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Proceedings of the 2019 Autumn Meeting of the EAED (Active Members’ Meeting) – Mallorca, 20 to 21 September, 2019

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From knowledge to wisdom, drawn from information

Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?

T. S. Eliot

“Leadership in the Dental Profession by defining the highest ethical standards and interdisciplinary communication through publications and educational presentations” have been the foundational scientific elements of the European Academy of Esthetic Dentistry. Hence, the EAED annual congresses have been established internationally as a distinctive “signature” academic event since its foundation in 1986. Moreover, its closed Active Members’ meetings, structured as Workshops, by investing the maximum advantage of the accumulated brainpower of its members, are designed to produce a particular output within the discipline of Esthetic Dentistry, focusing on a single clinical subject of interest. These Closed Meetings aim to generate reliable published scientific contributions to the dental literature.

While evidence-based information is an important component in clinical decision making for a successful treatment, the achievement of an excellent clinical outcome, as defined by the accomplishments of esthetic dentistry, requires additional knowledge and skills. Outstanding clinical performance, ongoing improvement of the operational dexterity, and updated application of dental materials and technologies are some of the crucial parameters defining the distinctive clinical achievement. Furthermore, the clinical interpretation of the documented experimental evidence as executed by the current experts on a specific clinical domain, enhanced by their extensive clinical experience, provides definition and demonstration of the limits in pursuing excellence. Their contribution as
essists to the EALD workshops by presenting their focused and elaborated papers, not only by providing cutting-edge information but also by projecting their engendered clinical criterion, enhances this unique academic event with the necessary contemplating spirit that generates most constructive discussions.

‘Anterior Missing Teeth and Growth’ was the subject introduced by Dr Franck Bonnet, the Scientific Chairman of the Workshop of the 2019 EAED Active Members’ meeting in Mallorca on 20 to 21 September. As a critical topic of esthetic dentistry, it is related to a most sensitive yet broad part of our dental population. It concerns patients from birth to the completion of growth and beyond. The aim of the workshop was to produce clear indications for carrying out the necessary multidisciplinary procedures when treating those young patients.

Gathering the accumulated feedback by brainstorming the various issues among the participating Academy members was the objective of the focused discussions monitored by the Moderators, which preceded the consensus conclusions and the proposed ‘Informed Consent’ documents. The extended amount of information that was used in order to encapsulate and preserve the precious knowledge and wisdom on the subject (quoting T.S. Elliot above), combined with the abundance of clinical figures forming almost an illustrated atlas, called for special publishing means. The Scientific Chairman and the Faculty of the Workshop, along with the Editor of the Proceedings, would like to acknowledge and express their gratitude to the Executive Committee of the EAED and Quintessence Publishing Company for the decision to preserve the integrity of the entire manuscript and accept to publish it as an independent edition – a Supplement issue of the International Journal of Esthetic Dentistry (IJED).

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Members and faculty of the EAED Mallorca Autumn Meeting posing on the grand stairway of the Castillo Hotel Son Vida.
Anterior missing teeth and growth

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The organizers, moderators, and speakers of the Scientific Program of the 2019 EAED Closed Meeting, from left: Dr Konrad Meyenberg, Dr Pascal Zyman, Dr Hadi Antoun, Prof Markus Herzeler, Dr Franck Bonnet, Dr Renato Cocconi, Dr Roberto Cocchetto, Dr Marco Rosa, and Prof Carlo Marinello. Missing: Dr Niko Perakis and Prof Aris Petros Tripodakis.
Scientific Chairman’s introduction

One of the most challenging situations encountered in dental practice today is the case of anterior missing teeth in relation to growth. Craniofacial growth in adolescents and young adults on the one hand, and ongoing continuous alveolar growth on the other create an unstable ground for a long-lasting successful restorative outcome. The limits on the decision-making process when generating a comprehensive treatment plan are dictated by the practitioner’s specialty, educational background, and clinical treatment habits. It is obvious that there is a need for multidisciplinary analysis and an approach that provides advice and direction toward a series of combined and properly coordinated successful therapeutic options.

At first, the questions raised in the decision-making process are whether to orthodontically close the space of the missing tooth or whether to preserve the edentulous space for tooth replacement. It has been well established in the literature that this decision is mainly related to and dependent on the craniofacial classification of the patient. On the other hand, orthodontic edentulous space closure has also been advocated, irrespective of the craniofacial classification. An actual debate between the two options, therefore, will have to take into consideration the potential clinical outcome on the basis of both dental and facial esthetics.

If preservation of the edentulous space for tooth replacement is decided, the restorative versus the implant solution present the two possible options. The common goal would be to replace the missing tooth while the tooth structure of the adjacent teeth is not compromised. Adhesive restorative dentistry can provide restorative compensation and substitution of teeth into homologous teeth in combination with minor orthodontic interventions such as distributing or shifting the gap. If opening the gap for an adhesive fixed partial denture (FPD) is decided, pontic-site development procedures concerning the hard and soft tissue parameters should also be taken into consideration, along with the long-term retention and stability of the adhesive bridge.

Implant treatment for the replacement of missing teeth still enjoys great popularity. However, growth can pose a medium- or long-term problem for the implant restoration due to the maintained ankylosed position of the implant in an environment where the adjacent teeth can shift or erupt. Adolescent craniofacial growth, on the one hand, and ongoing alveolar growth and continuous tooth eruption on the other are the risk factors potentially jeopardizing the long-term esthetic outcome of implant treatment.
Session I

The anterior missing tooth and orthodontics in the growing patient: open or close?

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Moderator’s introduction

There is an empirical saying that if, as a prosthodontist, you have a good orthodontist at your side, every case will also be an orthodontic case. If, however, no orthodontist is available, every case can be solved by prosthodontic means alone. Of course, the same is true the other way around: “What to do when you do not have a good prosthodontist to work with on your case.” The challenging theme in the title reflects this clinical dilemma.

Although long-term studies directly comparing the many relevant treatment options are lacking, and although there is still a lack of good-quality evidence regarding the best approach, meticulous multi- and interdisciplinary diagnosis and treatment planning remains imperative to define ‘the best strategy’ that will provide the optimal individual result for our patients. The aim of this workshop is to present a comprehensive and applicable (in the daily practice) overview of the diagnostic means leading to a targeted decision-making process and concrete clinical solutions.

The continuous aging of our patients, the associated demand for minimally invasive dentistry based on reversibility and ease of reintervention, the long-term experience of many cases, and also, importantly, the inclusion of new factors (3D radiographic diagnostics, better understanding of facial growth and aging, easier movement of teeth (corticotomy-facilitated orthodontics), should lead to new considerations in the treatment of the anterior missing tooth in the growing patient.

Today, based on a thorough diagnostic evaluation of a specific case, orthodontists are in most cases technically able to symmetrically or asymmetrically close gaps in the anterior region, thus eliminating the need for any tooth replacement. In this case, the prosthodontist is needed at most for minor esthetic alterations such as bleaching, odontoplasty, composite addition, veneer or single crown placement.
sides the advantage of being a straightforward solution for the dentist and patient, this strategy may provoke several general questions concerning esthetics and function: Is it a physiologic situation? What impact does it have on the dental arch? Is the dental arch smaller, is it V-shaped instead of U-shaped, does it lead to an open buccal corridor? What about soft tissue support? Does it reduce the space for the tongue? Does it need a lifelong retention, with all the possible consequences? What is the impact on overjet, overbite, and the vertical dimension of occlusion, what is the impact on the mandible? What about potential risks of orthodontic therapy in general?

If tooth replacement is considered at all, the gap may be brought to the posterior, esthetically less-demanding region of the dental arch. In this case, a compromise to close the gap prosthetically may be more easily found.4 However, specific questions concerning long-term behavior remain: What happens functionally to a first premolar in the canine position? What are the orthodontic, functional, aesthetic, and biologic consequences of a canine in the position of a lateral incisor or of a lateral incisor in the position of a central incisor?

The other strategy, which is to place the teeth at their original position and to specifically replace the missing tooth locally by several prosthodontic options (2-unit cantilever resin-bonded FPD, implant-support-
ed single-crown conventional 2-unit cantilever FPD, conventional 3-unit FPD, single veneer/crown on a autotransplanted tooth) sounds logical, reasonable, and desirable. However, besides the advantage of keeping the dental arch in a complete physiologic form, the several initially successful ‘prosthetic solutions’ in the long term may be compromised by possible biologic and aesthetic consequences such as additional growth, maturation, adaptation, and aging, apart from all the inherent risks of the restoration itself.

Whatever direction is chosen, what is indispensable is the in-depth understanding of the lifelong craniofacial growth/maturatio with significant individual variations, and its implications for implant placement as well as the professional aesthetic, functional, and biologic management of the alveolar ridge in both the vertical and horizontal dimensions.5–7

The aim of the orthodontic lectures is to: 1) display all the relevant diagnostic aspects that have an impact on the decision-making process of closing and opening the gap in the maxillary anterior region with a missing tooth; 2) present the advantages and disadvantages of opening and closing gaps during and after treatment in the long term (including cost effectiveness); 3) judge and value the ‘prosthetic solutions’ from the orthodontist’s point of view; and 4) include the growth factor in all the careful considerations.

References

Essay I

Orthodontic edentulous space closure in all malocclusions

Outcome evaluation of facial and dental esthetics

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Abstract

In patients with missing maxillary anterior teeth, orthodontic space closure is an evidence-based, effective treatment option, probably the best if the goal is long-term periodontal health. Nowadays, this approach is possible in all malocclusions as the first step of an interdisciplinary approach, which aims not only at an optimum esthetic and functional result, but moreover at reducing the invasiveness of the subsequent restorative treatment. Space closure should be considered the first alternative in growing patients and when the gingival margins are visible. This essay presents the rationale for space closure and provides clinical tips for interdisciplinary treatment planning and finishing.

Keywords: orthodontics, space closure, missing incisors, missing laterals
Introduction

Even if the advent of osseointegrated implants reduced the popularity of the ‘space closure’ alternative, there are still at least three major reasons to consider this alternative as the most appropriate option:

1. From a biologic, esthetic, and periodontal perspective, a natural tooth or a root is almost always better than a foreign body, while the possible negative lifetime side effects are minimal. This is especially the case for the esthetic zone, where the management of the transition zone between white and pink tissue requires an ideal balance of health and esthetics.

2. Considering that, in the vast majority of cases, orthodontic treatment is in any case necessary to correct the spontaneous migration of the adjacent teeth, the overall treatment time is shorter and the cost–benefit ratio superior to all existing alternatives. This is a crucial consideration in the treatment of growing patients and young adults.

3. Nowadays, ‘space closure’ is an evidence-based, long-term-effective treatment. It has been demonstrated that, in the long-term, space closure:
   - produces results that are well accepted by patients;
   - does not impair temporomandibular joint (TMJ) function;
   - preserves periodontal health.

Nordquist and McNeil compared mean 10-years posttreatment of 39 space closure and 19 space opening and prosthetic replacements (13 bridges, 6 removable plates). The authors concluded that:

1. Space closure patients are healthier periodontally than prosthesis patients.
2. There is no difference in occlusal function.
3. The presence or absence of canine rise is not related to periodontal status.
4. There is no evidence that canine Class I relation is the preferred mode of treatment.

Thordarson et al demonstrated that ground canines moved in the area of the lateral incisors are stable and safe in the long term (mean > 10 years).

Robertsson and Mohlin investigated mean 7-years postoperative of 50 adult patients (30 space closure vs 20 space opening and prosthetic replacements) and demonstrated that:

- Space closure patients are more satisfied than prosthesis patients.
- There is no difference in the presence of temporomandibular dysfunction (TMD).
- Prosthesis patients have more plaque and gingivitis.

Czochrowska et al investigated the substitution of a missing maxillary central incisor with the lateral incisor, comparing the space closure site to the contralateral central incisor mean 6-years posttreatment. These authors reported similar position and appearance, with no detrimental effects seen on the radiographs. They concluded that "the substitution of a central incisor with the lateral is a valid treatment modality, if the indications for such treatment are present and careful attention to detail in orthodontic and restorative treatment is exercised."

Jamilian et al compared the periodontal and esthetic outcome of 17 space closure sites and 14 implants mean 6-year postoperative. These authors reported similar, well-accepted esthetic results, no TMD, and evident infraocclusion in the implant patients, and concluded that space closure patients have better periodontal health.

Rosa et al demonstrated that space closure, including first premolar intrusion and canine extrusion, in patients with missing lateral incisors does not incur the risk of periodontal tissue deterioration or TMD problems in the long term (mean 10-years postoperative).

Josefsson and Lindsten compared the clinical and esthetic outcome of 28 single-implant restorations with 38 space closure sites 5 years after treatment and concluded that "if both treatment alternatives are available, space closure is preferable."

Besides, a recent systematic review confirmed that the lateral occlusal scheme has minimal impact on patient comfort, biology, and mechanical complications. Canine guidance and group function are equally acceptable.

If health and function are not under discussion, then esthetics becomes a major focus for orthodontists. After space closure, smile esthetics is not ideal,
even if reshaping of the mesialized canine has been performed. Apart from a tendency for space reopening, the periodontal profile is altered, the canine appears too yellowish, and the premolar is undersized for an adequate substitution of the mesialized canine. To overcome these limitations, a new method was introduced to finalize orthodontic space closure and optimize the overall esthetic outcome.9-12

The key points are:

- Space closure with correction of the malocclusion.
- Orthodontic extrusion of the canine and intrusion of the first premolar to correctly level the gingival margins.
- Detailed torque control during extrusion and intrusion to keep the roots in the dentoalveolar envelope.
- Minor restoration and vital leaching of the yellowish extruded canine moved into the place of the lateral incisor.
- Restoration and enlargement of the intruded first premolar so that it resembles and works as a canine.
- Localized gingivectomy and periodontal surgical recontouring for selected patients.9,12
- Restoration not only of a lateral incisor substituting a missing central incisor, but also in patients with congenitally missing lateral incisors (CMLI) because their entire maxillary dentition is undersized.13-18

These improvements introduced a significant change of approach in the treatment of missing teeth in the esthetic zone: no longer a mere ‘canine substitution,’ but an interdisciplinary treatment seeking excellence. The orthodontic treatment is the first fundamental phase, with the aim not only of closing the spaces and correcting the malocclusion, but also of creating the correct anatomic conditions (roots and periodontal tissue) to allow the dentist to perform minimally invasive restorations on the anterior teeth.

