis S⁴

¹ Department of Orthodontics, Lady Ridgeway Hospital for Children, Colombo

² Oral and Maxillofacial Unit, Colombo South Teaching Hospital

³ Department of Orthodontics, DGH Negombo

⁴ Department of Orthodontics, Lady Ridgeway Hospital for Children, Colombo

ABSTRACT

Introduction: Alveolar bone grafting (ABG) is an essential intervention in the management of cleft lip and palate. The precise timing of the ABG surgery had been debated for many years. Secondary ABG carried out prior to the eruption of the permanent canine has become a widely accepted procedure since it was first introduced in 1972. It is carried out in the mixed dentition stage to create an intact and continuous alveolar arch. **Objective:** To evaluate the success rate of alveolar bone graft surgeries in cleft lip and palate patients at Lady Ridgeway Hospital for Children Colombo. **Methods and Materials:** This Retrospective analytical study used a sample population of 100 patients who underwent Alveolar bone graft surgeries carried out by a single operating surgeon. Kindelan scoring system was applied to maxillary occlusal radiographs taken at least 6month after surgery. **Results:** 55% were Grade 1. 20% were grade 2 and 11% were Grade 3 No complete bony fill was seen in 5% of cases. **Conclusion:** Our figures revealed a clinical success rate of 75% (Type I and II). **Key words:** Cleft lip and palate, Alveolar bone graft, Kindelan score, Sri Lankan

INTRODUCTION

Cleft lip and palate conditions are common congenital deformities of the oro-pharyngeal region. Management of such conditions require involvement of multiple specialties who should intervene at various stages of a child's development from birth to adulthood.

Alveolar bone grafting is one such essential intervention which has various benefits that have been well documented. The precise timing of the ABG surgery had been debated for many years.

Secondary alveolar bone grafting carried out prior to the eruption of the permanent canine has become a widely accepted procedure since it was first introduced by Boyne and Sands in 1972 . It is carried out in the mixed dentition stage to create an intact and continuous alveolar arch. This allows proper eruption of the permanent dentition and also facilitates orthodontic tooth movements into previous cleft sites, thereby minimizing the need for prosthetic replacement of teeth. It also helps to stabilize the pre maxilla in bilateral cleft patients. In addition to the aforementioned benefits, alveolar bone grafting also improves the contour of the alar base and facilitates fistula closure .

Secondary alveolar bone grafting is now an essential part of the cleft lip and palate treatment protocol. The optimum time is decided individually. Usually its between 9-11 years when the unerupted cleft canine root is one-half to 2/3 rds developed and sometimes between 7-8 years if a well formed lateral incisor is present.

The advantages of a successful Alveolar bone graft are clear but various factors play a role in establishing whether or not the grafted bone survives. The type of cleft, whether unilateral or bilateral has been shown to affect the outcome of alveolar bone graft surgeries in some studies. The status of the cleft canine at the time of ABG surgery has been proved by various authors to be a major factor in determining the success of the graft . Having a tooth erupt through the newly grafted bone or moving a tooth orthodontically into it ensures its survival. In addition to that, the size of the cleft, presence of supernumeraries and decayed teeth in the cleft and pre surgical orthodontic expansion of the cleft site are also considered be factors which affect the outcome of ABG. Infection control and experience of the surgeon also plays a major role in the success of ABG. A protocol was developed jointly by the Department of Orthodontics LRH and the Oral Maxillofacial unit of the Teaching Hospital Kalubowila to cover all aspects, which contribute to the success of this surgery. Therefore it was essential to evaluate the success rate of alveolar bone grafts of our patients.

Various centers around the globe have carried out such researches and reported them accordingly. A radiographic tool is necessary to visualize the grafted site, and the type of tool used in previous studies vary from 3-Dimensional CTs, Intra Oral Periapical Radiographs or Occlusal radiographs. The indices used to analyze the grafted site also varied among previous studies with the Berglund score being the most commonly used. The Kindelan score and the Chelsea score were also used in certain studies.

According to CSAG (Clinical Standards Advisory Group) the success rate of Alveolar bone grafts in England and Wales had improved from 58% in 1998 to 95% in 2006 following implication of centralization. Such a study carried out in Sri Lanka would provide results which can be compared with international standards to identify shortcomings and to improve future care. Therefore the purpose of this study is to establish the radiographic outcome of Alveolar Bone grafts carried out in cleft palate patients registered in Lady Ridgeway Hospital for Children, Colombo. To the best of my knowledge similar studies have not been carried out in Sri Lanka previously.

OBJECTIVE

To establish the radiographic outcome of Alveolar Bone grafts carried out in cleft palate patients registered in Lady Ridgeway Hospital for Children, Colombo

METHODS AND MATERIALS

Study design

Retrospective analytical study

Setting

Lady Ridgeway Hospital for Children

Sample population

Consecutive alveolar bone graft surgeries carried out by a single operating surgeon between October 2009-September 2012 at the Oral and Maxillo Facial unit in the Colombo South Teaching Hospital.

Surgery involved Autogenous bone grafts from Anterior iliac crest.

Sample size

113

Study instrument

Maxillary occlusal radiographs taken at 6 month intervals as a routine, to assess the viability of the bone graft.

These radiographs were taken at 70 degree angulations to the vertical and centered through the cleft

The follow up time varied from being 6 months to 2 years.

Inclusion criteria

1. Patients who have undergone Alveolar bone graft (ABG) surgery between October 2009-September 2012.
2. Minimum period of 6 months since the ABG surgery. Therefore allowing time for the bone to be integrated and calcified.

Exclusion criteria

1. Patients who do not have minimum 6 months post operative period.

Criteria of evaluation.

Anonymous, standardized photographs were taken of each maxillary occlusal radiograph. These were then transferred to Microsoft power point slides for scoring. Two examiners in Glasgow did scoring independently. The examiners scored the postoperative radiographs under standardized conditions on two separate occasions.

The Kindelan scoring system was used as an audit tool to assess the amount of bony fill at the cleft site. It has four grades (Table 1 & figure 1). Grade 1 indicates more than 75% bony fill at the cleft site. Grade 2 shows 50-75% bony fill and anything less than 50% is scored as Grade 3. Cases with no complete bony fill are classified as Grade 4. The kindelan scoring system is frequently used and is easy to apply. The main advantage over the other scoring systems is that it does not require the permanent canine adjacent to the cleft to be fully erupted. This can take a significant amount of time following the graft.

Being a two dimensional assessment is a drawback as plain radiographs are susceptible to distortion and superimposition of adjacent structures. Although plain radiographs have various limiting factors, they are cheaper, easily accessible and give a low dose of radiation. Previous studies have shown that measuring outcome from a single postoperative radiograph using the Kindelan scoring system is a reliable method.

Table 1 Kindelan scoring system

Grade	Bony fill	
1	>75%	Success
2	50-75%	Success
3	<50%	Borderline
4	No complete bony fill	Failure

The two examiners (Examiner A and B) scored the postoperative radiographs under standardized conditions on two separate occasions. According to the Kindelan scoring system Grade 1 and 2 were considered as successful outcome of treatment, Grade 3 was borderline and Grade 4 was a failure.

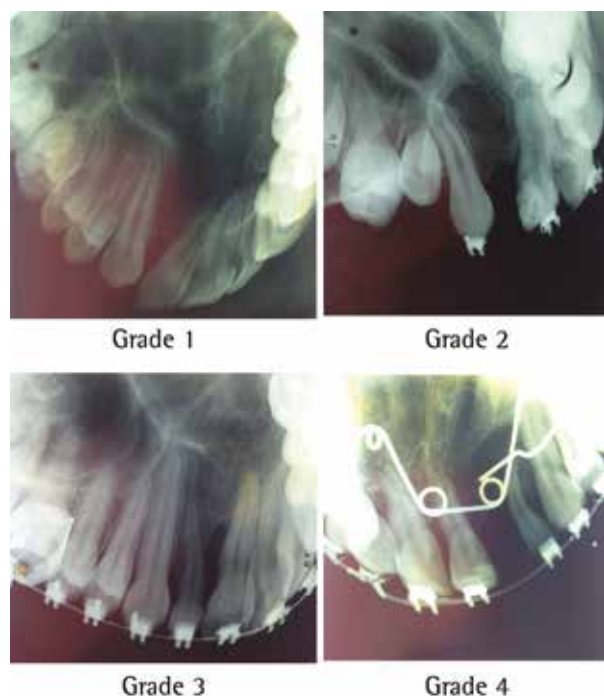


Figure 1

Statistical analysis

A Kappa statistic was used to measure intra-examiner and inter-examiner reliability as this was ordered categorical data. Bland Altman system was used to measure the strength of agreement for the Kappa coefficient.

Ethical Clearance

Ethical clearance obtained from Ethical review committee, Lady Ridgeway Hospital for Children. Radiographs taken as a routine during follow up visits were considered. Patients were not subjected to additional radiation for the purpose of this study.

RESULTS

Table 2 shows the results of the analysis done by the two examiners on two separate rounds, and Table 3 displays the average.

Table 2 shows the results of the analysis done by the two examiners on two separate rounds, and Table 3 displays the average.

Table 2 Results								
	Round 1 Examiner 1		Round 1 Examiner 2		Round 2 Examiner 1		Round 2 Examiner 2	
Grade 1	62	55%	56	50%	65	58%	66	58%
Grade 2	23	20%	25	22%	21	19%	22	19%
Grade 3	11	10%	15	13%	11	10%	11	10%
Grade 4	6	5%	5	4%	6	5%	4	4%
N/a	11	10%	12	11%	10	9%	10	9%
Total	113	100%	113	100%	113	100%	113	100%

Out of the 113 radiographs scored using the kindelan scale, 55% were classified as Grade 1 and 20% were Grade 2. Grades 1 and 2 are considered as clinically successful outcome. 11% were classed as Grade 3. 5% of the cases showed no complete bony fill and therefore scored as Grade 4. 10% of the cases could not be assessed.

According to the Bland Altman system the strength of agreement for the Kappa coefficient (very good 0.81-1.00; good 0.61-0.90; moderate 0.41-0.60; fair 0.21-0.40 and poor <0.21). ranging from 0.412-0.766 was obtained by the examiners which was acceptable.