Space closure irrespective of the craniofacial classification

Traditionally, the ‘space closure’ alternative is indicated in Class II malocclusions, in cases of mandibular crowding and incisor protrusion, while the main esthetic procedure is to grind the canine so that it resembles a lateral incisor. On the other hand, space closure would be contraindicated in Class III malocclusions, in patients with a short face/concave profile, and in the patients with large-sized canines.

Nowadays, by combining carefully detailed orthodontic, periodontal, and reconstructive procedures, it is possible to close the spaces and achieve a functional, esthetic, and long-term stable outcome in all malocclusions.9,12,19

Active treatment is to be planned in three steps:

- Space closure and correction of the malocclusion.
- Orthodontic finishing in the esthetic zone.
- Minimally invasive or noninvasive restorations on the anterior teeth.

1. Space closure should be performed with fixed appliances

Active orthodontic treatment should be performed in the permanent dentition. Even with the increased effectiveness of aligners, fixed appliances treatment is still the gold standard. Diagnosis in the early mixed dentition, combined with a serial extraction protocol, can be efficient for promoting spontaneous space closure and favorable migration of the adjacent teeth during the eruption period and reduces the difficulty of subsequent active orthodontic treatment. Maxillary space closure in Class I or III molar/canine malocclusions is usually less complicated when extractions in the mandible are planned. If patient collaboration is satisfactory, closure of the maxillary spaces can also be performed without mandibular extractions by pushing coil springs, supported by the diligent wearing of Class III elastics.9,10

Maxillary space closure is nowadays not only possible but also faster and predictable (without cooperation) in a short active treatment time (10 to 14 months) by using skeletal anchorage.19-21 Two temporary mini implants (temporary anchorage devices, TADs) placed in the palate are sufficient and effective to support a sliding mechanism, which moves all the posterior teeth mesially. This system does not require appliances in the mandible or Class III elastics as additional anchorage. The skeletal anchorage also allows for the closure of the space unilaterally with no cooperation (Fig 1).
Fig 1  (a) A 12-year-old female had the maxillary right central incisor traumatically lost 4 years before the first observation. (b) Before treatment, the overjet and overbite were within normal range. The maxillary midline was correct. Periodontal support was normal on the teeth adjacent to the edentulous area. No crowding was present in the mandibular arch. The occlusion and TMJs were stable. (c) The buccal cortical plate was slightly reduced in the missing area of tooth 11. (d) Two 8 mm mini implants (temporary anchorage devices, TADS) were placed in the palatal basal bone, on which a mesial slider was anchored that aimed to push forward the maxillary right permanent first molar. On the left side, the appliance was passively anchored on the incisors, canine, and first molar. (e) The unilateral space closure was performed over 10 months, without the patient’s collaboration. (f) The premolars, canine, and lateral incisor were pushed mesially by buccal mechanics, without any appliance in the mandibular arch. The maxillary right first premolar and the lateral incisors were intruded, while the canine was extruded to ideally level the gingival margins. (g) Orthodontic finishing lasted 9 more months with fixed appliances also in the mandibular arch. (h) Three years after the end of treatment, the lateral incisor in the right side replaced the central incisor, the canine substituted the lateral incisor, and the first premolar was in the place of the canine. The molars occluded in a Class II relationship. (i) Three years after treatment, the occlusion was normal on the left side. The natural roots of the right lateral incisor and canine ideally supported the periodontal buccal plate.
Fig 1 cont  (j) Three years after the end of treatment, the periodontal profile was stable after orthodontic manipulation by the intrusion of the right first premolar and lateral incisor associated with the extrusion and torque control of the right canine. Four composite restorations were performed by Dr Patrizia Lucchi on teeth 14, 13, 12, and fractured tooth 21. (k) Three years after treatment, a bonded retention persisted on five anterior teeth. (l) The periodontal support was within the normal range on the critical mesial portion of the mesialized and intruded lateral incisor. (m) The apically displaced mesiodistal bone crests of the intruded lateral incisor did not interfere with periodontal health. (n) Three years after treatment, the smile was natural looking. Space closure did not negatively interfere with facial esthetics.
2. Orthodontic finishing in the esthetic zone

Finishing starts from a detailed diagnosis, treatment plan, and positioning of the braces. The goal is to optimize the smile line and place the anterior teeth in such a way that minimally invasive or noninvasive restorations can be made. Orthodontic finishing in the anterior maxilla is particularly crucial when the gingival margins are exposed and in patients with thin periodontal phenotypes.

The starting point is the position of the maxillary incisors: the maxillary midline should coincide with the philtrum of the upper lip, and the long axis of the central incisors must be parallel to the long axis of the face, irrespective of the mandibular midline (Figs 2f and 2j). The vertical display of the maxillary incisors should be planned not only on the upper lip at rest, but also considering the smile line and the relation between the gingival margins and the upper lip during conversation and smile. The gingival margins should be visible according to the skeletal pattern, age, and sex of the patient.

The gingival profile can be adjusted orthodontically by extrusion of the mesialized canine and intrusion of the first premolar until the cementoenamel junction (CEJ) of the intruded first premolars is leveled with the central incisor, while the CEJ of the canine should be positioned 2 to 3 mm lower. Following the intrusion/extrusion movements, uneven bone peaks will become evident radiologically at the contact point (radiological vertical defect). The vertical movements are effective in remodeling the periodontal profile and do not compromise periodontal health in the long term.

Especially in case of a thin periodontal phenotype, it is crucial to keep the roots inside the dentoalveolar envelope by precise torque control. To prevent a possible space reopening, the roots should be placed with a distal angulation of 5 to 10 degrees. The mesiodistal stripping and palatal grinding of the canine should be finalized during the orthodontic finishing phase and will ensure optimum occlusion without any functional interference.

During this last phase of orthodontic treatment, close communication and decision making with the prosthodontist and the periodontist is of utmost importance for achieving the best possible interdisciplinary result for the individual patient.

Fig 2  (a) A 28-year-old male complained of esthetic discomfort due to interdental spaces, protruded central incisors, and two congenitally missing maxillary lateral incisors. (b) The malocclusion was a dentoskeletal Class II division 1 with normal periodontal support. There was mild crowding in the mandible, and the occlusion and TMJs were stable. (c) The maxillary incisors protrusion and interdental spaces were corrected with lingual fixed appliances. (d) Four years after treatment, and 6 months after the suspension of the maxillary retention, small interdental spaces re-opened as well as a 4 mm overjet. The teeth were stable in this position. (e) Following that, no further movement was noticeable, the composite buildups were substituted with ceramic restorations (Dr Giovanni Sammarco) on the anterior teeth and resolved the interdental spaces. The palatal surface of the central incisors and canines was restored to ‘fill’ the overjet and recreate a functional overjet. Nine years after treatment, the result was stable without any retention.
Fig 2 cont. (f) Fourteen years after orthodontic space closure, the dental esthetics was good and the interdental spaces had not reopened. The mandibular midline was deviated to the left due to the mandibular asymmetry. (g) The occlusal Class II molar relationship was stable. The first premolar was the substitute for the canine, while the canine was in the place of the lateral incisor. The esthetic balance of the teeth was within the normal range. (h) The maxillary incisors were orthodontically uprighted on the palatal plane, but the overjet was not fully corrected in order to prevent an excessive, unstable dentoalveolar compensation and retrusion of the lips. (i) The anteroposterior of the maxillary incisors was ideal on the palatal plane, and the overjet correction was partial. The orthodontic full correction of the overjet would have required a further retrusion of the maxillary incisors, with consequent worsening of the smile esthetics. (j) The maxillary midline was symmetric and centered on the upper lip philtrum. The overall smile and facial esthetics were acceptable (despite the narrow maxillary arch) due to the maxillary arch occluding on the retrusive mandible.
3. Minimally invasive or noninvasive restorations

Beyond the mere grinding of the canine so that it resembles a lateral incisor, multiple restorations are often necessary, not only for the compensation of existing anatomic variations in length, width, and thickness, but also to achieve long-term esthetics and function.

Restorative enlargement of the intruded first crown is almost always necessary to achieve balanced smile esthetics and a proper occlusion. The restoration will provide a new cusp, new contact points, and a new palatal working surface. The premolar’s palatal cusp should not be ground. Restoration of the central incisor is mandatory when his tooth is substituted by a lateral incisor, but also in patients with CMLI because their entire maxillary dentition is undersized.13-18

Outcome evaluation of facial esthetics

The esthetic benefits for the smile and profile are among the main goals of orthodontic treatment. Do extractions necessarily result in a flat face and narrow smiles? No, when properly indicated extraction is fundamental to improve the profile (Figs 3b and i) and the smile (Figs 3a and h) as well as to promote periodontal health and long-term stability.34,35 The success of orthodontic treatment depends on the careful analysis of all diagnostic elements and the establishment of a correct treatment plan.

Many dentists and orthodontists are convinced that in patients with missing maxillary incisors whose malocclusion does not require an orthodontic extraction treatment, space closure should be avoided because it may compromise the facial profile and narrow the smile. Conversely, they share the view that space opening in patients with a flat/concave profile will improve the posture of the lips, enhance the profile, and provide a ‘wider’ smile. This is a very superficial way to approach the issue. Actually, space closure could affect facial esthetics in both areas: the profile and the smile width. Important details are briefly outlined below.

![Image](https://example.com/image.jpg)

**Fig 3** (a) An 8-year-old female was missing the maxillary lateral incisors and showed a narrow retrusive maxilla with buccal corridors. (b) The strain of the peri-oral muscles, protrusive lower lip, and post-rotated chin defined the Class III hyperdivergent skeletal pattern. (c) The congenitally missing maxillary lateral incisors were diagnosed in the mixed dentition. (d and e) In the last stage of the mixed dentition, after the orthopedic palatal expansion, the orthodontic treatment plan was space closure in the maxillary arch and the extraction of the mandibular first premolars to resolve the minor crowding and promote ideal counterclockwise growth of the mandible as well as profile improvement.
At the end of treatment, performed with fixed appliances and composite restorations (Dr Patrizia Lucchi) on the six maxillary anterior teeth, the first premolar substituted the canine, while the canine was in the place of the lateral incisor. The occlusal contacts and periodontal profile were within the normal range. At the end of treatment, the smile line and smile arc were within the normal range. The smile was full, despite the extraction treatment. The enlarged central incisors were in good balance with the adjacent teeth and the face. The soft tissue profile improved significantly, the lips were relaxed, and the peri-oral soft tissue were well defined. The impressive improvement of the soft tissue profile is also due to the extraction therapy and slight uprighting of the incisors.
Space closure and profile

A widespread opinion is that the anteroposterior position of the maxillary incisor crowns is the main focus when planning soft tissue profile changes. Indeed, at the end of any orthodontic treatment, when occlusion is normal, the lips are resting on the crown of the maxillary incisors. Thus, if overjet is normal, what makes the profile more or less convex/concave is the position of the mandibular incisors and their relationship to the chin (Pogonion and Menton): skeletal pattern, vertical dimension, as well as the anatomy and position of the symphysis. In the absence of surgical procedures, the orthodontic treatment can tip the incisors at any age, while the position of the chin can be affected, mainly during growth, by the vertical control of the posterior teeth.

In a mild Class III case with a short face and concave profile, space opening with proclination of the incisors and prosthetic replacement of the missing incisors does not majorly affect the profile and lip posture. In patients with short faces (concave profile), what is relevant instead is an increase of the vertical dimension by means of extrusion of the molars, with consequent post rotation of the mandibular plane and profile convexity. This will also allow some extrusion and uprighting of the maxillary anterior teeth leading to a consequent improvement of the smile arc (Fig 4).

On the contrary, in hyperdivergent skeletal Class II cases with a convex profile, the overjet correction may require an excessive dentoalveolar compensation, ie, palatal tip and retrusion of the maxillary incisors. This will increase the nasolabial angle and flatten the profile. Moreover, a molar distalization and expansion procedure in the mandible should be avoided to prevent a mandibular post rotation and an increase of the anterior facial height. Both the maxillary incisors’ palatal tip and mandibular post rotation could produce an evident decline of the profile and worsening of the lip posture. In Class II cases with a convex profile and retruded mandible, after the maxillary incisors are well uprighted on the palatal plane, it is better to leave some overjet to be ‘filled’ and compensated for by the restorations (Fig 2).

Fig 4: (a) An 11-year-old female was missing the maxillary lateral incisors and as a consequence of that showed a narrow retrusive maxilla with buccal corridors and large interdental spaces in the maxillary arch. The smile arc was flat, and the smile line was hidden due to the vertical deficiency of the maxillary basal bone. (b) The profile was flat mainly because of the short face. The expected counterclockwise growth of the jaws will worsen the Class III profile in future.
Fig 4 cont  (c) Before treatment, the maxillary central incisors were protruded, while the premolars were in a Class III relationship. The treatment plan was to perform orthopedic palatal expansion and orthodontic space closure in the maxilla without any extraction in the mandible. (d) The superimposition shows the mesial movement of the maxillary molars to a Class II relationship, and the post-rotation of the occlusal and mandibular planes due to the molar extrusion. The maxillary incisors were extruded and uprighted to improve their exposure, smile line, and smile arc. The soft tissue profile improved despite the space closure. (e) At the end of the orthodontic treatment, the occlusion was a stable Class II molar relationship. Mesialized/intruded first premolars replaced the canines, and the extruded canines were in place of the lateral incisors. Immediately after the appliance removal, composite direct restorations were made by Dr. Patrizia Lucchi on the six anterior teeth. The central incisors were elongated to improve the smile arc. (f) Fifteen years after treatment, the soft tissue profile is within the normal range, despite the maxillary space closure and the counterclockwise growth pattern. (g) Fifteen years after treatment, the overall smile is full, and the smile arc is correct. The composite restorations had not been renewed or replaced and had deteriorated. A small diastema reopened between the central incisors.
Space closure and smile width

The existing data show that if orthodontic treatment has been carried out with a thorough diagnosis and careful planning, the choice of extraction treatment will not necessarily result in a buccal corridor that negatively affects frontal facial attractiveness. Conversely, nonextraction orthodontic treatment – by broadening the anterior sweep of the maxillary arch and increasing the buccal tip of the maxillary teeth – might flatten the smile arc, reduce the incisor display, and make the smile less youthful and attractive. Thus, once again, in case of missing maxillary incisors, the space opening alternative will not necessarily improve the smile esthetics; ‘expanding’ it could result in the opposite effect.

To improve the facial esthetics of the smile, it is recommended to expand the maxillary basal bone transversally and sagittally, to upright/extrude the maxillary teeth by respecting the periodontal envelope, to increase the vertical display of the maxillary anterior teeth, and to reduce the vertical exposure of the mandibular incisors and canines.

When the goal is a full smile, the most challenging malocclusions are:

- Skeletal Class II patients with a retruded mandible and the maxillary arch in good occlusion;
- Patients with maxillary vertical deficiency and those who do not show the maxillary gingival margins.

For these patients, orthodontics and/or prosthetic rehabilitation are not capable of providing adequate treatment. In the case of a growing young patient who shows these features, orthodontic space closure in the context of a surgical approach could be one of the best investments (Fig 5).

Outcome evaluation of dental esthetics

After orthodontic space closure, the esthetic appeal of the maxillary anterior teeth is suboptimal due to the different form and size of the mesialized dentition and to the anomalous periodontal profile: the gingival margins of the canines are higher than the gingival margin of the central incisors, while the short first premolars display a lower gingival contour. Without orthodontic normalization of the unnatural-looking periodontal profile and cosmetic restorations, it is impossible to obtain an ideal esthetic and functional result. This is even more difficult when a significant difference in size and color is evident among the canines and incisors.

However, for some patients with congenitally missing maxillary lateral incisors (CMLI), the final esthetic outcome could be acceptable by only reshaping the canines, even with no restorations and orthodontic remodeling of the periodontal profile. There is some evidence that laypeople do not notice all the esthetic details that are relevant to professionals (dentists, orthodontists, prosthodontists) and that mere space closure is evaluated more positively esthetically than prosthetic replacements.

There is general agreement that the most disturbing dental esthetic features are interdental spaces (black triangles) and asymmetric alterations. A unilateral crown width discrepancy of > 2 mm, and the discrepancy between the root angulation and the facial midline, are noticeable to all observers, while asymmetric alterations of the gingival exposure and cant of the occlusal plane seem to be more acceptable. These are the main reasons why in patients with unilateral CMLI, the extraction of the contralateral, especially when peg-shaped and smaller, is often better than unilateral space closure.

Tooth size is another major issue that may greatly influence esthetic treatment outcomes. While previous research assessed a close relationship between the degree of agenesis and the reduction in tooth width in patients affected by multiple congenitally missing teeth, recently an association between smaller teeth (eg, central incisors) and tooth agenesis has also been reported in subjects with CMLI as a single dental anomaly. Sometimes, differences in size and shape between the right lateral incisors are also present.

Small teeth (most importantly, the central incisors) should be recognized before treatment. When a patient presents large canines, the first question should be: Are the canines large or are all the teeth, including the central incisors, small? Often in cases where there are missing teeth, the central incisors are small and the canines are an ideal size, to substitute for the later-
al incisors. The ‘art of seeing’ rather than scientific evidence may be fundamental in the diagnostic phase.

Patients should be informed that if their teeth are small, some side effects are very likely to become noticeable after orthodontic treatment, these being:

- Reopening of the spaces and embrasures in case of space closure.
- Inadequate space for the implant in case of orthodontic implant site development.
- Inadequate vertical display of the central incisors and smile arc.
- Some overjet palatal to the maxillary central incisors.
- An unnatural-looking and unbalanced smile.

Fig 5  (a and b) A 17-year-old female was missing the maxillary lateral incisors and showed an inadequate smile after a previous orthodontic treatment (performed elsewhere) aimed to reopen the spaces. The smile line was hidden and the smile arc was flat due to skeletal vertical deficiency and to the buccal tip of the maxillary dentition performed during the wrong expansion therapy. (c and d) Ten years after space closure, the smile and face esthetics are ideal. Treatment consisted of orthodontic space closure, surgical correction of the anteroposterior vertical deficiency of the midface (Dr Mirco Raffaini), and six composite restorations on the maxillary anterior teeth (Dr Patrizia Lucchi).
Yellowish canines are to be ground palatally, mesially, and distally\textsuperscript{24} during the orthodontic finishing phase. The convex labial surface should be flattened after the torque correction: when the root is properly placed in the alveolar bone, the canine will be ground mainly in the incisal half, where the enamel layer is thicker. Small direct restorations are often necessary to fill the black triangle and embrasure mesially on the ground cusp of the canine. If the vital bleaching of the yellowish canine is planned, then a more whitish-colored composite should be used so that the vital bleaching will adapt to the white composite, and not vice versa.\textsuperscript{9}

A common mistake during the extrusion of the canine with labial appliances is the buccal root torque, with the consequent thinning of the buccal cortical plate and a higher risk of bone dehiscences or gingival recessions. These side effects can be prevented by detailed orthodontic palatal root control during extrusion.

Intruded first premolars do not need to be ground on the palatal cusp, while they should be restored in length and thickness, and sometimes mesiodistally if contact points are absent. The restorations will provide proper esthetics, while the guiding surfaces will be provided by the palatal sides.\textsuperscript{9-12} A common mistake during the intrusion of the first premolar by means of labial biomechanics is the buccal tip of the crown, resulting in an evident excessive overjet in the canine area. This will cause great difficulties for the dentist performing the restoration that aims to change the morphology of the crown of the intruded premolar into a canine.

Central incisors often need to be built up\textsuperscript{10} because patients with congenitally missing teeth have an undersized dentition,\textsuperscript{13-18} and sometimes the central incisors are different in size and morphology. The central incisors need to be enlarged, both in width and length, to obtain a correct thickness and smile arc.

- In Class II cases, some overjet may persist after the orthodontic correction and will need to be corrected by the restoration on the palatal side of the central incisors (Fig 2d and e).
- Conversely, in Class III cases it is often necessary to grind the canines palatally to achieve a correct overjet and anterior guidance. The restorations will preferably also increase the volume of the small central incisors on the buccal side.

When a lateral incisor is moved to the place of the central incisor, all aspects described above become even more difficult to manage. In any case, the lateral incisor should be intruded until the CEJ is at the level of the contralateral normal central incisor. This will allow the prosthodontist to place the limit of the restoration at the level of maximum circumference and reduce the unavoidable undercut between root and crown (Fig 1j, l, and m). To place the zenith properly, the root should be angulated 5 to 7 degrees distally. To reduce the risk of a black triangle, the crown of the lateral incisor should be no more than 2 mm from the adjacent contralateral central incisor. The angulation of the root and the amount of space closure should be planned with the prosthodontist, considering the periodontal phenotype, the smile line, and the possible reaction of the soft tissue to the planned restoration.

Soft tissue reaction to orthodontic intrusion and extrusion cannot be easily predicted in detail. If the periodontal support is intact and mature, soft tissue (the gingival margin) follows the vertical movements by 60% to 80% during intrusion,\textsuperscript{19,5c} and 90% during extrusion.\textsuperscript{24} There is a wide individual variation in the behavior of the soft tissue: the main difference is between adolescents and adults. In adolescents, it is common to observe a hypertrophy of the marginal gingiva due to poor oral hygiene. Besides, the altered passive or active eruption could jeopardize the response of the gingival margins to the vertical orthodontic movements. In a limited number of patients, a gingivectomy (and rarely, resective surgery) is necessary to remodel the soft and hard tissue.\textsuperscript{12} Patients with periodontal breakdown and attachment loss are expected to react in a different way.\textsuperscript{51,52}

According to the established occlusal requirements (overjet/overbite/anterior guidance) and esthetics (exposure of the anterior teeth/smile line/smile arc), the orthodontist and restorative dentist have to individually plan and adjust the size and position of the anterior teeth. The procedures to be considered and eventually planned in detail are:

- Mesiodistal stripping and palatal grinding of the crown of the canine,\textsuperscript{24} while its buccal surface is usually ground after the removal of the fixed appliances, in the context of the cosmetic restorations.
Stripping of the mandibular incisors.

- Whether to leave some interproximal space (in case of small teeth).
- Whether to leave some overjet between the palatal surface of the well-aligned central incisors and the incisal edges of the mandibular incisors.

The timing of the restorations is crucial for the success of the interdisciplinary treatment. Composite direct\(^6,12\) or semi-direct\(^5\) restorations should be done immediately after removal of the orthodontic appliance, together with the retention (fixed and/or removable). Eventual ceramic restorations should be performed after the settling of the occlusion, and at least 6 months after any retention of the maxillary anterior teeth. A group function is the preferable mode of occlusal finishing on anterior teeth\(^1,11,12\). A removable retention may be planned together with the orthodontist, considering the original malocclusion.

**Conclusions**

1. Space closure offers the great advantage that the entire treatment is finished immediately after the removal of the orthodontic appliances. This is fundamental in growing patients.
2. Space closure is an effective treatment modality with excellent evidence-based long-term stability.

3. Periodontal health is more predictable in the long term after space closure compared with any prosthetic substitution.
4. Space closure should be the preferred approach in growing patients, young adults, and patients with gingival margin display.
5. Nowadays, space closure is possible in all malocclusions.
6. If based on a correct diagnosis and a comprehensive treatment plan, space closure does not worsen the profile or the smile width.
7. Patients with CMLI have an undersized dentition with small teeth (eg, the central incisors).
8. Optimum care for patients with missing maxillary incisors requires an interdisciplinary comprehensive treatment approach.
9. Multiple restorations may be indicated after orthodontic space closure to achieve pleasing esthetics, good function, and long-term stability.
10. Direct no-prep composite restorations could be a valid mid- to long-term restorative option.

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Essay II

Space closure vs space preservation as it relates to craniofacial classification

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Abstract

Bilateral or unilateral congenitally missing maxillary lateral incisors is a common clinical situation that requires an interdisciplinary approach. It is often complicated by the presence of narrower teeth. Occlusal, periodontal, and esthetic considerations will influence the decision to close the space for a canine-lateral substitution or to open the space for a prosthodontic replacement of the missing lateral incisor. The team should define the proper dental position to provide a stable occlusion and dental esthetics obtained with a minimally invasive preparation. The restorative approach should provide a long-term functional and esthetic solution in the transitional period from adolescence to adulthood, reversible for future possible interventions.

Keywords: dental position vs dental form, space closure vs space opening, hypodontia with smaller teeth, implant or one-wing fixed dental prosthesis (FDP)
Introduction

The incidence of congenitally missing maxillary lateral incisors (CMLI) is approximately 2% in a Caucasian population.\(^1\)\(^2\) This form of hypodontia can be bilateral or unilateral; such a condition can occur with a contralateral small or peg-shaped lateral incisor, adding complexity to the restorative options (Fig 1). It should be taken into consideration that patients with CMLI often have narrower teeth than those without any dental anomalies, except for maxillary first molars.\(^3\) A missing or peg-shaped lateral incisor in the quadrant is a significant factor causing the reduction of the overall mesiodistal tooth widths of that quadrant, the maxillary central incisor being the tooth showing the greatest discrepancy.\(^4\)

Often, the orthodontist is the first to recognize this condition at an early age and needs to decide how to treat it, in consultation with the referring dentist and the restorative team. The interdisciplinary plan should provide a proper esthetic outcome, periodontal health, and long-term stability.

The bilateral space-closure solution provides satisfactory esthetics and functional long-term results,\(^5\)\(^-\)\(^7\) considering that it is already attainable during adolescence. The morphology, size, and shade of the maxillary canine in patients having orthodontic space closure and lateral incisor substitution can have a marked effect on perceived smile attractiveness.\(^8\) These factors have less relevance if all the six anterior teeth are to be restored, avoiding an excessive grinding of the canines; they will be transformed as large lateral incisors together with the enlargement of the narrow central incisors and of the premolar as premolar.\(^9\)\(^-\)\(^10\) This approach can reduce the risk of long-term space reopening. Since a reduction in size is found in both maxillary and mandibular teeth in this form of mild hypodontia,\(^3\) enlargement of the mandibular anterior teeth or thickening of the maxillary restorations might be necessary to avoid an increased overjet, as proposed by Rosa and Zachrisson.\(^10\)

The long-term periodontal indexes in space closure appear to be better than the prosthetic solution,\(^9\)\(^-\)\(^11\) and the esthetic results are judged more favorably by laypeople.\(^12\)

The space opening solution requires a prosthetic replacement of two possible categories: a single tooth implant or a resin-bonded fixed dental prosthesis (FDP).\(^13\) Single tooth implants have become a very popular prosthetic option, allowing the possibility of leaving the adjacent teeth untouched.\(^14\)\(^-\)\(^16\) This solution is often preferred by dentists.\(^12\)

After the orthodontic space opening during adolescence, the timing of the placement of the implants is a major issue to consider. The infraocclusion of the implant-supported restoration\(^17\) is quite common, and several individual factors related to facial growth, occlusion, dental continuous eruption, and wear should be evaluated. The infraocclusion is not easy to predict and shows great variability at any age.