DISCUSSION & CONCLUSION

This study recorded 75% success rate of Alveolar bone graft surgeries carried out in cleft lip and plate patients registered in Lady Ridgeway Hospital for Children Colombo.

There was a 5% failure rate. The causes of failure may have been due to ABG surgeries not being carried out in the optimum time due to late presentation.

Success rates of other similar studies around the globe varied from 58% - 100%. This audit provided us with valuable insight into the ABG surgeries carried out in our patients and it also gave us an opportunity to compare our results

Three dimensional volumetric assessment by cone beam CT can be a very accurate and a reliable method in the future.

ACKNOWLEDGEMENTS

Patients and Staff of Lady Ridgeway Hospital for Children Colombo.

Table 3 Results

	Average	
Grade 1	55%	Clinically successful
Grade 2	20%	Clinically successful
Grade 3	11%	Borderline
Grade 4	5%	Failed
N/a	10%	

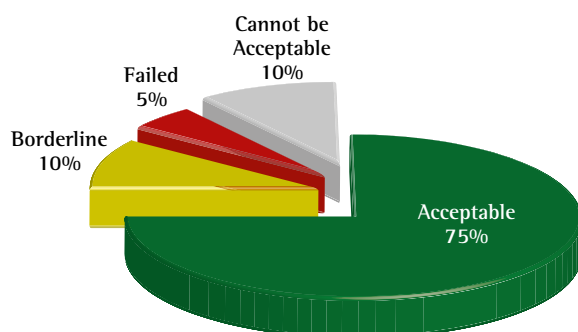


Figure 2

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7-7 U/L Damon Q Single Patient Kit: U3-3 High Tq, L2-2 Low Tq, Snaplink & Ti Tubes	740-1405
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5-5 U/L Damon Clear2 (U3-3), Damon Q & Damon Clear (L3-3) Single Patient Kit: Std Tq*	740-1407
5-5 U/L Damon Clear2 (U3-3), Damon Clear (U4&5/L3-3) & Damon Q Single Patient Kit: Std Tq*	740-1408
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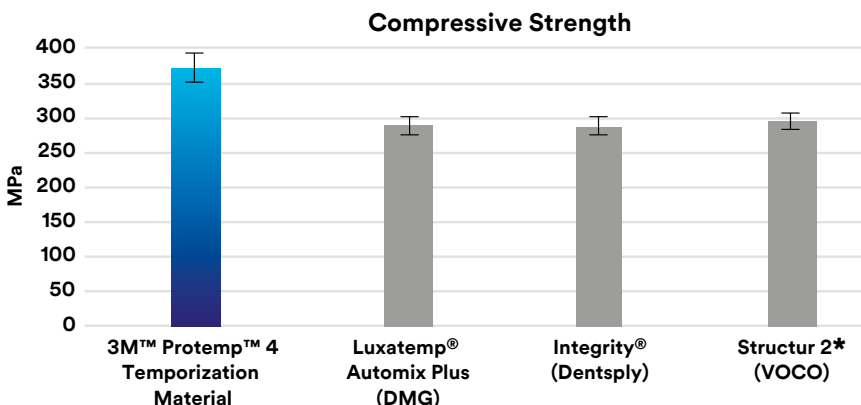
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Contemporary Techniques Used to Plan Orthognathic Surgery in a UK Teaching Hospital

Renuka Priyadarshanie¹, Muhanad Hatamleh², Giovanna Grados², Gavin Mack¹

1. Orthodontic Department, King's College Hospital NHS Foundation Trust, London, UK
2. Cranial and Maxillofacial Department, King's College Hospital NHS Foundation Trust, London, UK

ABSTRACT

The objective of this case series is to demonstrate different approaches carried out in a UK teaching hospital for orthognathic surgical planning.

Correction of dentofacial deformity is always challenging. For optimal aesthetic, functional and stable results, combined orthodontic and orthognathic surgical treatments are often required. Some deformities require facial reconstruction for the correction of the deformity. Careful pre-surgical planning with model surgery and fabrication of accurate surgical splints are the fundamentals in achieving a successful outcome in orthognathic surgery. For reconstructive surgery, bone grafts together with reconstructive plates are the gold standard for treatment. While the traditional technique of orthognathic surgical planning is still being carried out in many centres in the world, 3D planning for orthognathic and reconstructive surgery has increasingly become popularized among many clinicians over the last decade.

Three cases are presented in this paper, using the conventional orthognathic technique, 3D planning with printed wafers and 3D planning with customized reconstruction plates for orthognathic and mandibular reconstruction surgeries respectively.

Case 1

This patient had a class II skeletal deformity with mandibular retrognathism. The orthognathic surgery was mandibular advancement with bilateral sagittal split osteotomy. A conventional technique was used for orthognathic surgical planning.

Case 2

This patient presented with a class III malocclusion on a class III skeletal base with mandibular asymmetry, anterior open bite and maxillary cant. A 3D virtual planning was undertaken. The surgical splints were constructed using CAD/CAM technology.

Case 3

A patient presented with a deficient left side of the mandible. He had a reconstruction with iliac crest bone graft and printed titanium implant using selective laser sintering technology. In addition, simultaneous bimaxillary surgery to achieve class I occlusion was performed with the aid of 3D planning and printed surgical wafers.

The reported cases show the importance of careful planning in orthognathic surgery for achieving a successful outcome. They also demonstrate the versatility of different techniques used, depending on the nature of the jaw deformity and the type of the surgery.

Introduction

Treating dentofacial deformity is one of the challenging aspects in orthodontics and in maxillofacial surgery. Successful orthognathic surgery equally depends on surgical technique and surgical plan. The surgical plan involves diagnosis of skeletal and dental deformity and presurgical prediction of jaw movements. It is followed by a three-dimensional representation of intended movements, which are then transferred to surgical splints. These splints are used to replace the maxilla and mandible in the predetermined position intra-operatively.

In conventional orthognathic surgical planning technique, surgical movements are quantitatively determined by redirection of maxilla and mandible into the desired position on the lateral cephalogram. This can be achieved manually using paper templates or using computer software. Then, the mock surgery is performed on the mounted casts followed by the construction of surgical wafers to represent the new occlusion. These splints are placed on the relocated dentition intra-operatively in order to confirm the actual surgery matches the model surgery¹. The drawbacks of conventional technique includes multiple steps with excessive time consumption, diagnostic limitations of using lateral cephalograms for surgical planning in maxillofacial region, and possible errors in mounting casts.

Over the past few years, the development of 3-dimensional (3D) virtual surgical planning (VSP) has become more important for planning orthognathic surgery².

It involves the acquisition of a CBCT image and 3D reconstruction, virtual diagnosis and 3D virtual planning of orthognathic surgery³. Then, printed surgical wafers are used during the surgery to transfer the plan to actual surgery. More detailed visualization of the dentofacial anatomy³, less laboratory time consumption and less labor work are the main advantages of this new technique².

Computer-aided planning and navigation is a useful adjunct for surgeons in maxillofacial reconstruction. Such systems specifically focus on enhanced visualization tools and 3D modeling to give the surgeon the ability for precise preoperative surgical planning and designing patient specific implants preoperatively⁴. Advances in manufacturing technology and material science has led to the possibility of turning such virtual model or design into reality as physical replica models, surgical guides or cutting jigs, splints and patient specific implants for intraoperative use⁴.

In this paper three cases are presented which used (1) conventional orthognathic surgical planning (2) 3D orthognathic surgical planning with printed surgical wafers and (3) 3D planning with customized surgical plates for mandibular reconstruction in a UK teaching hospital.

Case 1

A 24-year-old female patient presented complaining of a small lower jaw. Clinical examination revealed a Class II division 1 incisor relationship on a Class II skeletal base with retrognathic mandible and increased Frankfort Mandibular Plane (FMPA). There was no significant facial asymmetry. Her upper and lower dental arches were mildly crowded and LR6 had been extracted previously. The overjet was 9 mm and overbite was reduced. Upper and lower dental midlines coincided with each other and with the facial midline. Canine relationships were a full unit Class II bilaterally (Figure 1).



Figure 1. Patient's initial presentation

Based on clinical examination and radiographic findings, the necessity of both orthodontic treatment and orthognathic surgery to attend her malocclusion was clear. The ideal surgical treatment was a Le-Fort1 maxillary impaction to attend her increased vertical proportions and a BSSO (bilateral sagittal split osteotomy) to advance mandible. Since the patient's

only concern was the small lower jaw, the eventual orthognathic surgical plan was only BSSO to bring the mandible forward.

Upper second premolars were extracted to relieve upper arch crowding. LL6 with root canal treatment was also extracted to balance the extraction of LR6. Presurgical treatment was carried out with fixed appliance (0.022" x 0.028" slot, MBT prescription). Lower first molar extraction spaces were utilized for lower arch alignment and decompensation. At the end of 16 months of orthodontic treatment, alignment of upper and lower dental arches, decompensation and arch coordination were satisfactory. Orthognathic surgical planning was done on lateral cephalogram manually, using a mandibular paper template. The template was moved forward until a good posterior teeth interdigitation and an overjet of 1mm were achieved. Molar relationship could not be determined since her lower first molars have been extracted. The amount of mandibular forward movement was measured and recorded as 7mm.

Two sets of impressions were taken with irreversible hydrocolloid. One was to analyze the pre-operative occlusion, and the other one was to perform mock surgery. Orthodontic brackets were blocked out with wax to prevent tearing and distortion of the impression during removal. Wax bite registration in centric occlusion was done in order to determine the patient's occlusion for mounting the models on the articulator.

Impressions were poured with type IV dental stone. The models were mounted in a semi adjustable articulator using the patient's wax bite. Face bow registration was not necessary in the mounting because, (1) anteroposterior and vertical position of the maxilla

was determined by clinically and cephalometrically, (2) tripod occlusal stability existed between the maxillary and mandibular models, (3) no maxillary occlusal cant was present⁵.

A horizontal line was drawn on the mandibular cast just below the roots of the teeth. Then a second line was drawn 10mm below the first line. A digital caliper was used to measure the vertical distance between base of the lower cast and (1) lower incisal edge, (2) tip of canines, (3) buccal cusp tip of first premolars (4) distobuccal cusp tip of upper second molars. Horizontal distances were also measured from the articulator pin to the above reference points on teeth.