![Fig 1](image-url) Adult patient Alessia DC. Unilateral congenitally missing tooth 22, impacted tooth 23, peg-shaped tooth 12.
The indication to place the implant when two serial cephalometric radiographs, taken 6 months to 1 year apart, do not show any vertical growth (on average 16 to 17 years of age for females, and 20 to 21 for males) seems to be less effective due to the continuous process of bone remodeling and tooth eruption. The infraocclusion of the single-tooth implant cannot always be solved by elongating the incisal margin or placing a new crown. It could become a severe esthetic and functional problem.

This progressive infraocclusion suggests that the implant placement in a young patient be delayed as long as possible, especially in patients with a high smile line.

Therefore, after the orthodontic space opening, a prosthetic solution needs to be provided that can be considered satisfactory for the patient in the long and delicate period from adolescence to adulthood. Furthermore, the frequent problems of darkening of the labial gingiva due to resorption of the alveolar bone and the interproximal papillae health and morphology of possible gingival recessions make the single-tooth implant very risky in patients with vertical maxillary excess and a high smile line.

The second prosthetic alternative after space opening is a resin-bonded FDP. Currently, the best choice for this solution is a 2-unit (one wing) and not a 3-unit (two wings) prosthesis, because in the former the risk of secondary caries due to loose wings is less relevant. The one-wing design also reduces mobility problems and offers better long-term stability.

**Mild hypodontia with smaller teeth**

Since “form is everything except for position and size,” the interdisciplinary treatment should address all these three factors. The orthodontist should resolve all the positional problems before the restorative dentist deals with the form of the teeth.

A logical hierarchy of decisions should be followed to create the premises for a stable occlusion, periodontal health, and acceptable dental and facial esthetics. In an interdisciplinary treatment, the orthodontist first plans the occlusion, considering the problems of dental position and size. A 3D virtual set-up can be used to facilitate this task, allowing 3D planning of the occlusion.

### Position before form

**Mandibular crowding and mandibular extractions**

The orthodontist should start the occlusal planning from the mandibular arch. After deciding the proper inclination of the mandibular incisors, taking into account the crowding and leveling of the curves of Spee and Wilson, the space needed for the orthodontic corrections must be defined. If extractions of mandibular premolars are necessary, this will have an important consequence: the mandibular premolar extraction will call for bilateral space closure and substitution of the canines in the maxillary arch (with consequent extraction of the small or peg-shaped lateral incisors in unilateral agenesis) (Fig 2).

**Maxillary incisors retraction and Class II**

The second orthodontic step is to plan a possible maxillary incisors retraction. If the intention is to correct a positive overjet by orthodontic retraction of the maxillary incisors, then space closure will be the preferred solution. Since the maxillary incisor retraction can induce a reduction of support for the upper lip and/or excessive projection of the nose, pay attention to the changes in the nose–lip unit and the consequent esthetic limitations (Figs 3 and 4).

A large overjet induced by a severe skeletal Class II relationship might require a surgical mandibular or maxillomandibular advancement. In this case, space opening is a viable alternative, as long as the space for the lateral incisors is not obtained through an excessive protrusion of the incisors.

**Maxillary crowding**

If the retraction of the maxillary incisors is not very significant, a third logical step would be to analyze the maxillary arch size problems with a space analysis of the two maxillary quadrants. In this analysis, a space of 6.5 mm is attributed to the lateral incisors (Fig 5) in order to comply with the necessary space for future implants, or to avoid excessive grinding of the canines in case of substitution of the lateral incisors. This
Fig 2  Adult patient Alessia DC. 3D digital plan: extraction of two mandibular premolars due to mandibular crowding and minimum anchorage space closure. As a consequence, small tooth 12 was extracted and bilateral space closure and substitution of the canines was performed.

Fig 3  Young adult patient Veronica R. Orthodontic retraction of the maxillary incisors to correct a positive overjet. Bilateral space closure and canine substitution.

Fig 4  Young adult patient Veronica R. Bilateral space closure and canine substitution (a). After space closure, the six maxillary anterior teeth were restored. Composite restorations after 6 years (b) (restorative dentist: Paolo Ferrari, Parma, Italy).

Fig 5  Adult patient Ryan L. 3D planning of a bilateral space opening. Space of 6.5 mm for the two implants as lateral incisors. A space of 9 mm for the two central incisors.
implies a space of at least 9 mm for the small central incisors for a better height-width ratio (Fig 6). With regard to this, if there is a severe lack of space (4 mm or more in each quadrant), space closure will be the most reliable option and a Class II molar relationship will be achieved by mesialization of the maxillary posterior buccal segments. This orthodontic movement can be facilitated by the use of TADs to reduce biomechanical side effects.

The significant potential crowding makes the space opening option less reliable, since one can end up with an excessive protrusion of the incisors or an insufficient space for restorations.

**Molar distalization**

If the lack of space is less relevant (< 3 mm), the distalization of the maxillary buccal segments and of the maxillary canines should provide the requested 6.5 mm for the maxillary lateral prosthetic replacement. Distalization of the maxillary molars can be significantly improved by the use of TADs, but it becomes less predictable when dealing with a mandibular deficit, especially if the molars are in full Class II occlusion and the adolescent patient shows a vertical or posterior mandibular growth pattern. If mandibular growth is not favorable, distalization of the buccal segments in achieving a Class I occlusion and proper spaces for the lateral incisors becomes less predictable.

**Unilateral missing lateral incisors**

A common challenging situation is a missing lateral incisor in one quadrant and a small lateral incisor in the other. Following the previously mentioned logical steps, if the orthodontist needs mandibular premolar extractions or retraction of the maxillary incisors to correct a positive overjet or to center the maxillary midline, the extraction of the small lateral incisor and a symmetrical space closure should be considered, thus creating the premises for symmetric restorations.

There are cases where there is a missing lateral incisor and a Class II occlusion on one side, and a small lateral incisor and a Class I occlusion on the opposite side (subdivision). The space opening solution may allow for prosthetically replacing the missing lateral incisor and restoring the small lateral incisor, giving both a normal size and achieving a Class I occlusion. Before following this treatment path, it is advisable to check for the presence of dental asymmetry in the mandibular arch (often related to mild skeletal asymmetry). In fact, the distalization of the maxillary buccal segment can be more demanding on the side where the mandibular canine is more posterior (shorter mandibular size; Fig 7). In this case, it might be preferable to extract the small lateral incisor and proceed with symmetrical space closure, or to face the restorative challenge of the canine substitution on one side and the enlargement of the small lateral incisor on the opposite side (Fig 8). In both cases, restorations of all the anterior teeth are often needed (Fig 9).
Fig 7  (a and b) Late adolescent Jessica G. Unilateral congenitally missing tooth 12 and peg-shaped tooth 22. Mandibular dental asymmetry. The right mandibular canine is more posterior than the contralateral canine. The decision was to close the agenetic space located at the same side of the more retrusive mandibular quadrant.

Fig 8  (a and b) Late adolescent Jessica G. Palatal mini implants (TADs) were used to facilitate the unilateral mesialization of the maxillary right posterior segment.

Fig 9  (a and b) Late adolescent Jessica G. Case after orthodontic unilateral space closure. Spaces were left to obtain an ideal size for no-prep restorations. Six anterior no-prep feldspathic veneers (restorative dentist: Niko Perakis, Bologna, Italy).
Class III

In an adolescent with a mild skeletal Class III relationship, the opening or closing option can be chosen depending on the amount of available space. The use of TADs makes the required orthodontic movements more predictable. Attention should be paid to avoiding excessive Class III dental compensation of the incisors, for esthetic reasons and so that the surgical option is not precluded in case of unfavorable late growth.

Retraction of the maxillary incisors and consequent space closure, using spaces provided by the missing lateral incisor, can be performed in some cases of surgical Class III relationships.31

Spaced maxillary arch and size of teeth

Space opening is the first option to consider in cases of a spaced maxillary arch with a Class I molar relationship. It can be challenging to distalize maxillary canines when they have erupted in a mesial position. TADs and corticotomies can facilitate this orthodontic movement.32,33 The orthodontic distalization of the canines increases the buccolingual alveolar width,34 which will remain stable over time.35 In the author’s experience, this event will still require the improvement of hard and soft tissue support for future implants or ovate pontics.

Both maxillary and mandibular teeth can be small in size; therefore, it is possible to orthodontically obtain a Class I occlusion, but with reduced spaces for the lateral incisors (around 5 mm). Posterior stripping can be used to obtain at least 6 mm of space for future implants, but this size can be excessive if the maxillary central incisors are also small (intra-arch size discrepancy).

If implants are to be used, it is still advisable to orthodontically open a space, both intracoronal and intraradicular, of 6.5 mm34 for maxillary lateral incisors. If this is the prosthetic choice and the central incisors are only 7 mm in width, the orthodontist should open an extra space of at least 7.5 to 8 mm to accommodate their enlargement. The advent of a smaller implant and platform-switching design has been shown to have a positive effect on the amount of bone remodeling, more favorable than the one attained with standard implants.32 If the choice is to maintain the smaller tooth size, resin-bonded FDPs36 can be an alternative to implants.

Smile line – vertical maxillary deficit and excess

The smile line and the vertical position of the maxilla should also be considered. A low smile line and a vertical maxillary deficit favor implants as a convenient prosthetic solution.

Vertical maxillary excess and a hyperdivergent growth pattern of the mandible (ie, long faces) often present a high smile line and lip incompetence. From an esthetic standpoint, when both options are avail-
able, space closure presents long-term advantages over space opening. A high smile line is not per se a contraindication for space opening, but it is wise to consider a safer prosthetic choice that can reduce the long-term risks related to implants placed in the esthetic zone.

A resin-bonded FDP can be an option. One-wing FDPs (Fig 10) can overcome some of the instability issues found with a two-wing design, where deep overbite and proclined incisors seem to be related to a higher incidence of failure; directional mobility problems are reduced with a one-wing design, with a better long-term prognosis.

The material of choice, the bonding surface, the bonding technique, and the thickness of the connector are parameters relevant to the long-term prognosis of the one-wing design (Fig 11). The orthodontist can bond a 0.5-mm thickness of resin on the palatal surface of the central incisors or canines during the orthodontic leveling to reduce the enamel preparation for the wing of the FDP. All contacts in excursions must be carefully checked and also carefully examined, regarding the cantilever and the alveolar bridge. Often a soft tissue augmentation is necessary to optimize the emergence profile of the ovate pontic (Fig 12). Long term, an ovate pontic can be affected by the ongoing eruption of the adjacent teeth, but the esthetic consequences are easier to correct than a significant infraocclusion of an implant in the esthetic zone.
Form after position

Orthodontic finishing

During the finishing stage of treatment, in case of symmetric or asymmetric space opening or closure, the orthodontist should follow the indications of the restorative dentist (Fig 13) to obtain a tooth position that will allow the best restorative outcome with minimally invasive preparation or no preparation (Fig 14). The restorative dentist knows best how to compensate for minimal positional inefficiencies or orthodontic limitations. Digital Smile Design (DSD) could help the visualization and communication among the team members.

Postorthodontic retention during adolescence

After orthodontic treatment, adolescent patients with missing lateral incisors need a restorative solution that is esthetically satisfactory in this very sensitive period of life. After appliance removal, teeth need to be retained by thermoplastic aligners or by fixed composite retainers in order to avoid minimal dental movements before restorations.

Direct or indirect composite restorations or ultra-thin CAD/CAM (polymer-infiltrated ceramic-network [PICNI] or resin nanoceramic [RNC]) veneers⁴³ (Fig 15) can achieve proper esthetic and functional results. At an older age, ceramic veneers can be considered. Altered passive eruption can represent an esthetic
Fig 15  (a and b) Late adolescent patient Gaia M. Congenitally missing teeth 12 and 22. After space closure and canine substitution, a minimal invasive periodontal surgery was performed to address the altered passive eruption and gingival outline.

Fig 16  (a and b) Late adolescent patient Gaia M. Six CAD/CAM ultrathin no-prep veneers (PICN: Enamic).

Fig 17  (a and b) Late adolescent patient Gaia M. Final result after orthodontic treatment and after CAD/CAM no-prep veneers of the six maxillary anterior teeth (restorative dentist: Stefano Patroni, Piacenza, Italy).
limitation and might require minimally invasive periodontal surgery (Figs 16 and 17).

In case of space opening, the inclination is to delay the implant placement as much as possible in the esthetic zone. Therefore, after orthodontic treatment, prosthetic solutions that need to endure for several years should be used, offering a feasible esthetic and functional result during late adolescence and young adulthood. The use of a removable retainer with a prosthetic tooth is an easy and inexpensive option, but it cannot be considered an acceptable long-term solution. A night-time Hawley retainer can be considered, or a night guard can be prescribed if the patient shows bruxing habits.

A one-wing resin-bonded FDP could be an excellent transitional solution both for esthetics and function; it might also become a permanent solution if the patient is satisfied and not necessarily willing to proceed with implants in the future. It can easily be repaired in the case of breakage or debonding. If an improvement of the pontic site is required, the option of a soft tissue enhancement can be considered to obtain an esthetic emergence profile of the ovate pontic.

It has been proposed to use a mini implant-retained pontic as a semi-permanent solution, which allows for the vertical growth of the alveolar process and improves its bone density over a period of 5 years. Nevertheless, the convergence of the roots during the retention phase might be a problem for implant placement in the future.