After taking the measurements, the mandibular cast was separated from the base between the two horizontal lines. Then the mandible was brought into Class I occlusion with the maxillary cast and fixed with soft wax. Then mandibular cast was sealed to its base with sticky wax. The same horizontal and vertical distances were remeasured. The difference between first and second measurements was equal to the amount and the direction of mandibular movement. The difference of +7 mm in the horizontal plane at the incisal edge of lower central incisors showed that mandible has moved forward by 7mm. Splints were fabricated with auto polymerizing resin. The upper and lower casts were coated with a layer of separating medium (cold mold seal) and left to dry. The undercuts were blocked with putty. Acrylic is rolled into a cylindrical shape at dough stage and adapted to the lower teeth. Then the upper cast was closed into occlusion. Excess acrylic was trimmed with scissors and left for curing. All the external surfaces were sandpapered, pumiced, and polished (Figure 2).



Figure 2. Mounted casts in centric occlusion (left). Mandibular cast is fixed after mock surgery (middle) and the surgical wafer (left)

The wafer was used to position the mandible during the surgery. There were no intraoperative and post-operative complications. After combined orthodontic and surgical treatment, there was a marked improvement in jaw relationship and occlusion. The patient was extremely happy with new appearance and the bite (Figure 3).



Figure 3. Post-operative facial, cephalometric and intraoral views

Case 2

A 28-year-old female patient reported with a chief complaint of a shifted lower jaw towards the right side. She had a Class III incisor relationship on a Class III skeletal base with average FMPA. Her malocclusion was complicated by marked facial asymmetry and negative 2mm overjet measured on right side central incisors. She also had an upper and lower dental midline discrepancy by 3mm. Her upper dental midline was coincident with her facial midline. Lower dental midline was shifted 3mm from upper centerline, but coincident with the chin point (Figure 4).



Figure 4. Patient initial presentation

Following diagnosis with the aid of clinical examination and radiographs, it was planned to perform both orthodontic and bimaxillary orthognathic surgical treatments to correct her malocclusion.

Presurgical orthodontics were carried out with fixed orthodontic appliance (MBT prescription, 0.022"x0.028" slot). After 18 months of presurgical orthodontic treatment, the alignment, decompensation and arch coordination were satisfactory. The required

orthognathic surgery was a Le Fort 1 maxillary osteotomy for differential impaction of maxilla and a BSSO to bring the mandible into class I occlusion. 3D planning was performed in the preparation for the orthognathic surgery.

A CBCT scan was obtained using an i-CATTM device. It was processed and 3D virtual model of patient skull and mandible was constructed using CMF Pro. Plan software (v 3.0; Materialise). Upper and lower impressions of the patient's mouth were taken and poured with dental stone to produce upper and lower dental casts. The CBCT did not show accurate occlusal anatomy due to noise and scatter around the teeth secondary to patient's metallic fixed orthodontic appliance. This prevents accurate upper and lower teeth intercuspsation to determine the planned new occlusion and construction of surgical wafers. To overcome this, both the upper and lower dental casts were scanned (3 Shape R700) separately and in the final occlusion to produce e-casts. Then, the e-teeth were amalgamated with CBCT to create enhanced reconstruction of upper and lower dental arches (Figure 5).

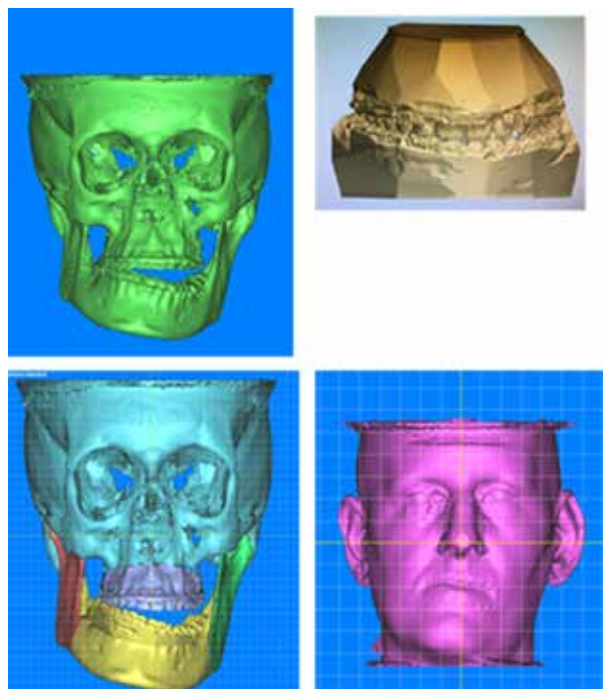


Figure 5. CBCT showing noise and scatter around teeth (top left). Scanned upper and dental casts in final occlusion (top right).

CBCT image amalgamated with e-teeth (bottom left). CBCT soft tissue image (bottom right)

Virtual Le Fort 1 and BSSO were performed to the maxillary and mandibular composite models

respectively. The maxilla was advanced 6mm and impacted 1mm anteriorly. Differential impaction was done on left (3mm on UL6) and right (1mm on UR6) hand sides to correct the occlusal cant. The mandible moved backward by 1mm and to the right side by 3mm for the scanned final occlusion.

The final surgical plan with simulation of both soft and hard tissue relationships was shown to the patient and discussed (Figure 6). Then, the working files were imported into 3-matic software (Materialise, Leuven, Belgium) to design the intermediate and final splints. These were 3D printed in biocompatible resin using a 3D printer (object 250, Stratasys).

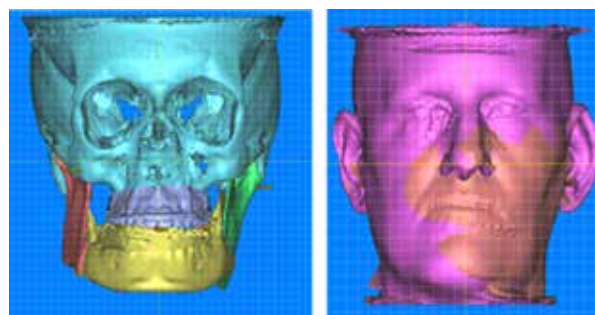


Figure 6. CBCT images of hard tissues (left) soft tissues (right) after virtual bimaxillary surgery

The actual bimaxillary surgery was done using the splints. After combined orthodontic and surgical treatment, there was a marked improvement in jaw relationship and occlusion. The patient was highly contented with the result (Figure 7)



Figure 7. Post-operative facial, cephalometric and intraoral views

Case 3

A 21 year old male reported complaining of a deviated lower jaw. He had Class II division 1 incisor relationship with average vertical proportions. The malocclusion was complicated by severe facial asymmetry with deficiency of left side mandible and chin shifted to the

same side (Figure 8). He had multiple missing teeth posterior to the lower left canine and severely proclined lower labial segment. The mandibular deficiency was secondary to facial trauma during his childhood. His temporomandibular joint function was satisfactory.

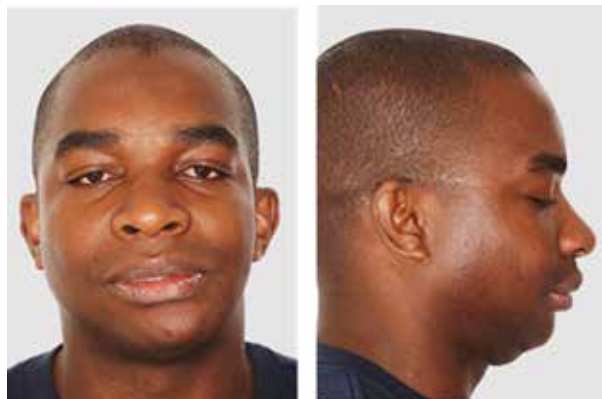


Figure 8. Pre-treatment facial views

Based on the clinical examination and radiographic findings it was decided that the patient would benefit from combined orthodontics, orthognathic surgery and reconstruction of deficient left side of the mandible. The orthodontic treatment plan included fixed appliance treatment for alignment of teeth and coordination of dental arches for final occlusion. The orthognathic surgical plan was Le Fort 1 osteotomy of maxilla and bilateral sagittal split osteotomy of the mandible

Treatment proceeded with fixed orthodontic appliance (MBT prescription, slot size 0.022"x0.028") which resulted in good alignment and arch coordination in 13 months.

CBCT of the head was obtained and converted into 3D virtual model as previously described. Upper and lower e teeth were amalgamated with the 3D images (Figure 9).

Virtual Le Fort 1 (3 mm maxillary advancement, 3 mm rotation of upper centreline to the left and 1.5mm anterior down fracture) and BSSO (6.5 mm advancement and 2 mm rotation of lower midline to the right) were performed as previously described. The final maxillary and mandibular positions were imported into design software (3-Matic; Materialise), and intermediate and final wafers were designed and printed in biocompatible resin.

Following bimaxillary virtual planning of orthognathic surgery, reconstruction of the deficient left side of the mandible was planned virtually. The mirror image of the normal right side of the mandible was moved to match

the remaining left side of the mandible until maximum symmetry was achieved. Then, the virtual designing of reconstruction plate and guides for screw placement were carried out using the same software. Finally, the plate and the guides were printed with titanium and resin respectively (Figure 10).

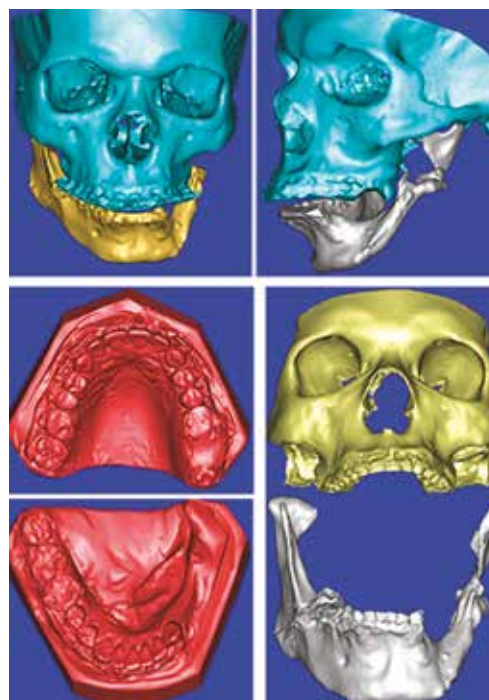


Figure 9. CBCT showing deficient left side of the mandible and noise and scatter around teeth (top). Scanned upper and dental casts (bottom left) and CBCT images amalgamated with e-teeth (bottom right)

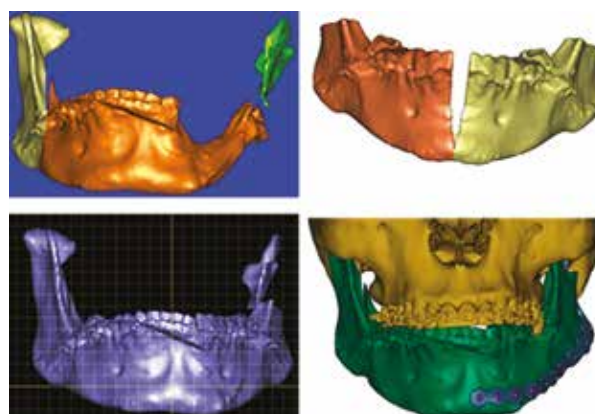


Figure 10. 3D reconstruction of mandibular deficiency; Mandible after virtual BSSO (top left), mirror imaging of normal side to deficient side (Top right), symmetry achieved (bottom left) and virtually reconstructed plate (bottom right)

Bimaxillary surgery was done as planned using the splints. The titanium plate was fixed to body and the

condyle of the deficient side of the mandible. The fixation screw guides were used for accurate positioning of the plate. Then, a bone was graft harvested from iliac crest and secured to the titanium plate with titanium screws at the body of the mandible. This was for future dental rehabilitation with osseointegrated implants.

There were no intraoperative or post-operative complications. The patient was satisfied with the aesthetic and functional outcome (Figure 11).



Figure 11. Post-treatment facial views

Discussion

Conventional planning has been the most commonly used method of orthognathic surgical planning before development of the virtual planning. It has been used for more than 50 years with good and reliable outcomes⁶. However, this requires an extensive radiographic analysis, dental model fabrication and surgical splint preparation which require an extensive time commitment, and a firm grasp of dental material⁷.

The lateral cephalometric radiograph used in this technique is a 2D (two-dimensional) representation of a 3D object and therefore has diagnostic limitations. When using semi adjustable articulators, models are articulated using a face bow recording to determine position of maxilla to condyle hinge axis. It is also an aid for vertical positioning of the maxilla with respect to a chosen horizontal plane of reference⁵. However, customary use of semi-adjustable articulators and a facebow in orthognathic surgical planning has been debated⁸. The mandibular rotational axis is not located in the mid-condylar head (and hence the articulator condylar axis), but is typically more than 2 cm posterior and 1–2 cm inferior to this site^{9,10}. This variation in the location of the centre of mandibular rotation causes clinically significant errors in the horizontal maxillary position with simulated maxillary impaction movements¹¹. Such articulator errors are compounded

by errors in the facebow recording due to inaccurate orientation of the maxillary model relative to the Frankfort (horizontal reference) plane¹². This results in inaccurate splint fabrication leading to incorrect surgical movements compromising the outcome¹².

Furthermore Mock surgery on dental casts is only a partial view of the actual surgery and is a repositioning of the dentition to the desired position to make a splint. Therefore, in conventional orthognathic surgical planning, positioning of craniofacial complex is loosely made through an estimation of the casts to the lateral cephalometric radiograph¹.

The first case described here is a good example to describe conventional planning. Since surgical movement is only in anteroposterior direction and is relatively straightforward, there was no need for 3D planning. In an academic institution with trainees and maxillofacial technicians, the traditional method is neither time or cost restrictive. In fact, it is found to be highly educational and informative. It allows the new surgeon to have an outstanding spatial relationship of the 3-dimensional movements necessary to perform successful orthognathic surgery, which will facilitate their true intraoperative experience⁷.

Recent advances in CBCT as well as CAD/CAM technology have led to an emergence of several computer-assisted surgical simulation software programs with a wide range of applications¹³. One of the main advantages of 3D planning over conventional planning is the ability of the clinician to visualize the dental arch, bony skeleton, and the soft tissues and thereby obtain more information of the anatomy of the area of interests. It enables practitioners to focus more on facial harmonization in all 3 planes rather than on the facial profile³. It can also quantify dental cant, yaw deformities, and other facial asymmetries that would have been otherwise undetected in physical examination, 2D lateral cephalometric analysis, and in conventional orthognathic planning^{3, 13,14}. The assessment of the deviation of dental midlines from facial midlines and the position of the chin are much more difficult clinically in the presence of facial asymmetry or occlusal plane tilting³. This can be fulfilled easily and more accurately with 3D planning³. This technique has shown similar precision to surgical planning in a semi-adjustable articulator⁶ and significantly less laboratory time involvement than conventional planning². Due to the complete digitization of the treatment plan, virtual planning offers many other important advantages over conventional treatment planning. Treatment plans can

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Intra oral characteristics of a series of Oculo-Auricular-Vertebral (OAV) Spectrum patients referred to the Lady Ridgeway Hospital for children, Sri Lanka.

Azeez MA¹, Wanninayake WMDAS², Basnayake AS³, Gunasekera R⁴, Yasawardene S⁵, Jayathilake M⁶, Nilini DDC⁷, Deepthi de Silva⁸

1. Senior Registrar in Orthodontics, Lady Ridgeway Hospital for Children, Colombo
2. Demonstrator, Department of Physiology, Faculty of Medicine, University of Kelaniya
3. Consultant Orthodontist, Lady Ridgeway Hospital for Children, Colombo
4. Consultant Plastic Surgeon, Lady Ridgeway Hospital for Children, Colombo
5. Consultant ENT Surgeon, Lady Ridgeway Hospital for Children, Colombo
6. Speech and Language Therapist, Lady Ridgeway Hospital for Children, Colombo
7. Research Assistant
8. Professor in Medical Genetics, Department of Physiology, Faculty of Medicine, University of Kelaniya

Introduction

The Oculo- Auricular-Vertebral (OAV) spectrum is a well-recognized but rare congenital malformation syndrome associated abnormalities involving the first and second branchial arches. It has a reported prevalence is between 1 in 3500 to 1 in 5600 live births although its prevalence in Sri Lanka is not known. The asymmetric involvement of the eye (especially causing epibulbar dermoids), variable ear malformations (varying from microtia and anotia to minor malformations and preauricular tags) and vertebral involvement (varying from bifid and hemivertebrae to major spinal anomalies associated with scoliosis) are its cardinal features. Many affected cases also demonstrate hemifacial microsomia, macrostomia, cleft lip and or palate, cranial nerve palsies (especially the VIIth nerves) and maxillary and mandibular hypoplasia. Other anomalies that have been identified frequently include congenital cardiac malformations, renal structural anomalies and limb malformations. There is a reported male predilection of 3:2 reported in the literature.

The OAV spectrum encompasses the spectrum of hemifacial microsomia, microtia +/- skin tags and the Goldenhar syndrome(GS) (Fig 1). The GS which was first described in 1845 by Carl Ferdinand Von Arlt, although Maurice Goldenhar was given the credit for describing various characteristic features in 1952 and Robert Gorlin coined the term OAV Spectrum in 1963.



(Fig 1) Features of OVA

The aetiology of OAV is unknown with both environment and genetic factors being implicated. The majority of Goldenhar syndrome cases are sporadic but some reports suggest variable autosomal dominant inheritance and the report of association with consanguineous marriage also suggests the possibility of autosomal recessive inheritance. Teratogenic factors associated with OAV include maternal diabetes and maternal infections (rubella and influenza).

This paper endeavors to describe the intra oral features of OAV patients referred to Lady Ridgeway Hospital and briefly review the literature associated with OAV spectrum

Methodology

A group of OAV cases (n=40) referred to a clinical geneticist between January 2009 and June 2017 were identified and invited to attend for a review appointment. Of these fourteen (n=14) patients attended the review appointment. They were examined both for extra oral and intra oral features. Intra oral features included soft and hard tissue analysis. The examination was performed by an orthodontist.

Results

There were six males (43%) and eight females with an age range of 7 months to 14 years. 0 patients were identified as having OAV spectrum during this period of which 14 responded to the recall visit. The age range among these 14 patients were and comprised of 6 males and 8 females.

Extra oral examination (Table 1)

Eleven patients (78%) demonstrated varying degrees of facial asymmetry with nine cases (64%) having predominantly right sided hemifacial microsomia and the remainder being left sided. Nine cases (64%) had a convex soft tissue profile, 5 (35%) had a flat profile while none had a concave facial profile. Five cases (35%) showed malar flattening including one patient having bilateral malar flattening.

One cases had a repaired cleft lip and palate. Macrostomia was noted in 7 patients (50%). Only one patient complained of temporo-mandibular joint pain while 11 patients (78%) had no TMJ symptoms. Two cases were too young to elicit any disorder. Mandibular path of closure was normal in 3 patients (21%) while 1 (7%) had displacement and 9 (64%) showed a degree of deflection to the defective side.

On assessment of skeletal relationships, 7 (50%) were class I, 5 (35%) were class II and 2 (14%) were class III. Ten patients (71%) had a significant reduction of ramus height on the affected side and one (7%) had bilateral shortening of the ramus which led to a severe class II malocclusion.

Vertical assessment revealed that 10 (71%) had an average FMPS value while 3 were (21%) high angle, whereas 1 (7%) patient was a low angle case.

Three cases (21%) had incompetent lips on lip competency evaluation.

Intra oral examination (Table 2)

Nine patients (64%) had a normal sized tongue with macroglossia seen in 2 patients (14%), a small tongue in 2 (14%) cases and a hyperactive tongue in one case. None of the patients demonstrated any restriction of tongue movements.

Hard tissue analysis revealed that 6 patients were in their deciduous dentition and 8 were in mixed dentition. Three children (21%) were identified as having delayed tooth eruption when compared with norms for chronology of tooth eruption.

Maxillary canting was assessed and 5 patients (35%) showed positive discrepancy for canting of the maxillary dentition.

When analysis for malocclusion was performed, 6 (42%) had a Class I type of malocclusion, 3 (21%) a Class II division 1 malocclusion and 2 patients (14%) showed a Class III trait. None demonstrated traits of a Class II division 2 type of malocclusion.