Conclusions

1. Today, the adolescent patient often requires a satisfactory esthetic solution after orthodontic treatment.
2. Congenitally missing lateral incisors often require interdisciplinary treatment by an experienced team.
3. Clinical experience and technical skills of the team are relevant to the success of the overall treatment.
4. Dental position should be planned before dental form.
5. Digital planning and TADs can help the treatment.
6. The option of space opening or closing is not simply based on the personal preference of the operator and must involve the (informed) patient in the final decision.
7. Some positional situations (mandibular and maxillary lack of space, maxillary incisors retraction) can preclude the option of space opening.
8. Some growth patterns (Class II with vertical or posterior mandibular growth) can reduce the option of space opening.
9. Some skeletal conditions (vertical maxillary excess) or morphologic conditions (high smile line) create esthetic limitations for the option of space opening.
10. In case of space opening, small tooth size should be considered and might contrast with an ideal 6.5-mm space for an implant.
11. In case of space opening, a one-wing FDP can offer a long-term esthetic solution.
12. One-wing FDPs can represent a viable alternative to implant restorations, whose survival rate differs from the success rate.
13. In case of space closure, the six anterior teeth are often involved in the restorative treatment.
14. Composite restorations can represent a valid restorative option.
15. Can no-prep or minimal-prep CAD/CAM veneers be an alternative to composite restorations?
16. Minimally invasive periodontal surgery is necessary to address situations of passive eruption and improve the esthetic outcome.
17. Soft tissue augmentation could be useful for the esthetics of the ovate pontic but is difficult for the adolescent patient to accept.

Acknowledgments

I express my gratitude to Dr Silvia Rapa, my partner, for her help in defining the logical sequences behind the orthodontic decision to close or open the spaces in different situations of CMLI. I really value the cooperation that I have had over the years with my restorative partner, Niko Perakis, whose clinical contribution in the restorative field has been fundamental.
References


Clinical Statement

Staged restorative treatment plan intervention during the various orthodontic treatment phases

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Abstract

New digital technologies have significantly improved patient treatment modalities, especially in interdisciplinary cases. Tooth morphology can be modified at different stages of orthodontic treatment. Defining and achieving the final tooth form at the beginning or during the treatment can help the orthodontist to move teeth into the correct position quickly and more easily. The reshaping of anterior teeth can be obtained using digital technologies and CAD/CAM procedures. Composite resins are preferred to ceramics because they can be modified and adjusted whenever necessary. The parameters to assess the timing of restorative intervention are related to the age of the patient, degree of tooth eruption, and space availability in the interproximal area, especially if an additive approach is indicated to enlarge teeth.

Keywords: reshaping, anterior teeth, composites, adhesive techniques, multidisciplinary treatment, digital technologies
Introduction

Reshaping anterior teeth by an additive or subtractive procedure is necessary to obtain an adequate final esthetic result in both space closure and space preservation scenarios. Tooth morphology can be optimized at different stages of orthodontic treatment. Defining and achieving the final tooth form at the beginning or during the orthodontic treatment can help the orthodontist to move teeth into the correct position more effectively. The parameters to assess the timing of restorative intervention are related to the age of the patient, degree of tooth eruption, and space availability in the interproximal area, especially if an additive approach is indicated to enlarge teeth. Patients with CMILI often have narrower teeth than patients without any dental anomalies. In these cases, composite materials are preferable to ceramics as they can be modified and adjusted whenever necessary.

 Normally, final restorations can be carried out only at the end of the treatment. New digital technologies have significantly improved patient treatment modalities, especially in these interdisciplinary cases. A digital workflow helps the team members to plan the clinical case, to interact during the treatment, and to verify every clinical step effectively. Freehand composites, CAD/CAM indirect restorations, and the flowable composite injection molding technique can be used to change tooth morphology during the treatment and optimize the final clinical result.

Case presentation

A 12-year-old female patient had lost her central incisors in a bicycle accident when she was 11 years old (Figs 1 and 2). The parents reported that the teeth were re-implanted immediately. Multiple abscesses occurred during the following months. Root resorption of both central incisors was detected radiographically (Fig 3). The patient also had significant crowding in the maxillary and mandibular dental arches. She was thus referred to our team 1 year after the traumatic incident had occurred. As the infection was not under control, the extraction of both central incisors was necessary early in the treatment.

Fig 1 Extraoral examination at the beginning of the treatment.

Fig 2 Intraoral frontal view at the beginning of the treatment. The prognosis of the central incisors is poor.

Fig 3a to c Cone beam computed tomography (CBCT)-guided position of palatal implants. The orthodontic supporting appliance anchored to palatal implants helped tooth movements and maintained the maxillary midline position (orthodontist: Renato Cocconi, Parma, Italy).
The extraction of the two mandibular first premolars was also necessary due to the lack of space in the mandible to guarantee correct tooth alignment and occlusal stability at the end of the treatment. Our interdisciplinary approach aimed to replace the extracted teeth without any prosthetic replacement. The lateral incisors, canines, and premolars were mesialized in the position of central incisors, lateral incisors, and canines, respectively. The restorative dentist reshaped all the anterior teeth with a noninvasive adhesive technique at different stages of the treatment to help the orthodontist to visualize the final tooth form and achieve the optimal tooth position. To select the best treatment strategy for the patient, the involved clinicians needed to follow a specific sequence in the decision-making process (Table 1).

### Interaction between position and tooth shape

A fully digital orthodontic approach allowed the positioning of two palatal temporary mini implants, providing the required anchorage for an effective orthodontic appliance (TAD). This helped to mesialize the lateral incisors and canines as well as move the posterior buccal segments into the correct position while the maxillary midline position was maintained (Fig 3). At the first restorative check, the final tooth position was almost achieved (Fig 4a). A large gingival overgrowth was detected between the central incisors, unsupport ed by bone underneath (Fig 4b). After consultation with the periodontist, it was decided not to remove the hypertrophic soft tissue at this stage of treatment. The lateral incisors, the canines and the first premolars had to be intruded and mesialized further (Fig 5a and b).
Fig 5 (a and b) Restorative clinical requests. The lateral incisors, canines, and first premolars had to be intruded and mesialized. To achieve the final tooth position, the diameter of the canine should be reduced and the crowns of all the anterior teeth reshaped. Additive areas are depicted in green and subtractive areas in red.

Fig 6 (a and b) Actual dimensions of the canine and lateral incisor (8.4 mm and 7.1 mm, respectively) and correct diameters of future central and lateral incisors (7.6 mm and 8.6 mm, respectively). (a) The canine should be reduced by 0.8 mm and the lateral incisor enlarged by 1.5 mm. (b) The canine shape impedes a correct lateral incisor enlargement.

**Restorative intervention during the treatment**

To provide the correct final tooth form and facilitate tooth alignment, the restorative dentist reshaped all the anterior teeth at this stage of the treatment. The first step was to reduce the diameter of the canines to that of lateral incisors. For this reason, their cervical area was reduced mesiodistally and buccally. Thus, the space for the restoration of the central incisor was also obtained (Fig 6a and b). After tooth polishing, intraoral scanning of the maxillary and mandibular arches was performed. A new digital setup and virtual design allowed the restorative dentist to define the correct maxillary anterior tooth form, volume, and space distribution.

The lateral incisors were digitally enlarged and lengthened. The canines were reduced in width and length, and, to take on the function of canines, the premolars were increased in length (Fig 7a and b). The virtual outcome allowed the technician to transfer the optimized tooth form onto the actual teeth in their position, simply by dragging and dropping the digital design (Fig 8a and b). Six ultrathin no-prep CAD/CAM resin nanoceramic (RNC) veneers were then prepared and checked on a stereolithographic model before clinical delivery. A few modifications were then required to obtain a suitable tooth form directly in the patient’s mouth after the adhesive fixation (Fig 9a and b).
Fig 7  (a and b) Canine and lateral incisor reshape prior to the restorative phase. New digital setup and wax-up defined the correct maxillary anterior tooth distribution and form.

Fig 8  A fully digital approach allowed for the transfer of the optimized tooth form (a) onto the real tooth in its actual position (b) by dragging and dropping the digital wax-up.

Fig 9  (a) Six resin nanoceramic CAD/CAM laminate veneers were delivered. (b) Few modifications were required to optimize the final tooth form.
End of the orthodontic treatment and final restorative approach

Once the provisional restorations were in place, the orthodontist could finish the treatment in a very predictable way as all the parameters regarding tooth length and width were in place (Fig 10). Only minor tooth form modifications were necessary. Using adhesive techniques, the restorative dentist optimized tooth form and emergency profiles (Fig 11) and obtained a natural-looking diastemata closure adding composite material to the RNC laminate veneers (Fig 12). A bonded fiber splint at the level of the palatal aspect of the anterior teeth maintained the final result over time.

Conclusions

Comprehensive planning combined with simplified and faster interdisciplinary clinical procedures are the aims of modern dentistry. New digital technologies have significantly improved patient treatment modalities, especially in providing new tools to define tooth morphology before and during orthodontic treatment. Freehand composites, CAD/CAM resin-based restorations, and injection-molded flowable composites allow for the change of tooth morphology during the treatment to optimize the final clinical outcome. Composites are preferred to ceramics as they can be modified and adjusted whenever necessary. Defining and achieving the final tooth form as early as possible can help the orthodontist to move teeth into the corrected predicted position. In this way, the proposed treatment sequence also becomes cost effective.

Acknowledgments

I express my gratitude to Dr Renato Cocconi, whose knowledge in the orthodontic field has been precious to develop protocols and guides for the decision-making process in interdisciplinary clinical cases. I also express my gratitude to my dental technician, Giuseppe Mignani, for his expertise and help.
References


Discussion

Moderator: Carlo Marinello
Editors: Aris Petros Tripodakis and Stefano Gracis

Growth – remodeling – aging

Carlo Marinello: An adolescent patient comes to your office for an orthodontic treatment. Will growth have an impact on the stability of the treatment in the years to come? What are the influences of factors such as growth, remodeling, and aging?

Marco Rosa: Growth is a generic term. What is meant by growth? Growth of the alveolar processes, of the jaws, of the skull? Aging of the hard and soft tissues? Growth pertains to all these factors and never stops. We start growing as a fetus and we stop aging and changing when we die. Whatever we do to the smile and the face is related to growth. Therefore, the answer to your question is ‘yes’ – residual growth and physiologic changes of aging will have an impact on stability, even after 16 years of age.

Carlo Marinello: All these factors play a role, as is shown in the growth curves. Teeth are mesializing and extruding over time. With implants we do see changes over time (infraocclusion; interproximal contact loss), but the question is: What really happens after orthodontic treatment? Is it just adaptation with possible negative consequences?

Marco Rosa: The teeth adjacent to the implant restoration are expected to erupt, with great individual variation, including during adulthood. After orthodontic treatment, stability and retention strategy are the main issues. Even if orthodontic treatment is correctly planned and performed, some changes are normally expected due to adaptation to residual growth and aging. For example, the mandibular anterior teeth move, abrade, and become crowded continuously during life. This is also perceived as a negative consequence.

Renato Cocconi: Nobody can exactly predict growth as a geometric event from A to B. At the beginning of an orthodontic treatment we can recognize patterns of growth that we need to confirm during treatment with progressive reevaluations that will allow us to adapt our goals.
**DISCUSSION**

**Hadi Antoun:** To answer these questions, there are some facts that need to be considered:
- Growth continues throughout life.
- Growth is independent of face type and gender.
- There are big differences among individuals.

**Tidu Mankoo:** I do not think we should call it growth but rather ‘age-related changes or adaptation.’ In a 50-year-old patient who received an implant, the possible changes observed during the next 10 to 15 years might occur not due to growth, but more likely due to the decreasing skeletal volume. ‘Age-related change’ is the right term.

**Roberto Cocchetto:** I agree that these modifications may be presented as age related, but I do not agree that the problem is the decreasing skeletal volume. We are still dealing with growth, and this is clearly supported by the literature.

**Tidu Mankoo:** Plastic surgeons know all about facial changes over time. Most of the esthetic treatments they provide in older patients are related to an increase in volume, in order to compensate for the loss in volume of the osseous structures. Loss of skeleton is the reason implants are found more buccally over time, not because of a change in position.

**Devorah Schwartz-Arad:** I believe that ‘craniofacial changes’ is a more appropriate term. The properly placed implant will be found more buccally and apically over the years, while the cavities of the craniofacial complex will be enlarged. Changes occur to volume, position, and size. All three of these aspects change together as a unit with age. The word ‘aging’ or ‘remodeling’ is preferable to growth.

**Stefan Paul:** There are two patterns of growth: vertical and horizontal. What impact do they have?

**Marco Rosa:** The skeletal pattern is of great importance in all orthodontic treatments. Vertical and horizontal patterns of growth are often correlated. In growing patients, the growth prediction is a fundamental part of the orthodontic treatment plan as it can influence the pattern of growth, both in a positive and negative way. The direction of growth can be predicted, but we cannot predict how much the child will grow.

A general rule in case of missing incisors is to close the spaces in growing patients and also whenever the gingival margin is visible, ie, in case of a vertical skeletal pattern. In a hyperdivergent patient, extractions in the mandibular arch may also be indicated. In patients with short faces and Class II skeletal discrepancies, the exposure of the maxillary teeth is suboptimal; in these cases, mandibular extractions should be avoided. The prosthetic replacement of the missing teeth may be an alternative solution. In the case of Class III relationships, space closure is possible although more difficult.

**Post-orthodontic retention and stability**

**Carlo Marinello:** Is a retainer a must, and does the retainer have an impact on growth?

**Marco Rosa:** Retention is a normal procedure after a comprehensive orthodontic treatment in the permanent dentition. The type and duration of the retention strategy are related to the original malocclusion and patient’s expectations. If the goal is to maintain a perfect alignment of the mandibular incisors and prevent changes that occur due to aging, a lifelong retention strategy is advisable. Rotated teeth, open bite, and deep bite correction as well as the teeth adjacent to an implant restoration require special attention.

It is important to help the patient to understand the difference between relapse and aging before the start of treatment. All patients in my practice sign an informed consent form stating that if they do not want to experience changes over time, they will need to wear a retainer forever.

**Carlo Marinello:** In a case of Class II division I with an open bite at the end of the orthodontic treatment, the anterior teeth were enlarged palatally with thick crowns in order to fill the open space and to stabilize the occlusion. Was no additional retention needed? Would the tongue-to-lip equilibrium not be modified?
Marco Rosa: In a Class II malocclusion with a retrusive mandible, the correction of the overjet requires an excessive ‘dentoalveolar compensation,’ ie, an excessive, unstable, palatal inclination of the maxillary incisors. These teeth should be ideally uprighted on the palatal plane, if the mandible is retrognathic, some overjet will persist, to be filled by the restoration of the palatal surface of the maxillary incisors.