Among other features were anterior crossbites in 3 (21%), 2 (14%) showed posterior crossbites, three had an increased overjet (21%) and 2 (14%) had reduced overjet while 5 were normal (35%). A proper overjet measurement was unable to be taken in 4 patients owing to exfoliation of deciduous or unerupted permanent central incisors.

The overbite was also evaluated and 2 had an anterior open bite, 2 had reduced overbite, 2 (14%) showed deep bite and 5 (35%) had a normal overbite. In 3 patients it was not possible to assess the degree of the overbite. One patient had supernumerary teeth, 1 had a double tooth and 1 had hypodontia.

Speech assessment demonstrated that 10 patients (71%) had normal speech, 2 (14%) cases had nasality while 2 were too young to be assessed.

Breathing patterns analysis revealed only one case to be a mouth breather. All 14 patients showed satisfactory periodontal condition while caries assessment showed 8 patients (57%) who had some degree of caries and restorations.

Table 1 - Extra Oral Examination

Patient Number

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Male/Female	F	F	F	F	F	M	M	M	M	M	F	M	F	F
Age (Years)	7	6	10	7	14	4	2	4	7/12	7	9	5	1	4
Facial Asymmetry	-	+	+	+	+	-	+	+	+	+	+	+	+	-
Profile	Flat	Flat	Flat	Convex	Convex	Convex	Convex	Convex	Convex	Convex	Convex	Convex	Flat	Flat
Malar flattening	-	+	+	+	-	-	-	+	-	-	+	-	-	-
Macrostomia	-	-	-	-	+	+	+	-	-	-	+	+	-	+
Microstomia	-	-	-	-	-	-	-	-	-	+	-	-	-	-
TMJ Symptoms	-	-	-	+	-	-	-	-	NE	-	-	-	NE	-
Abnormal Mandibular Closure	-	+	+	+	+	-	+	+	NE	+	+	+	+	-
Abnormal Ramus Height	-	+	+	+	+	+	+	+	NE	-	+	+	-	-
Skeletal Relationship (Class)	I	III	III	I	I	II	I	I	II	I	II	II	I	II
FMPA	Avg	High	High	Avg	Avg	High	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Low
Lip Incompetency	-	-	-	-	-	+	-	-	NE	+	-	+	NE	-
Speech Nasality	-	+	-	-	-	-	-	-	NE	+	-	-	NE	-
Mouth Breathing	-	-	-	-	-	-	-	-	+	-	-	-	NE	-

NE – Not Examined

Table 2 - Intra Oral Examination

	Patient Number													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cleft Lip and Palate	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Macroglossia	-	-	-	-	+	-	-	-	-	-	+	-	NE	-
Microglossia	-	+	-	-	-	-	-	-	-	-	-	+	NE	-
Abnormal Tongue Movements	-	-	-	-	-	-	-	-	-	-	-	+	NE	-
Teeth Abnormalities	-	-	-	-	-	-	-	-	-	-	+	+	-	-
Carious Teeth	+	+	+	+	-	-	+	-	-	+	+	-	-	-
Good Periodontal Health	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Anterior Crossbite	-	-	+	+	+	-	-	-	-	-	+	-	-	-
Posterior Crossbite	-	-	+	-	-	+	-	-	-	-	-	-	-	-
Anterior Openbite/ Reduced Overbite	-	+	-	-	+	+	-	-	-	-	-	-	+	-
Deep Overbite	-	-	-	-	-	-	-	-	-	-	+	+	-	-
Increased Overjet	-	-	-	-	-	-	-	-	-	-	+	+	-	-
Decreased Overjet	-	+	-	-	+	-	-	-	-	+	-	-	-	-
Midline Deviations	-	+	+	+	+	-	-	-	-	+	-	+	-	-
Maxillary Canting	-	+	+	-	+	-	-	+	-	-	+	+	-	-

NE – Not Examined

Discussion

Although the external manifestations of the OAV spectrum are evident at birth and lead to the diagnosis of this condition, the intraoral manifestation becomes more evident with growth of the child. The oral manifestations are a reflection of the reduced growth especially in the upper and lower jaws which lead to malocclusions as was observed in this small series of cases. The other problem that can be caused by this is breathing difficulty but this was not commonly observed in these cases.

Most of our patients demonstrated facial asymmetry and maxillary and mandibular as per the literature. Khawaja et al (2016) states that orthopaedic symptoms of orofacial pain and dysfunction have not generally been considered part of Goldenhar Syndrome complex. Our cases had no symptoms of orofacial pain except for one patient complaining of TMJ pain. Martelli et al (2010) reported orofacial features of 6 patients and out of them 2 (34%) were cleft lip and palate patients and one patient had temporomandibular disorder. Our series of patient showed only one (7%) with cleft lip and palate which was repaired. This tallies with the figure quoted in the literature which is 7 - 25% as reported by Tasse et al in 2005.

The hypoplastic maxilla or mandible have been reported to require surgical correction using distraction osteogenesis with possible bone grafting although none of the cases in this series required this surgery. Chauhan and Guruprasad (2015) mentioned about a Goldenhar Syndrome case with Tessier's 7 cleft of the lateral face which required Distraction Osteogenesis for correction.

Ashokan et al (2014) states that Goldenhar Syndrome like features can be seen in Treacher - Collins syndrome as well. However in Treacher - Collins the facial presentation is very symmetrical unlike in Goldenhar Syndrome. Also Treacher - Collins syndrome does not show any ocular defects. Other rare syndromes that may need differential diagnosis are Wolf - Hirschhorn Syndrome, Townes - Brocks Syndrome and Delleman Syndrome.

These cases had reasonable levels of dental hygiene as this is essential prior to offering interceptive orthodontics.

The multiplicity of the malformations and their variability makes it necessary for this condition to be diagnosed early and for assessment by a multidisciplinary team including orthodontists in order to monitor the development or progress of intra oral pathologies and plan for appropriate interventions. Other members of the team may include ENT surgeon, plastic surgeon, clinical geneticists and speech and language therapists.

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PREDICTABLE RESULTS USING CLEAR ALIGNERS: CASE REPORTS

Inderpreet Singh¹, Sana Bint Aziz², Gurkeerat Singh³

1. New Delhi,

2. Department of Orthodontics, Sudha Rustagi College of Dental Sciences and Research,

3. Faridabad, Department of Orthodontics Sudha Rustagi College of Dental Sciences & Research, Faridabad

Abstract:

Clear aligners have become the treatment of choice for treating mild to moderate malocclusions in patients who are concerned for esthetics compromise of fixed orthodontic appliance treatment. Two case reports are presented to demonstrate the effectiveness of clear aligners in resolving crowding due to orthodontic relapse and spacing in the anterior teeth region. In both the cases, predicted results were achieved using clear aligners which was simple and convenient for both the patient and the clinician.

Keywords: Clear aligners, Relapse, Crowding, Midline diastema, Relapse

Introduction:

The introduction of clear aligners has added a new dimension to orthodontic treatment worldwide. Patients who would never accept the aesthetic and/or functional compromise of fixed orthodontic appliances may be offered a more comfortable option with significant dental health advantages¹. Clear aligners were introduced by Align Technology (San Jose, California, USA) marketed as "Invisalign"™ in 2000 and the majority of the published data revolves around this brand. With the advent of 3D printing and more predictable software additional companies are now entering the market. Initially aligners were not capable of controlling root movement and more complex tooth movement but advances in design and placement of bonded composite attachments have seen expansion of the range of tooth movement over substantial distances². Experienced clinicians have found that clear aligner therapy for more complex treatment needs often fails to yield the same degree of precision anticipated with fixed appliances. This necessitates more careful case selection and counselling when offering this treatment to patients. Two suitable cases are presented, illustrating the ease and simplicity with which clear aligners could resolve the malocclusion in patients who refused fixed orthodontic alternatives.

Case Report 1:

A 21 year old female patient presented with relapse of her malocclusion two years after cessation of removable retainer wear after treatment with full fixed appliances involving extraction of all first pre-molars. The patient was now in college and did not want re-treatment with fixed appliance. She presented with Class I molar and canine relationship and mild upper and lower crowding (Fig.1). Initial records were taken and the case logged onto the K-line (K Line Europe, Lileinthalstr 74, 40474 Dusseldorf, Germany) portal. It was decided to resolve the anterior crowding in both the arches using "K line" clear aligner therapy (Fig.2). 0.2 mm interproximal reduction (IPR) was performed in the mandibular anterior segment, per contact, to facilitate unravelling of the crowding. The patient was instructed to wear the appliance all the time and only remove it while eating, drinking and toothbrushing or flossing. At the end of the treatment, the crowding had completely resolved in both the arches and the canines and molars were maintained in a Class I relationship. The patient was satisfied with the outcome (Fig.3) and a bonded lingual retainer (BLR) was placed in both the arches for retention (Fig.3).

Case 1

(Fig 1) Pre treatment records



Extra oral photographs



Intra Oral Photographs



Pre treatment OPG



Post treatment OPG

(Fig 2) During treatment Intra Oral Photographs



(Fig 3) Post treatment records



Extra Oral Photographs



Intra Oral Photographs

Case Report 2:

A 32 year old female patient presented with a chief complaint of spacing between her upper front teeth (Fig.4). The clinical examination revealed a midline diastema in the upper arch and spacing between the lower anterior teeth with Class 1 molar and canine relationship (Fig.4). Since the patient was esthetically demanding, K line clear aligner therapy was suggested to which she readily agreed. Her initial records were taken and uploaded to the "K line" portal (Fig.5). A 3D simulation of the treatment progress was presented and the treatment outcome was predicted (Fig.6). Attachments were placed on both the maxillary central incisors and all the first molars. Interproximal reduction (IPR) was performed in the lower arch according to the presented IPR estimate sheet (Fig.7). Aligners were delivered to the patient for 2 week intervals (Fig.8). The treatment took 10 months to close the anterior spaces (Fig.9) and deliver an esthetically pleasing smile to the patient (Fig.10). The position of the posterior teeth remained unchanged and the Class 1 molar and canine relationship was maintained while the anteriors were retracted to close the anterior spaces. Bonded lingual retainers (BLR) were placed in both arches at the end of the treatment. The patient was satisfied and happy to have received an esthetic as well as comfortable solution to close the anterior spaces without braces.

(Fig 4) Pre- treatment photographs



Extra oral Photographs

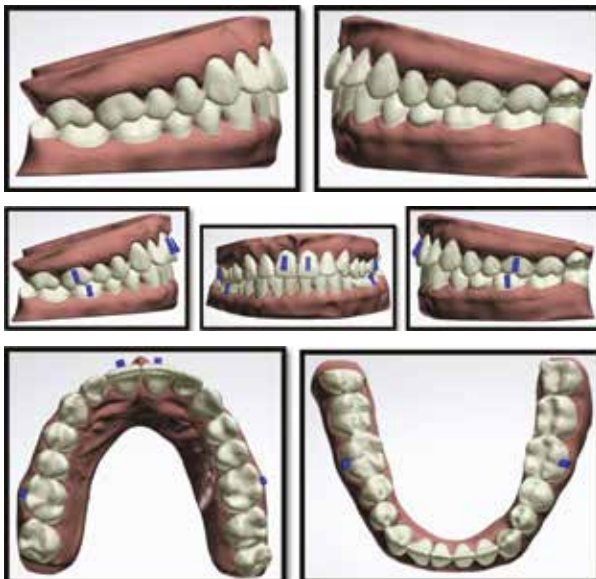


Intra Oral photographs

(Fig 5) Pre- treatment digital models



(Fig.6) Predicted treatment outcome generated by computer with attachments



(Fig.7) IPR done

		IPR ESTIMATE																			
		Upper Right										Upper Left									
		16	15	14	13	12	11	21	22	23	24	25	26								
		D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M
aligner number																					
IPR in mm																					
aligner number																					
IPR in mm																					
aligner number																					
IPR in mm																					
		Lower Right										Lower Left									
		46	45	44	43	42	41	31	32	33	34	35	36								
		D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M
aligner number																					
IPR in mm																					
aligner number																					
IPR in mm																					
aligner number																					
IPR in mm																					

(Fig 8) Kline Clear aligner inserted



(Fig. 9) Post treatment intra oral photographs



Before

After

(Fig 10) Comparison of smile before and after the treatment

Discussion:

Clear aligner therapy was introduced to resolve minor tooth irregularity and treat problems of orthodontic relapse.³ Clear aligners have become a treatment of choice for esthetically concerned patients who do not want fixed appliance treatment and present with mild to moderate crowding, spacing or relapse problems. In this study, a case of mild crowding due to orthodontic relapse was successfully treated using K line clear aligners. It was convenient and simple to treat the relapse problem with aligners and the treatment did not take more than 5 months to completely resolve the problem. A second case of spacing, where the patient did not want fixed orthodontic treatment, was managed easily with aligners. Moreover, with use of this appliance, excellent patient cooperation with minimal discomfort, better esthetics and oral hygiene was experienced when compared to fixed appliances. The point that needs to be mentioned here is patient compliance and the initial diagnosis of the case. The diagnosis of the individual case is paramount and it cannot be delegated to a lab or technician. For the success of cases treated with the clear aligner systems both patient cooperation as well as a correct diagnosis is essential.

The cases presented here show the efficacy of aligners in managing mild to moderate malocclusions. Boyd et al⁴ successfully treated similar malocclusions which involved mild to moderate crowding and space closure using the Invisalign* system. However, there are currently some limitations to the clear aligner appliance regarding case selection, cost, experience for computer treatment planning, difficulty in certain tooth movements and cases involving the mixed dentition or impacted teeth.⁵ According to Duncan¹, quality results with aligners can be achieved if attention is given to case selection, treatment planning, software modifications, clinical management and resolving treatment tracking issues. With the innovation of new attachments, advances in material science and the detailed analysis and comprehension of outcomes from specific strategies, , the scope of aligners will most likely expand for correcting more complex cases involving rotations, deep bites, open bites and unusual extractions in the near future.⁶

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Mini-implants for the management of vertical maxillary excess: A case report.

Parekh Chandani¹, Vandekar Meghna², Vaid Nikhilesh³

1. Former Resident, YMT Dental College & Hospital, Navi Mumbai, India

2. Professor & Chair, YMT Dental College & Hospital, Navi Mumbai, India.

3. Visiting Professor, European University, DHCC, Dubai, UAE.

Excessive gingival display during smiling, or gummy smile, is an aesthetic problem for some patients. It may result from a variety of etiological factors; therefore, proper diagnosis is critical before beginning the treatment.

In adults, when the gummy smile is caused by overgrowth of anterior vertical maxillary excess, the outcome may not always be successful by conventional orthodontic therapy alone. In such cases, surgical therapy, such as Le Fort impaction or maxillary gingivectomies, are often indicated to achieve a good smile. However, if patients are unwilling to undergo surgical treatment, an alternative method must be considered to treat the gummy smile.

Some investigators have shown successful intrusion of teeth with mini-implants as anchorage. Temporary anchorage devices (TADs) have changed the conventional conception of anchorage control and biomechanics in orthodontics. They have replaced many traditional types of mechanics and simplified orthodontic treatment. Lin et al.⁽¹⁾ demonstrated successful treatment of gummy smile patients using that skeletal anchorage.

The present clinical case describes the treatment of an adult patient with gummy smile using miniscrew anchorage

Diagnosis and etiology

An 18-year-old male patient presented with the chief complaint of gummy smile. The facial photographs showed excessive gingival display on smiling, slightly convex profile, and incompetent lip. When the patient smiled, he showed more than 4 mm of gingival exposure in the incisor region and more than 6 mm in the posterior region (Fig. 1).

The intraoral examination revealed Class I molar relationship on the left side and Class II relationship on the right side, mild mandibular arch crowding, 4-mm overjet, and moderately deep over bite, and the maxillary midline was deviated 3 mm to the right.



Fig. 1. Pre-treatment facial and intraoral photographs.

Cephalometric analysis showed a skeletal Class II relationship with an A point, nasion, B point angle (ANB) of 80 and an excess of dentoalveolar height on the molars and incisors. The McNamara analysis evidenced maxillary excess (A to nasion perpendicular [A-NPerp] 2 mm). Despite the dentoalveolar maxillary excess, the nasolabial angle was obtuse (nasolabial angle 94°). The mandible presented excessive length (condylion to the anatomic point Gnathion [Co-Gn] 120 mm, maxillomandibular difference of 23 mm) and was protruded in relation to the cranial base (from the pogonion to the nasion perpendicular [Pog-NPerp] 6 mm). However, this was masked by the LAFH, which was also very increased (Lower Anterior Facial Height [LAFH] 70 mm), thus contributing to the vertical pattern. The maxillary and mandibular incisors were buccally tipped and protruded (distance between the upper incisor tip and the nasion point A line [1-NA] = 7 mm, the angle between the upper incisor and nasion point A line [1:NA] 33°, distance between the lower incisor tip and the nasion point B line [1-NB] = 10 mm, the angle between the lower incisor and nasion point B line [1:NB] 35°, and Incisor Mandibular Plane Angle [IMPA] = 105°). The radiographic image is presented in Figure 2 and the cephalometric measurements in Table 1.



Fig. 2. Initial lateral cephalometric radiograph

PARAMETERS	PRE TREATMENT VALUE
SNA	82°
N Pr. To A (mm)	-2 mm
Eff. Mx. Length (mm)	89mm
SNB	74°
N Pr. To Pog (mm)	-16 mm
Eff. Mn Length (mm)	112 mm
ANB	8°
Mx – Mn diff (mm)	23mm
Beta angle	24°
Jarabak's Ratio (%)	68.9%
LAFH	70 mm
U. Incisor to NA (deg/mm)	33°/7 mm
L. Incisor to NB (deg/mm)	35°/10 mm
L. Incisor to mandibular plane	105°

Table 1

Cephalometric summary

ANB, A point, nasion, B point angle; A-NPerp, A to nasion perpendicular; Co, Condylion; LAFH, Lower Anterior Facial Height; FH, Frankfort horizontal plane; FMA, Frankfort mandibular plane angle; FMIA, Frankfort Mandibular Incisor Angle; Gn, gnathion; Go, gonial; IMPA, incisor to mandibular plane angle; LI, lower lip; LS, upper lip; NA, nasion point A; NB, nasion point B;; Pog, pogonion; SNA, sella nasion point A; SNB, sella nasion point B

Treatment objectives

The treatment objectives were

- 1) to reduce the gummy smile and protruded profile, and
- 2) to additionally distalize the maxillary right teeth, which was needed to correct the maxillary midline and obtain a good functional Class I molar and canine relationship.

Treatment alternatives

Two alternatives were presented to the patient to eliminate the gummy smile:

- 1) extract the left first premolar to achieve a canine Class I relationship and correct the dental midline, followed by maxillary impaction orthognathic surgery to eliminate the gummy smile and improve the profile; or
- 2) extract the maxillary first premolars and the mandibular second premolars, and use mini-implants as anchorage for retraction and intrusion.

After a review of the risks and benefits of the two options, the patient chose the more conservative method. The second alternative was elected because of some advantages of being less invasive and requiring a shorter treatment time.

Treatment progress

Maxillary first molars were banded with buccal tubes and lingual convertible tubes for a removable transpalatal arch. Transpalatal and lingual arches were placed to counteract buccal crown tipping toward the mini-implants. Mandibular first molars were banded and fixed; preadjusted edgewise appliances with 0.022 x 0.028-inch slot brackets were bonded in the remaining teeth.

Both arches were then aligned and leveled beginning with 0.012-inch nickel-titanium archwires up to 0.019 x 0.025-inch stainless steel archwires. At that time, the maxillary arch was changed for a 0.021 x 0.025-inch stainless steel wire and the transpalatal arch was adjusted in place (Figure 3 and 4).



Fig. 3. Post Levelling and Aligning facial and intraoral photographs.



Fig. 4. Post Space Closure facial and intraoral photographs.

Then, two mini-implants were placed between the maxillary central and lateral incisors and two between the maxillary first molar and second premolars (1.8 mm in diameter and 6 mm in length (Fig. 5). An intrusive force of 100g in the anterior region and 150g (2) in the posterior region was applied by E- chain from the mini-implants to the maxillary archwire. Also, active modules were tied to the archwire straight were tied with a posterior vector of force to intrude and distalize the teeth.