The equilibrium between tongue, lips, and all functional issues is of crucial interest both in the diagnostic process and for the stability of the final outcome. Unfortunately, there are many options and very weak scientific evidence. Functional balance cannot be measured and manipulated in a predictable way; thus, the only judge is time. Time is the fourth dimension. We must use time to understand when the situation is stable in order to go ahead with the ‘definitive’ restorative rehabilitation. It is a risk to proceed with any prosthetic rehabilitation immediately after the completion of the orthodontic treatment, especially after an excessive dentoalveolar compensation to fix a large open bite and/or overjet.

The restorations should be planned after some months of observation without any retention of the maxillary anterior teeth, and will also compensate for some minor space or misalignment.

Anyhow, a removable retention is advisable, especially if the lip competence is not relaxed.

Carlo Marinello: You mentioned that when you extract teeth you have more stable cases. Are there any other parameters that can affect the long-term stability of your cases?

Marco Rosa: Dental crowding can be fixed by extractions or by expansion. All cases with crowding may be treated without extractions, but if the diagnosis is correct, 25% to 30% of patients with crowding must be treated with extractions.

The available scientific evidence provides sufficient guidelines to prevent relapse. We know that the mandibular arch form is stable and individualized for each patient. The mandibular arch should be used as a template to align the maxillary arch. Another parameter is the mandibular intercanine width. We know that if we expand the intercanine width by more than 1 mm, even in the mixed dentition, the alignment of the mandibular incisors will relapse. We know that, in the long run, borderline crowded patients treated with extractions are more stable. If the patient accepts a lifelong retention, we could also expand the arches beyond those limits, but expansion may induce not only esthetic worsening but also attachment loss and periodontal breakdown. Rotated teeth and the orthodontic correction of some vertical discrepancies (open/ deep bite) also require major care and a specific retention strategy.

Renato Cocconi: The stability of the result is very important but should be related to its quality. Nobody wants to achieve a stable wrong result. Our goals are proper dental and facial esthetics as well as occlusal and functional stability; also, trying to maintain these in the long term. As an example, if we have a patient with a 2 CMLI and a positive overjet, we can choose a bilateral space closure and canine substitution only if the retraction of the maxillary incisors is not producing a facial decline. We need to apply rigorous yet self-corrective protocols, providing solutions that, especially in young patients, can be reversed and will allow re-interventions in the long term.

Aris Petros Tripodakis: The issues regarding growth, aging, and stability are united as years go by. When you finish the case, what kind of anterior overbite would you like to achieve, and how often do you check the posterior support of the occlusion, which with aging tends to be reduced? Do you or the dentist recall patients to check that adequate posterior support of the occlusion is still present, which helps to prevent overloading of the anterior teeth?

Renato Cocconi: We try our best to obtain a proper overbite and overjet for incisor and canine discclusion, with posterior centric stops to hold the occlusion. This can be more precisely obtained by using the restorations that are frequently planned for the maxillary anterior teeth. We usually place a temporary removable thermoplastic retention until the completion of the restorative phase; after that, every case is followed for 2 years. The most frequent form of retention is a fixed mandibular retainer bonded only on the mandib-
ular canines, and a removable maxillary Hawley retainer that is worn every night for 1 year, after which its use is progressively reduced. Over time, the patient is asked to wear it once a week, to ensure that everything remains stable. After that, the restorative dentist follows up the patient once a year.

**Giano Ricci:** If you must treat a periodontally involved patient orthodontically, how do you stabilize the case, especially if the patient is a tooth clencher, tongue thruster, etc?

**Marco Rosa:** In case of severe attachment loss and periodontal breakdown, removable appliances are not appropriate. The anterior teeth should be treated with lifelong splints.

**Renato Cocconi:** In a case with tongue thrust, the anterior teeth are splinted after the placement of the restorations. We use a removable retainer at night-time with a special design to hold the tongue in position.

**Tidu Mankoo:** When the teeth are repositioned, the vertical positioning of the gingival zenith needs to be aligned. When brought mesially to replace the lateral incisor, the root of the canine must be inclined palatally to compensate for its buccal eminence. The severe reshaping of the crown of the tooth, however, is not highlighted. Grinding is required not only labially but also on the palatal surface, since the tooth has to be erupted to make it look like a lateral incisor. I kindly ask you to highlight this very important clinical aspect.

**Marco Rosa:** The vertical positioning of the gingival zenith is managed by a slight extrusion of the mesialized canines. Mesiodistally, the gingival zenith should be managed by placing the roots with a 5- to 10-degree angulation. The amount of canine grinding should correlate with the type of malocclusion, root inclination, and tooth size.

In a Class II malocclusion, the palatal grinding of the canine is minimal because, at the end of the orthodontic treatment, it is better to prevent an excessive dentoalveolar compensation of the maxillary anterior teeth. Therefore, the thick canine is touching the mandibular incisors, while 2 to 4 mm of overjet persists on the central incisors. One problem, especially when the canine is extruded, is that the root tends to move in the buccal direction so that periodontal eminence appears, the alveolar bone crest becomes thinner, and a major risk of dehiscence and/or recession become evident in patients with thin periodontal phenotype. It is very important during the extrusion of the canine to provide a palatal root torque.

In a Class III malocclusion, at the end of the orthodontic phase, the central incisors are usually in gentle contact with the mandibular incisors, and the canine must be ground extensively on the palatal side. When the root inclination is correct, the canine crown can be ground near the cusp on the buccal side, where the enamel layer is thicker.

Finally, when planning an interdisciplinary treatment, it is crucial to consider that patients with congenitally missing incisors have small teeth. In other words, the central incisors must be enlarged, and the canine should not be excessively ground so that it is made proportionate to the adjacent small teeth.

**Renato Cocconi:** During space closure, the orthodontic movement of the maxillary canine should be performed in stages:
- Mesialization of the crown.
- Mesial angulation of the root that otherwise will interfere with the intrusion of the premolar.
- Palatal torque to its root. This torque should not be excessive because it could project the tip of the crown too buccally, inducing unnecessary grinding.
- Extrusion and grinding, particularly of its palatal surface.

**Tidu Mankoo:** What if the canine is moved mesially, as described, but a space is deliberately opened in the first premolar area for the placement of an implant, since this is an easier area to control?

**Renato Cocconi:** Opening a space posteriorly and moving the canine as a lateral incisor will lead to all the restorative issues related to the substitution of the canine in place of the lateral incisor and of the premolar in place of the canine. It could be a feasible option in the case of an implant placement in a high smile...
line. Distalizing the canine for a one-wing bonded ovate pontic for a lateral incisor would be a better long-term solution.

Marco Rosa: Space closure anteriorly while space opening posteriorly is possible and also easier, but it requires extra prosthetic work and means higher costs. Nowadays, by means of temporary skeletal anchorage, it is possible to move all the maxillary third molars to erupt in occlusion with the mandibular second molars.

Stefan Paul: When you have a 21-year-old patient in your office, do you place an implant? Will growth pattern be one parameter that can determine the decision?

Renato Cocconi: Patients with a long face often present a hyperdivergent mandible and a vertical maxillary excess. If so, the presence of a high smile line in a young patient makes the choice of a single-tooth implant in the esthetic zone very risky. If the case of a CMI requiring a space-opening solution, a one-wing ovate pontic could be a satisfactory option in terms of esthetics and long-term stability; this option is also easy to repair in case of breakage and the possible need for reintervention in the future. An implant (as late as possible) could be a possible option.

Marjan Strub: In a scenario where you have a growing patient with an ankylosed anterior tooth, there are three options: extraction, decoronation or single tooth distraction osteogenesis. What is your recommendation?

Renato Cocconi: It depends on several factors. How relevant is the infraocclusion of the ankylosed central incisor in relation to the growth pattern and age of the patient? If the infraocclusion is very relevant and we expect lots of further vertical maxillary growth, I would consider the option of extraction and the possibility of autotransplantation of the premolar or obtaining an orthodontic substitution with the adjacent lateral incisor. If the infraocclusion is not excessive, we do not expect a lot more vertical growth and the central incisor is fairly close to its final position. In this case, a block section and a distraction osteogenesis can be an option, knowing that the tooth will then remain ankylosed in its new position. If the infraocclusion is not too severe and we need to move the maxillary anterior teeth, ie, to correct a positive overjet in a Class II situation, then I would prefer a decoronation in order to maintain the bone level and to deal with the missing central incisor at the end of the orthodontic correction.

Early orthodontic treatment – prevention

Debora Vilaboa: At what time do you think it would be ideal for a consultation from a dentist in order to predict growth issues and avoid future retreatment in children with genetically missing teeth?

Carlo Marinello: Very important question! We should screen patients at an early age. We are talking about growth; we should not lose the opportunity for an early diagnosis. It is our duty to address sleep apnea and similar problems very early. Issues such as breastfeeding and tongue (soft tissue) development must be considered. The awareness must start very early. We should not be looking at patients mostly from a mechanical point of view. We need to understand the physiology behind each problem and, for example, start early with babies when the palate can expand. We must act prophylactically.

Renato Cocconi: I agree that the orthodontist should act as a sentinel, screening patients at the age of 7 to 9 years, because the orthodontist is often the first person to recognize important conditions like hypodontia or pediatric obstructive sleep apnea syndrome (OSAS), and refer that patient to a pediatrician, an ENT specialist or a neurologist. This is a complex problem that needs a team approach; it should not be downgraded to a condition that could simply be cured with a palatal expansion or by avoiding extractions. We need scientific evidence and the propensity for an interdisciplinary approach to avoid unrealistic expectations.

Carlo Marinello: I totally agree with what you just said; there is no evidence yet. However, in the study by Guilleminault et al (Guilleminault C, Sullivan SS, Huang YS. Sleep-disordered breathing, orofacial growth, and
prevention of obstructive sleep apnea. Sleep Med Clin 2019;14:13–20), the authors looked at patients who were treated early and due to this fulfilled an early prophyllaxis. Debora’s question was going in this direction: we should take care of children earlier and not wait until problems occur.

Marco Rosa: I agree with screening children between the ages of 7 and 9 years, but for males it could also wait until 10 years. We must have an early diagnosis between the ages of 7 and 9 years; thus, we need at least a panoramic radiograph. We also need to determine whether the parents have missing or impacted teeth. If the lateral incisors are missing, we also have to check the position of the permanent canines; if they are ectopic, we can intervene and intercept the problem by serial extractions or by expansion during the mixed dentition. After the extraction of the primary teeth, the ectopic canines have a very high probability of spontaneous eruption; otherwise, they may remain impacted.

Besides, by serial extractions of the primary lateral incisors and canines, it is possible to let the permanent canines erupt in the place of the missing lateral incisors and reduce the invasiveness of the subsequent orthodontic treatment.

Renato Cocconi: We try to facilitate the eruption of the maxillary canine as close as possible to the central incisors to obtain a proper development of the hard and soft tissues in the agenetic area, trying to prevent a defect, particularly if we will choose to open the space for a prosthetic replacement.

 MISSING ANTERIOR TEETH AND ORTHOGNATHIC SURGERY

Devorah Schwartz-Arad: How often do you find it necessary to do a Le Fort I orthognathic advancement due to the closure of the space of the lateral incisors?

Renato Cocconi: Currently, LeFort I to advance and down fracture the maxilla is used to obtain a better definition of the midface, more support of the upper lip, and improved dentition exposure. In Class III borderline cases, we do not use LeFort I to compensate for the retraction of the maxillary incisors, induced by the decision to close the spaces of the missing lateral incisors. The space closure and the consequent mesialization of the maxillary posterior buccal segments can be obtained with the support of TADs. Orthognathic surgery is used when the severity of the skeletal discrepancy or the request for esthetic improvement exceeds the limits of orthodontics.

Roberto Cocchetto: It is important to relate our treatments to growth. Orthognathic surgery in a Class III patient, for example, is never performed in teenagers because late growth is to be expected. Similarly, growth is what contraindicates placing an implant at this young age. The decision for both orthognathic surgery and the placement of implants should be age related. There is a point after which growth becomes irrelevant in orthognathic surgery, but it may still be relevant for implant placement, where even minimal variations can affect the esthetic result.

Carlo Marinello: Thank you to all involved in the discussion.

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Conclusions

The anterior missing tooth and orthodontics in the growing patient: open or close?

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The management of congenitally or traumatically missing maxillary anterior teeth in adolescents or adults remains a challenge in dentistry. Apart from periodontal and surgical interventions, dental solutions are based either on tooth movements within the dental arch (orthodontics) and/or a tooth- or implant-supported replacement of the missing tooth (prosthodontics). Orthodontics takes responsibility for the position and the size of the teeth, whereas prosthodontics manages their form and shade. The challenge is to find a balance between a dynamic, minimally invasive, age-based dental solution and the potential long-term consequences of the dental treatment. A staged procedure, starting with the least invasive measure, is always indicated.

Staged treatment planning

The decision-making process for a specific treatment depends on the specialty involved per se, the educational background and clinical experience of the dentist, and the wishes and financial situation of the patient. It also requires a comprehensive early diagnosis, and interdisciplinary treatment planning that involves an informed patient (informed consent) in the whole process. In this way, the invasiveness of the orthodontic and prosthodontic treatment is decreased.

Treatment planning must be guided by the least invasive and least risky therapy, which simultaneously guarantees mid- to long-term stability and the potential for easy reintervention and reversibility. Early diagnosis may reduce the necessity of treatment and may prevent overtreatment. Since the life expectancy of our patients is extended, and lifelong changes (such as growth, aging, remodeling, and maturation) are important aspects, dynamic, age-based, and individual treatment planning is necessary.