The objective of the full slot maxillary archwire in conjunction with the transpalatal arch was to control the tendency of maxillary teeth to incline in the buccal direction due to the force of coil springs from the mini-implants. The transpalatal arch was contracted and reinserted in the palatal tubes to annul the buccal

moment generated by the force of the coils. The transpalatal arch was also adjusted to allow posterior movement of the left teeth. After adequate intrusion to eliminate the gummy smile after 12 months, the right side Class II was nearly corrected and Class II elastics were necessary to conclude the anteroposterior correction on that side. Intermaxillary elastics were applied with 0.018-inch stainless steel wires in the brackets for better interdigitation of occlusion. The mini-implants remained stable during treatment and were removed under topical anesthesia.



Fig. 5. Mechanics For Maxillary Impaction And Distalization Using Microimplants.

After debonding and debanding, a removable Begg wrap around retainer was placed. The total active treatment time was 32 months (Figs. 6 and 7).



Fig. 6 Post Treatment facial and intraoral photographs



Fig. 7 Begg's Wrap around retainer for both maxillary and mandibular arch

Treatment results

The gummy smile was nearly corrected, and in full smile view, the patient showed no more than 1 to 2 mm of gingiva. The post-treatment photographs and dental casts demonstrated Class I canine and molar relationships with normal over bite and overjet, and the dental midlines were coincident to each other and with the facial midline. The cephalometric analysis and superimposition showed intrusion and distalization of maxillary molars, which caused self-rotation of the mandible. The maxillary incisors were intruded and retracted. The maxillary anterior alveolar bone and gingiva were moved lingually and upward by tooth movement (Fig 9). The post-treatment cephalogram (Fig. 8) evidenced acceptable parameters compatible with the extent of movement.



Fig. 8. Final lateral cephalometric radiograph

Discussion

In this case, the mini-implants remained stable during the time of intrusive force application (12 months) (Fig. 5). The treatment time (32 months) was a little longer because of one-half Class II correction on the right side. The molar was distalized to correct the one-half Class II and intruded (Fig. 9). The mandible presented counter clockwise rotation during treatment, as observed on the tracing at treatment completion (red line). The protruded profile was straightened with this movement (Fig. 9). In an ideal situation, about 1 to 2 mm of gingiva will be apparent when the patient smiles (Fig. 6).



Fig. 9. Superimposition

Excessive gingival display can be divided into several categories according to etiologic factors (3-4). The patient presented lip incompetence at treatment onset (Fig. 1). Many factors are involved in lip protrusion, and it is obvious that the amount of protrusion can be controlled by various orthodontic and surgical procedures. Retracting or protracting the incisors surgically or orthodontically can achieve concordant lip position. Superimpositions of pre-treatment and post-treatment cephalometric tracings showed significant improvement in teeth inclinations and angulations.

When gummy smile is found in adults with long-face syndrome, caused by excessive vertical maxillary growth, orthognathic surgery is generally required to intrude the maxilla and eliminate the excessive gingival display. The increase in vertical facial height may be confirmed by cephalometric analysis. Specifically in this patient, the LAFH was 70 at treatment onset. Potential risks of jaw surgery include excessive hemorrhage, infection, loss of tooth vitality, and periodontal loss, as well as risks inherent to anesthesia. Because the risks and treatment costs could be high, our patient was reluctant to undergo surgery. He was willing to accept a compromised result.

This case report demonstrated that the use of miniscrew anchorage for maxillary intrusion is a viable alternative to orthognathic surgery for some patients who present with the chief complaint of gummy smile and who refuse surgery. Minimal patient cooperation (5) was required

except for good oral hygiene. The mini-implants remained stable during all the active treatment time and were demonstrated to be an adequate anchorage option for the orthodontic treatment of an adult patient with gummy smile.

Conclusions

The maxillary molars were intruded and distalized to correct the maxillary midline and obtain a good functional Class I molar and canine relationship. The maxillary incisors were intruded and retracted, allowing the alveolar bone and gingiva to move lingually and upward by tooth movement.

The treatment objectives were achieved with reduction of the gummy smile and protruded profile. Individualized diagnosis and treatment planning are essential to appropriately address each patient's needs and goals.

Each patient should be individually evaluated to determine if a nonsurgical approach may provide acceptable correction. The orthodontic treatment with skeletal anchorage cannot replace orthognathic surgery; however, considering the costs and risks of surgery, it may be used as an alternative for selected cases and if a patient refuses surgery, as demonstrated in this successful case of correction.

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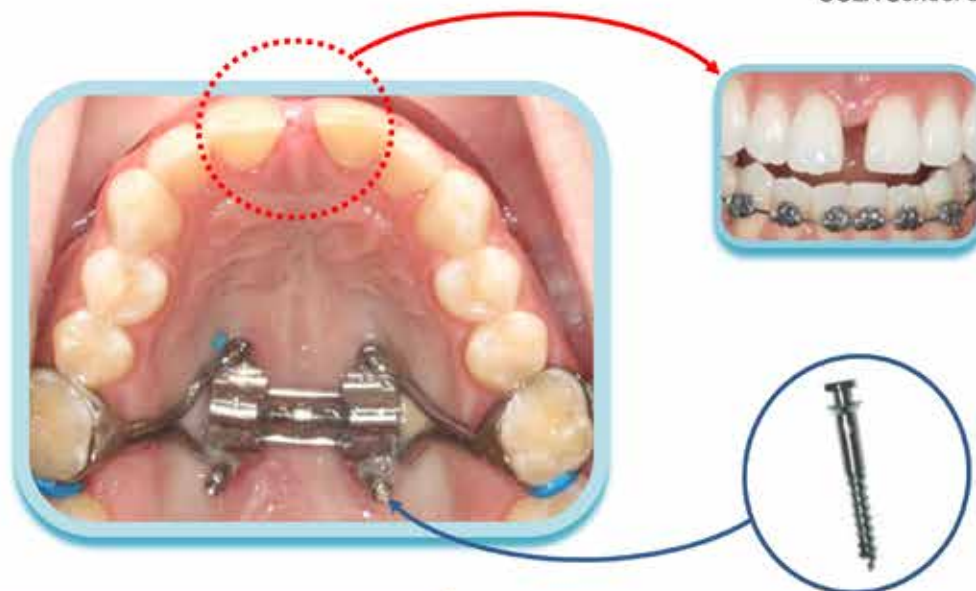
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UCLA School of Dentistry



Components

Item	Qty	Description
	1	M.S.E.
	4	Micro-Implant
	1	Mini Hand Driver
	1	Long Engine Blade
	1	Short Engine Blade

<M.S.E. Specification>

(mm)

Width	Length	Thickness	Arms diam.	Expansion screw diam.
15.0	15.2	3.5	1.5	0.8

*Maximum expansion : 8 mm / 11 mm

*Total number of turns for maximum expansion : 38 turns (*8 mm)
50 turns (*11 mm)

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Miniscrew Implant Supported K-Loop (MISK) Spring for molar distalization.

Prabhat Kumar Chaudhari¹, Sandhya Maheshwari², Saba Khan³, Om Prakash Kharbanda⁴

1. Assistant Professor, Division of Orthodontics and Dentofacial Deformities, Centre for Dental Education and Research (CDER), All India Institute of Medical Sciences (AIIMS), New Delhi- 110029. INDIA.
2. Professor, Department of Orthodontics and Dentofacial Orthopaedics, Aligarh Muslim University, Aligarh-202001, India.
3. Assistant Professor , Department of Orthodontics and Dentofacial Orthopaedics, Aligarh Muslim University, Aligarh-202001, India.
4. Professor and Head, Division of Orthodontics and Dentofacial Deformities, Centre for Dental Education and Research (CDER), All India Institute of Medical Sciences (AIIMS), New Delhi- 110029. INDIA.

Abstract:

This paper deals with the introduction of a treatment modality for maxillary molar distalization using Miniscrew Implant Supported K-Loop (MISK) spring. The MISK spring consist of one active unit and one anchorage unit. The active unit uses K-loop spring attached bilaterally or unilaterally as needed between first molar tube and first premolar bracket. The premolar arm of the K-loop spring extended vertically for its attachment with anchorage unit to provide anchorage for molar distalization. The anchorage unit uses miniscrew implant. A typodont model was prepared to evaluate the effectiveness of MISK spring. Subsequently, MISK spring was tested for efficacy in a case. It was found that the MISK spring is efficient in distalization of maxillary molars.

Key words: Molar distalization, K-loop spring, Miniscrew implant.

Introduction:

Non-extraction treatment with intra-oral maxillary molar distalization has been in practice with buccal or palatal approach. Recent systematic reviews¹⁻² concluded that Pendulum appliance is most commonly used appliance among all appliances for intraoral molar distalization with Nance button and its variation for anchorage reinforcement, but it was not enough to neutralize the side effects of the anchorage loss and anterior anchorage loss are always critical with molar distalization appliances. Net amount of molar distalization utilizing conventional anchorage ranges from 40 to 80%.³ Recent study by Kinzinger et al using miniscrew-supported periodontal anchorage of the skeletonized distal jet showed that skeletal anchorage allows greater molar distalization in the total movement as 86.56 to 91.71%.³ This study signifies the efficacy of skeletal anchorage for intraoral molar distalization as an treatment alternatives to conventional anchorage. Palatal intraoral molar distalizing appliance apply distalization force closer to centre of resistance of molars, the molar experience therapeutically undesired mesio-palatal and disto-buccal rotation.

By changing the movement to force ratio with K-loop⁴ spring it is possible to achieve control tipping, uncontrolled tipping or bodily movement of maxillary molar depending upon the requirement of each case. But anterior anchorage was always critical with K-loop spring appliance. We have modified the premolar arm of the K-loop spring by extending it vertically for its attachment with miniscrew implant to make an innovative anchorage design to provide absolute anchorage for molar distalization. Through this paper we have tried to highlight a treatment modality for maxillary molar distalization using Miniscrew Implant Supported K-Loop (MISK) spring for nonextraction treatment of patients with a Class II malocclusion without proclination and mesial movement of the anterior teeth.

Materials and Methods:

Fabrication of MISK-spring:

The MISK spring consists of one active unit and one anchorage unit. The active unit uses K-loop spring attached bilaterally or unilaterally as needed between first molar tube and first premolar bracket. The premolar arm of the K-loop spring extended vertically for its attachment with anchorage unit to provide anchorage for molar distalization (Fig. 1A). The anchorage unit uses miniscrew implants in the buccal alveolar bone between maxillary first premolar and canine (or between premolars) for absolute anchorage to resist the anteriorly directed force on anterior teeth during molar distalization (Fig. 1A).



Figure 1: Miniscrew implant supported K-Loop spring;
A- Basic wire bending design placed on typodont model; B- Moment and force produce by MISK spring

Biomechanics of MISK spring:

K-loop spring consists of two vertical loops of 8mm length and 2mm in width separated by a 'V' bend in 0.017by 0.025 inch TMA wire. The legs of 'K' are bends down 20 degree. After compression of spring between 1st premolar and molar, it produces opposite forces on the molar and premolar below the centre of resistance of teeth. These forces produce the clockwise tipping on molar and the counter clockwise tipping on the 1st premolar. The 20 degree bend in the spring legs produce moments that counteract the tipping moments created by the force of appliance. These moments are reinforced by moment of 'V' bend in the spring as loop is squeezed into the place. Hence, molar is expected to undergo a translatory movement but no movement of premolar should occur as the premolar arm is attached to the miniscrew implant and the reciprocal forces are absorbed by miniscrew implant (Fig. 1B).

Typodont Study Model:

Typodont setup was prepared using prefabricated cold cure acrylic shells mounted on hinge articulator. Occlusion setup on typodont was done in wax with Class II molar and canine relation bilaterally and well aligned upper and lower teeth. The K-loop spring was placed between maxillary molars tube and 1st premolars bracket and the extended premolar arm of the K-loop spring is ligated in the bracket slot of

miniscrew implants (Fig. 2 A-E). The typodont was seated in a box with a heat lamp for 30 minutes to soften the wax, to allow movement on the typodont. This process provides simpler control on wax softening than using a water bath. Pattern and amount of tooth movement was accessed on typodont and it was found that maxillary first molars were distalize on both side by 4 mm (Fig. 3 A-E) measured at marginal ridges of molar and premolar, however amount of tipping could not be accessed.

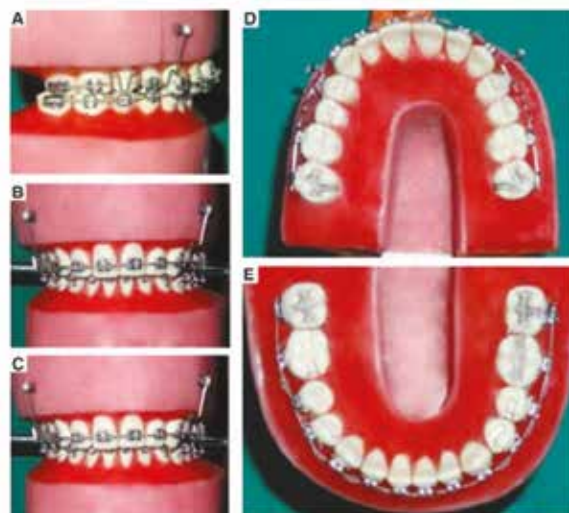


Figure 2: Class II malocclusion setup on typodont with MISK spring in place (A-E).



Figure 3: Maxillary molar distalization by MISK spring after lamp heating on typodont (A-E)

Clinical Report:

In this case (Fig. 4 A-B) the K-loop spring was placed between maxillary 1st molar tube and 2nd premolar bracket and the extended premolar arm of the K-loop spring was ligated with miniscrew implant between 1st and 2nd premolars. Under infiltration local anaesthesia,

titanium alloy miniscrew of 1.5-mm diameter and 8-mm length (SK Surgicals, Pune, Maharashtra, India) was inserted into the buccal alveolar bone between the right maxillary first and second premolars because there was not enough space in buccal alveolar bone between 1st premolar and canine. Treatment was continued for four months. It was found that the MISK spring provided correction of Class II molar relationship (Fig. 4 C-F) by distalization of right maxillary molar by 4mm measured at marginal ridges of molar and premolar.



Figure 4: Photographs and radiographs showing maxillary molar distalization using MISK spring (A-F).

Results:

Based on typodont study (Fig. 2&t3) and photographic (Fig. 4 A-D) and radiographic record (Fig. 4 E-F) of clinical case, it is concluded that the MISK spring effectively distalizes the maxillary molars to correct the Class II molar relationship by moving the maxillary molars distally.

Discussion:

In routine orthodontic practice Class II malocclusion is the one of the most frequently encountered malocclusion. Various orthodontic appliances like functional appliances, headgears, and multibracket fixed appliances with Class II elastics have been used for non-extraction treatment of Class II malocclusion. But both headgear and removable appliance need patient co-operation for successful orthodontic treatment.⁵⁻⁶

Pendulum and distal jet appliances also have been used for distalization with successful results but they have disadvantages of more laboratory time and high cost. Despite the use of different component in the design of Pendulum appliance to minimize the anchorage loss, anterior anchorage loss has been a problem with their use.^{1-2, 7} In recent years, Miniscrew implants have been used with intraoral molar distalization appliances to avoid anchorage loss.^{3, 8-10} Combining the findings of our typodont study and clinical report, it is suggested that MISK spring is effective in maxillary molar distalization without the disadvantages of anchorage loss associated with conventional molar distalization appliances. Regarding patient comfort, there was no

complaint by patient using the MISK spring, apart from difficulty with tooth brushing.

The limitation of this study was that the results cannot be claimed as valid predictor, due to the fact that natural tissue could not be simulated by typodont and MISK spring used in a single case. Hence clinical trial with large sample size will be needed to confirm the results with the quantification of amount of bodily movement and tipping for molar distalization. Based on limited evidence provided by this paper future trials should be designed, carried out and reported according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines for its wider application.¹¹

Conclusion:

It is concluded that the MISK spring effectively distalizes the maxillary molars to correct the Class II molar relationship in both typodont and clinical model by moving maxillary molars distally.

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TEMPLATE FOR POSTED ARCH WIRES

Rajaganesh A¹, Basnayake S¹

District General Hospital Negombo, Lady Ridgeway Hospital for Children Colombo

Stainless steel Posted arch wires are a very useful adjunct to the clinical orthodontist's armamentarium. They may be utilized during the retraction and space closing phases in orthodontic treatment. The pre-soldered posts provide support for attachment of elastics, springs and other auxiliaries. Valuable chair-side time is saved by eliminating the need to manually solder or crimp hooks or bend loops in the wire. These wires are supplied in various fixed inter-post distances for both maxillary and mandibular arches dependent on the inter-bracket distance for their placement.

Selecting the wire with the precise inter-post distance for each patient may prove tricky if a curved template is not available. Otherwise as the arch is curved a flexible ruler is necessary to make an accurate measurement of the inter-bracket distance of the patient. In the absence of a flexible ruler the clinician may have to guesstimate and try in many wires, which may result in contamination and the necessity for re-sterilization of the wire.

This simple template may save time and prevent wastage when selecting your posted wires in the future.

Firstly, on a blank paper trace out all the available posted wires in ascending order of inter-post distance measurement (Fig 1). Make sure to mark the post as well for each of your tracings (Fig 2). Once laminated a template is now ready to use. (Fig 3)

When a patient is ready for a posted wire, mark the existing wire in the desired location before wire removal (Fig 4). Then remove the marked wire and match the markings with the template to select the precise wire with the necessary inter-post distance (Fig 5).

the appropriate wire may then be selected for the packet (Fig 6).

This is a simple method that can be done by your assistant.

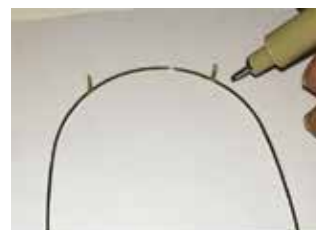


Figure 1

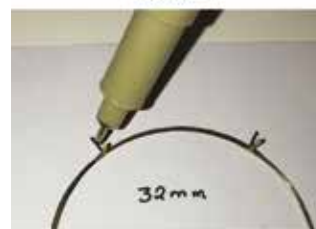


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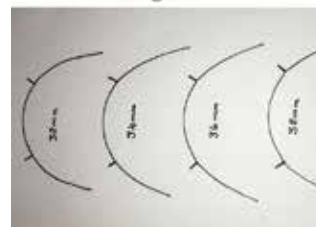


Figure 3



Figure 4

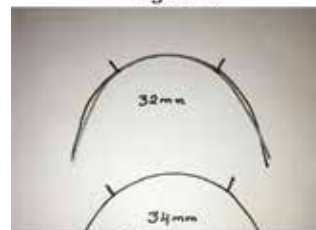


Figure 1



Figure 6

DAMON™ SYSTEM

Your Best Face Forward

The Damon System is a proven combination of passive self-ligating brackets, high-tech archwires and minimally invasive treatment protocols designed as a gentle, light force system with benefits that are more than just straight teeth. With the Damon System, doctors are able to employ face driven, streamlined mechanics to provide the treatment experience patients appreciate – beautiful faces and broad smiles, with fewer office visits and greater comfort. More than 5 million patients have been treated with the Damon System and thousands of orthodontists around the world continue to rely on the system for its remarkable advantages for doctors and patients. Available in metal and aesthetic bracket options, the Damon System allows you to treat a wide variety of cases with outstanding results so your practice and your patients can put their best face forward.



CAN YOU SEE WHO'S WEARING DAMON CLEAR BRACES?



"I loved my Damon™ Clear braces...people didn't even know that I had anything on my teeth. I now feel comfortable knowing my teeth look great."

— Christine, Damon Clear patient

LA SOLVE

La Solve (PVT) LTD

No. 42, Norris Canal Rd,
Colombo 10, Colombo, Sri Lanka.

TEL - +94 112 678 025/
+94 714 742 393/
+94 774 444 242

Clinpro™ Tooth Crème

0.21% w/w Sodium Fluoride

Anti-Cavity Paste with Tri-Calcium Phosphate



**Winning Formula
Helps Prevent Cavities**

With Innovative
**Tri-Calcium
Phosphate**
Exclusively From 3M ESPE

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For Inquiries:

3M Lanka (Private) Ltd, 65 C, Dharmapala Mawatha, Colombo 07

Contact: 0703358540 (Saiba)