Retention and stability

In summary, at present the extent of the changes due to growth cannot be predicted. However, a pattern of growth can be recognized and verified with sequential multiple reevaluations that influence the treatment progress. An interdisciplinary team approach respecting minimal invasiveness is mandatory.
In indicated cases, the ‘space closure’ option represents a biologic, functional, evidence-based, and cost-effective solution. It has the advantage of being a straightforward strategy for the dentist and the patient and is the first alternative for growing patients. Orthodontic treatment aims to correct malocclusion, obtain stable and functional occlusal contacts, place the roots well inclined into the periodontal envelope, close the anterior spaces, and display the anterior teeth through minimally invasive restorative procedures to achieve the desired esthetic and functional results as well as long-term stability.

The finishing phase of orthodontic treatment for the space closure treatment option requires close communication/decision-making between the orthodontist and the prosthodontist so as to plan the best possible patient-oriented result.

The space opening option always includes prosthodontic measures, which per se might be subject to changes due to growth and might have a negative influence on the surrounding periodontal and/or peri-implant tissue. A so-called ‘correct final solution’ does not exist; a staged and progressive decision-making process led by noninvasiveness is reasonable.

After orthodontic treatment, a main challenge is retention and stability. For the latter, time is the fourth dimension in orthodontics. In specific cases (mostly patients without extractions), a lifelong retainer may be necessary; it is important to help patients understand (before they sign the informed consent) what the difference is between relapse and aging.

It is highly risky to proceed with any prosthetic rehabilitation immediately after the completion of orthodontic treatment. The factor of time (as previously mentioned, the fourth dimension in orthodontics) must be considered when deciding whether the situation is stable enough to proceed with the definitive rehabilitation.

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**Proposed form for Informed Consent for orthodontic treatment of anterior missing teeth**

**Marco Rosa and Stefano Gracis**

*Note: This is intended as a general guideline for developing an individualized form for your specialist dental practice and is not necessarily prescriptive.*

**Dear patient**

This document serves to highlight the concepts verbally communicated to you during your visits; therefore, not only the advantages of orthognathodontic therapy but also its generic risks, and to receive your consent to perform this therapy. It is a fact that a good final result is obtained with informed/collaborating patients and their parents.

**Treatment objective**

Correction of the malocclusions and space closure in the area of the missing teeth (attached Treatment Plan). Collaboration between you and the specialist is mandatory for obtaining a good final result. On your part, this essentially consists of: a) attending appointments; b) maintaining scrupulous oral hygiene (insufficient oral hygiene may make it necessary to discontinue treatment); c) complying with the therapeutic prescriptions in the manner and at the times requested by the specialist, both during active treatment and in the retention phases; and d) promptly notifying the dental office in case of discomfort, pain or changes in the structure of the appliances.
Possible temporary discomfort during therapy

The teeth and surrounding tissues, subjected to the action of corrective equipment, will require a short adaptation phase and new oral hygiene and eating habits (avoid hard, crunchy, and sticky foods). Even if the equipment is made of materials certified in accordance with the CEE 93-42 directive, using resistant systems and subjected to quality controls, they are subject to wear and tear. The utmost care and respect of the equipment is therefore recommended, avoiding trauma, impact or compression from excessive chewing. In the case of these issues or if you have any doubts, it is essential to contact the specialist dental office as soon as possible in order to remedy the problem in good time.

Generic risks of orthodontic treatment

Orthodontic therapy, like any medical procedure, presents some generic risks of which you need to be aware. As far as caries is concerned, orthodontic appliances are not responsible for tooth decay, but their presence allows bacterial plaque – the real causative factor – to accumulate more easily. Therefore, you are expected to devote greater care and patience to oral hygiene maneuvers to completely remove plaque and food debris from your teeth.

The risk of ingestion or aspiration of part of the equipment cannot be excluded.

Periodontal disease (inflammation, bleeding, gingival recession, loss of periodontal support) is linked to the presence of bacterial plaque that accumulates more easily during orthodontic therapy, hence the need for more specific and individualized oral hygiene. In the event of the objective finding of poor patient collaboration, accompanied by a worrying accumulation of bacterial plaque, the therapy might be temporarily or permanently suspended, in your best interests, in order to resort to specific treatments.

Reduction of the length of the dental roots

This event, which consists of a limited reabsorption of the root, can occur during therapy. Radiographically, this is seen as a simple remodeling of the apex, without interfering with the health and life of the teeth themselves. Major resorption can only be observed in some cases, often associated with particular situations such as dental trauma, anatomical anomalies, endocrine disease, drug taking or an individual’s predisposition, which interfere with bone metabolism. In such cases, therapy might be stopped temporarily or permanently.

Accidental injury

The presence of the equipment can, in case of trauma or breakage, represent an element harmful to the surrounding tissues (oral mucosa, face, eyes). In particular, it is recommended not to use extraoral removable equipment during physical activity or in other critical situations and to put it on and take it off with the help of an adult.

Extractions

Some cases will require the removal of primary (baby) teeth or permanent teeth. There are additional risks associated with the removal of teeth that you should discuss with your family dentist or oral surgeon prior to the procedure.

Orthognathic surgery

Some patients have significant skeletal disharmonies that require orthodontic treatment in conjunction with orthognathic (dentofacial) surgery. There are additional risks associated with this surgery which you should discuss with your oral and/or maxillofacial surgeon prior to beginning orthodontic treatment.

Temporary anchorage devices

Your treatment may include the use of a temporary anchorage device (ie, a metal screw or plate attached to the bone). There are specific risks associated with these devices. The screws could possibly become loose, which would require their removal and possibly relocation or replacement. The screws and related material
may be accidentally swallowed. If the device cannot be stabilized for an adequate length of time, an alternative treatment plan may be necessary. It is possible that the tissue around the device could become inflamed or infected, or the soft tissue could grow over the device, which could also require its removal, surgical excision of the tissue, and/or the use of antibiotics or antimicrobial rinses.

It is possible that the screws could break (i.e., upon insertion or removal.) If this occurs, the broken piece may be left in the mouth or may be surgically removed. This may require referral to another dental specialist. When the device(s) are being inserted, it is possible to damage the root of a tooth or nerve, or to perforate the maxillary sinus. Usually, these problems are not significant; however, additional dental or medical treatment may be necessary. Local anesthetic may be used when these devices are inserted or removed, which also carries risks. Please advise the doctor placing the device(s) if you have had any difficulties with dental anesthetics in the past.

Unpleasant situations/complications that could arise during therapy but that are not related to it

Trauma/loss of dental vitality: Trauma suffered in the past (even if unnoticed) may have caused damage to the pulp of the tooth. It is possible that the consequences of this occur during orthodontic treatment, in which case specific (endodontic) therapy will be required.

Dental ankylosis: This refers to the fusion of bone and tooth root. This condition does not allow the ankylosed tooth to be moved. Both primary and permanent teeth can be affected. The ankylosis of the included teeth, which are still in the bone and do not have the possibility of spontaneous eruption, cannot be diagnosed a priori. Although this occurrence is very rare, once ascertained it may make it necessary to extract the tooth itself.

Allergies: Allergies to acrylic resins and/or nickel, or any other allergic phenomena, will imply a change in the treatment plan or its suspension. They must be reported to the specialist as soon as possible.

Pain or noise of the temporomandibular joint: Pain in the joints where the jaw connects with the temporal bones of the skull base and the related neuromuscular structures can occur at any time in an individual’s life. Their etiology is multifactorial; they are not linked to orthodontic therapy and have a cyclical trend.

Unpleasant situations that can occur after treatment

Dental misalignment

Constant change is a constant in life. Facial structures are also subject to this evolutionary law: it is normal, for example, for the mandibular incisors to become crowded or wear slightly with age. It is therefore necessary at the end of the active treatment to use ‘restraint’ devices, the type of which will be decided on a case by case basis. An unfavorable growth of the maxillary bones could require retreatment using similar or different modalities.

In the case of the occurrence of any of the aforementioned complications, a referral for further treatment to your family dentist or another dental or medical specialist may be necessary. The fees for these services are not included in the cost of the orthodontic treatment.

The undersigned undertakes to comply with the instructions provided by the specialist as well as attend appointments for periodic checks, and understands that failure to comply with these procedures might affect the achievement of an optimal final result and the cost of treatment.

The undersigned declares to have been correctly informed and to have answered all the questions on the proposed treatment plan regarding the methods of treatment, any problems connected with it, and alternative therapies. Therefore, having discussed and understood what is reported, the patient gives consent to the proposed treatment.
Session II

Replacing the anterior missing tooth and growth

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Moderator’s introduction

For more than 50 years, dentistry has sought a more conservative approach to replacing a single missing tooth versus a conventional fixed prosthesis, which involves the cutting of sound tooth structure. Treatment possibilities have evolved from bonding a natural extracted tooth or a composite resin restoration to the adjacent teeth, to the adhesive bridge, and lately to the single-implant–supported crown.

Advances in conservative dentistry have been made and different treatment modalities are proposed including edentulous space closure and substitution of missing teeth, gap opening, tooth replacement with adhesive bridges, and gap distribution or shifting and restorative compensation. All these treatment options have shown good long-term survival rates and esthetic results but there remains a potential for relapse, debonding, and fractures. On the other hand, the single-implant–supported crown is a predictable method for tooth replacement. It allows a conventional oral hygiene technique, while stability and function are improved. Also, soft tissue modifications can be achieved, including recreation of the interproximal papillae. When placing an implant in the esthetic area, augmenting hard and soft tissue is also required in most cases. While osseointegration around implants is a well-documented phenomenon, implant designs continue to undergo structural modifications in order to fulfill the prosthetic requirements, aiming to meet the challenge of achieving esthetic results.

The most prevalent causes of anterior tooth loss are childhood trauma and congenital disorders. Timing of implant placement for those young patients is paramount. Placement of implants at an early age when the face is still growing transversely, sagittally, and vertically could result in implant infraocclusion, buccolingual disharmony, diastemata, gradual loss of labial bone, lingual shifting, and an altered gingival profile. Moreover, for the growing child, early implant ankylosis poses an even greater risk as it may disturb normal development of the jawbones. In the same manner, adult patients who are dentally mature are also not immune to altered hard and soft tissue levels, as reported by several authors, due to the continuous tooth eruption of the neighboring teeth.
Historically with the advent of implantology, restorative dentistry techniques in treating partial or full edentulism have been essentially considered as a therapeutic option only for temporization. However, as cases of esthetic failure of osseointegrated implants have been observed when implant-supported restorations have been applied for the replacement of anterior missing teeth, restorative dentistry is gaining more interest, particularly through the evolution of bonding techniques and the relevant biomaterials.

Finally, should we consider that neither of the two fields is superior to the other and that both are reliable techniques? Or does patient selection prevail, given the fact that every patient is unique? The purpose of this session is to unlock the mystery and to know how to set the indication of these therapeutic options through the discussion of clinical cases, and based on expert opinion and data from the literature.

References


Essay III

Adhesive restorative options for restorative space management in the anterior zone with or without orthodontic pretreatment: some clinical considerations and case presentations

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Abstract

An unfavorable relationship between the form and dimension of the dental arch and the number, dimension, and shape of the existing teeth can pose several esthetic, biologic, and functional problems. In this article, the various restorative options are discussed based on clinical and scientific evidence: Gap closure and substitution of missing teeth: restorative transformation of substituted teeth into homologous teeth with odontoplasty, direct composite, etched pieces or porcelain veneers. Gap opening and tooth replacement with all-ceramic adhesive bridges, including pontic site development. Gap distribution and restorative compensation with direct composite restorations, etched pieces or porcelain veneers. Gap shifting and restorative compensation with all-ceramic adhesive bridges, composite, etched pieces or veneers. Gap compensation by reconstructive compensation without orthodontics. The reconstructive tools including composite restorations, ceramic veneers, and adhesive bridges are discussed, and numerous cases are presented to illustrate the concepts.

Keywords: adhesive restorative options, restorative space management, substitution of missing teeth, direct composite restorations, ceramic veneers, adhesive bridges
Some general considerations

An unfavorable relationship between the form and dimension of the dental arch and the number, dimension, and shape of the existing teeth (typical Bolton 3 or 6 discrepancy, malformed or undersized teeth, agenesis of teeth, tooth loss due to early trauma) can pose several esthetic, biologic, and functional problems. In many cases, an optimal result cannot be achieved by orthodontic, restorative, or reconstructive means alone. Furthermore, patient desires, capacity of compliance, and financial considerations are important factors to be included in the treatment concept.6,26

For all options discussed below, the clinical sustainability is well documented in the literature. All options show high survival rates and low complication rates in the hands of the experienced clinician. From the multitude of long-term studies, systematic reviews, and case documentations it can be extrapolated that both resin-bonded bridges17-18 and veneers19-20 behave similarly well and may reach 10-year survival rates of 95% or more, and reintervention rates over 10 years that are lower than 5% to 10%, given proper indication and handling.10,11,12,16

The cost effectiveness of resin-bonded bridges extrapolated over a patient’s lifetime is also very favorable compared with full-crown bridges and single tooth implants.18 Since currently the standard extension of a resin-bonded bridge is now two-unit (one-wing) and no longer three-unit (two-wing), the risk of secondary caries due to loose wings is no longer relevant.17 The standard materials for resin-bonded bridges are either zirconia or lithium disilicate glass-ceramics.11,13-16

Glass-ceramic veneers seem to perform slightly better than feldspathic veneers, indicating that materials with increased strength show better clinical performance.25 There are also attempts from the industry to use even stronger materials such as zirconia to fabricate veneers as well. However, since neither long-term results nor sufficient clinical experience are available, it should be considered today as an experimental procedure.

Direct restorations with composites are today an indispensable and attractive noninvasive way of reshaping teeth. The essential techniques for success are widely available and very well documented.26-30 The multitude of parameters such as type of adhesive materials and procedures, handling properties, curing techniques, operator skills, etc. have an explicit and important influence on the outcome. In line with this, a recent systematic literature review shows quite inhomogeneous results. Some data, however, reach the same level as veneers.31 In the light of easier modes of reintervention, and given a proper indication, direct composites can no longer be regarded as principally inferior to veneers.

The goals of modern treatment concepts must include high long-term success, minimal invasiveness, and high potential for reintervention, with minimal risk of complications.32 This is the case with the aforementioned options. This essay will concentrate on the available restorative and reconstructive adhesive options, but it will not discuss the detailed implantologic or orthodontic options, which are presented in separate essays in this article.

Restorative or reconstructive corrections without preceding orthodontic treatment?

If the patient’s wishes cannot be met by orthodontics alone, the question remains as to whether they could be met with restorative and reconstructive measures alone, which would be a significant simplification of the whole process. The premise for this, however, is that the occlusion is rated as stable in the long term.

As long as this is possible in a minimally invasive and reintervention-friendly way, restorative or reconstructive treatment alone is an attractive option for the patient to minimize the risks of arch instability and tooth position instability and relapse after orthodontic treatment, in addition to the unavoidable lifetime den toalveolar and jaw basis changes.

The exclusive restorative or reconstructive treatment is acceptable from a periodontal and preventive standpoint, provided the roots are in a favorable position and the tooth crowns do not need to be prosthetically retruded but should be protruded and enlarged for esthetic reasons. A favorable root position means that the emergence at the gingival level is correct and in line with the adjacent teeth. A clear no-go for prosthetic compensation alone is a situation with heavily crowded teeth. Above all, if teeth are conoid or slight-
ly lingually inclined, the minimally invasive adhesive options are inviting.

Orthodontic treatment alone to completely avoid restorative or reconstructive corrections?

It looks tempting at first glance to avoid any restorative or reconstructive corrections and close gaps irrespective of missing or undersized teeth. If the functional and esthetic analysis of the existing teeth allows, this is the preferable option. There is no evidence that space closure compared with space opening in the case of missing maxillary lateral anterior teeth would lead to an increased rate of TMJ problems, recessions, abfractions, and abrasions. However, this may in some cases lead to esthetically less-satisfactory results.

In the light of the aging dentition, it must also be taken into account that a simple orthodontic concept of only closing gaps without respect to proper dimensions and proportions of the respective teeth with regard to adequate arch and face dimensions can lead to practically unsolvable esthetic problems later on; patients who want to improve the esthetics of their aging dentition find that the size, position, and play-ground for shape improvements is limited by a strongly limited space available due to initially small teeth.

Restorative and reconstructive options

The five restorative and reconstructive options to treat a dentition with anterior gaps may be summarized as follows, as single measures or in combination, and with or without a preceding orthodontic treatment phase.

1. Gap closure and substitution of missing teeth: restorative transformation of substituted teeth into homologous teeth with odontoplasty, direct composite, etched pieces or porcelain veneers.
2. Gap opening and tooth replacement with all-ceramic adhesive bridges, including pontic site development.
3. Gap distribution and restorative compensation with direct composite restorations, etched pieces or porcelain veneers.
4. Gap shifting and restorative compensation with all-ceramic adhesive bridges, composite, etched pieces or veneers.
5. Gap compensation by reconstructive compensation without orthodontics as reconstructive tools to be used for the aforementioned options. With this option, the following means should be considered:

1. Adhesive form corrections

Composite restorations or ceramic veneers offer excellent long-term results. Whereas composite restorations will preferably be used in the growing patient or to recontour parts of the clinical crown, veneers will be preferred if the clinical crown as a whole needs a change of shape and dimension, e.g., in the case of a substitution of a central incisor by a lateral incisor, or when a color shift is needed that cannot be achieved by external bleaching alone (e.g., in the case of a substitution of a lateral incisor by a canine).

2. Adhesive tooth replacement

If one tooth is missing, the concept of two-unit adhesive bridges is widely accepted as the most promising solution, if all-ceramic bridges may be used. Either zirconia or glass-ceramic frameworks perform well. If a three-unit resin-bonded bridge is planned to keep the position of the adjacent teeth or to improve the load capacity, a classical metal framework with retentive micropreparations should be considered, since all-ceramic frameworks for this indication do not show a promising long-term outcome. Also, if more than one tooth needs to be replaced, metal frame works are still preferred. As framework materials, either nonprecious or noble alloys can be used.

Case presentations and some technical considerations

Ten illustrative cases are shown in short to highlight the considerations and provide some evidence from the literature concerning important technical details. It is evident that as clinicians we need to find answers to the clinical challenges and the related questions, ac-
cepting that we will not find satisfactory answers to all the questions when we plan a case. The main consideration, therefore, is to use a progressive approach. This means the younger the patient, the more potential for reintervention, and subsequently the importance of minimally invasive concepts.

Therefore, for the growing and young adult patient, direct techniques are the first choice, whereas for mature patients, degradation and fatigue of tooth substance may be better compensated for by slightly more invasive indirect techniques such as full veneers or even bonded partial all-ceramic crowns; in addition, bleaching is no longer effective to compensate for darkened tooth colors.

1. Gap closure

Restorative transformation of substituted teeth into homologous teeth with direct composite or veneers

Case 1: Both maxillary canines were placed orthodontically at the position of the missing lateral incisors (agenesis) (Fig 1). Since the canines were rather small and did not differ much in color from the central incisors after external bleaching (which is a good indication for this approach), only incisal shortening and a minimal shape correction with direct composite are necessary in such a case. The correct orthodontic positioning of the canine in this case is essential: adequate extrusion to achieve an ideal gingival architecture.⁶

Case 2: The canines at the position of the missing lateral incisors were considerably darker than the other anterior teeth and not responding well to external bleaching (Figs 2 and 3). Therefore, two thin veneers (feldspar porcelain) with minimal preparation were inserted to compensate for both the shape and color of the canines. The missing permanent mandibular central incisors were replaced with a four-unit adhesive bridge (porcelain-fused-to-metal [PFM] technique).

Case 3: The two maxillary central incisors were lost due to an accident when the patient was a young girl (Fig 4). The gap was closed by moving the remaining anterior teeth toward the midline. Since it was a Class II occlusion with prospective missing space in the buccal area, this was an elegant solution. If all teeth had been present, two premolars would have had to be extracted in the maxilla. The two lateral incisors in the position of the central incisors were first built up with composite, and in a later phase, when the patient was around 20 years of age, rebuilt as central incisors with all-ceramic partial crowns (Figs 5 and 6).
Fig 1  Case 1  Initial and final situation: direct composite restorations.

Fig 2  Case 2  Initial situation of maxilla with micropreparation; final mandibular adhesive bridge.

Fig 3  Case 2  Final result.
2. Gap opening

Tooth replacement with all-ceramic adhesive bridges, including pontic site development

The following rules should be followed for construction:

**Recommended minimal dimensions of the framework in the anterior zone**

1. **Connector**: height x width: 3 x 2 mm for zirconia, 4 x 4 mm for lithium disilicate glass-ceramics.\(^{11}\)

2. **Gap opening**: Tooth replacement with all-ceramic adhesive bridges, including pontic site development

   The following rules should be followed for construction:

   **Recommended minimal dimensions of the framework in the anterior zone**

   1. **Connector**: height x width: 3 x 2 mm for zirconia, 4 x 4 mm for lithium disilicate glass-ceramics.\(^{11}\)

2. **Gap width**: > 7 mm should be considered as an increased risk for fracture for a two-unit all-ceramic bridge.\(^{11}\)

3. **Wing dimensions**: bonding area for the wings should reach 30 mm\(^2\) (preferably in enamel only) to properly withstand shear forces under loading, and the recommended thickness should ideally be 0.7 mm or greater, both for all-ceramic and metallic frameworks.\(^{11}\)
Case 4: Both maxillary lateral incisors were missing (agenesis) and had been replaced by another clinician with bonded three-unit ZrO2 bridges (Figs 7 and 8). These bridges broke and debonded after a short time, as was to be expected. This is a typical example of what can go wrong if basic rules are violated. It is obvious from the literature that all-ceramic adhesive bridges should principally be constructed as two-unit bridges.\textsuperscript{20,22} In addition, neither the wing extension nor the wing thickness were respected. The defects resulting from the inadequate former preparation of the canines and inadequate wing area were rebuilt with composite, and the residual defects at the central incisors were used as positional grooves for the new frameworks. A shallow palatal groove and rounding off of the palatal enamel ridges at the connector site is helpful to allow proper seating and better stability of the framework. In addition, overcontouring of the margins can be avoided.

Due to the limited space for the adhesive wings, a 3Y partially stabilized ZrO2 framework was used. The use of glass-ceramics is not advisable in this case. A thin ceramic veneering is performed on the buccal side of the pontic (Figs 9 to 15).
Fig 9  Case 4  Composite buildups and micropreparations.

Fig 10  Case 4  Provisional RPD; site development for ovate pontics; analog impression.

Fig 11  Case 4  CAD/CAM processing of zirconia frameworks; overextension for milling.
What type of zirconia should be used for adhesive bridges?

The material of choice is 3Y partially stabilized ZrO₂. Generally, the use of 4Y- or 5Y-ZrO₂ is not recommended. The increased content of cubic (fully stabilized) ZrO₂ leads to considerably lower mechanical properties. These materials may have a slightly better transparency as one of the esthetic components compared with 3Y-ZrO₂; however, the respective refractive index around 2 (or more) is still much higher than enamel, dentin, cementum, and lithium disilicate glass-ceramic materials (all around 1.5 to 1.6), which causes still more diffuse internal and surface reflection.

Adhesive cementation of zirconia frameworks

The frameworks are sandblasted using a tribochemical conditioning of the surface with 30 μm particle size SiO₂/Al₂O₃ (Rocatec Plus, 3M Espe) and a pressure of 2.5 bar (distance 10 mm, perpendicular blasting direction) to achieve an active and ideally textured surface. The ceramic surface is then first cleaned in an...
ultrasonic device (alcohol) and primed with a combination of methacryloyloxydecyl dihydrogen phosphate (MDP) and silane (Clearfil Ceramic Primer Plus; Kuraray). As cement, the transparent Panavia V5 (Kuraray) is used after acid etching the enamel and conditioning and priming the dentin and enamel with Panavia V5 tooth conditioner. This approach is the most predictable and easiest to use in the clinic.

Important: Panavia V5, in contrast to Panavia 21, does not contain MDP in the paste itself; therefore, the use of the MDP-containing (and silane-containing) primer on the zirconia surface is imperative.

Development of the pontic site area
When dealing with a unilaterally missing lateral incisor (agenesis), often the contralateral incisor is smaller than normal or has a conoid shape. This is an ideal indication for an adhesive bridge to replace the missing tooth, since the smaller the gap, the better the mechanical situation for a two-unit bridge. In addition, the edentulous ridge area is easier to condition for the pontic integration or for soft tissue augmentation procedures. An ovate pontic design should always be preferred as a standard design due to its esthetic advantages and biologic acceptance as well as ease of cleaning with dental floss.

Case 5: The unilateral missing lateral incisor was replaced with a two-unit all-ceramic adhesive bridge after orthodontic treatment (Fig 16). Since the tooth color was rather transparent and light at the same time, and the intermaxillary space was sufficient for a 4 x 4 mm connector design, a glass-ceramic material (IPS e.max Lithium Disilicate; Ivoclar Vivadent) could be used, with thin buccal veneering of the pontic. As a preparation concept, an almost non-prep design was used. The only preparation that was required was the rounding of the enamel at the connector site. The downside of a non-prep and non-retentive design is the difficulty of proper positioning of the wing during cementation. The ceramic was etched for 20 s with hydrofluoric acid according to the manufacturer’s instructions (Ivoclar Vivadent); a primer containing silane was used, and the enamel was etched with phosphoric acid. A flowable, light-cured composite of medium viscosity was used as a cement (Fig 17).

The pontic site can be developed with different methods. If it is a narrow gap between the adjacent teeth before the orthodontic opening, ridge augmentation procedures can often be avoided, when the teeth are slowly separated from each other. A provisional removable denture can be used after completion of the orthodontic treatment to displace and redistribute the soft tissue and to form the papillae.

If this is not sufficient, a tissue augmentation procedure is indicated, mostly soft tissue only. The main advantage of a pontic is that there is no need for a bony socket, as is required for an implant. The site must then be developed to accept an ovate pontic by
using the provisional removable partial denture (RPD) as a scaffold. It is very effective to underline the provisional pontic with composite to shape the soft tissue non-surgically into the right form. However, the edentulous ridge will not increase its vertical dimension during the growth period and will not later adapt to the repositioned adjacent teeth during the lifelong eruption. In this respect, only the passive eruption of the adjacent teeth will compensate partially for the continuing active eruption, if an ovate pontic with a deep basal part is integrated initially. It is often observed over time that the pontic loses its initial tight soft tissue contact due to the effects described above. However, this is mostly much better tolerated by patients than an implant, which seems to be in an intruded and protruded position due to the same long-term effects. Case 6 may illustrate this process.

Case 6: The patient presented with a missing central incisor after an accident early in life. The ridge was rebuilt using both a xenograft material (Bio-Oss; Geistlich) and a soft tissue graft to build up the ridge (Figs 18 and 19).

An adhesive three-unit PFM bridge was inserted almost 30 years ago. After 22 years, at the time the patient presented, the bridge was still in place, but the decreased contact between the pontic and soft tissue receptor site could no longer be seen. From a me-
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From a mechanical standpoint, three- or four-unit adhesive bridges should preferably be supported by a metallic framework, either nonprecious alloys or noble alloys, which are esthetically easier to veneer with porcelain. The bonding procedure is principally the same as already described above for ZrO2 frameworks. However, to prevent a grayish effect of the wings on the abutment teeth, an opaque cement should be used (e.g., Panavia V5).

Four-unit adhesive bridges with a metal framework to replace two missing mandibular central incisors may also be able to stabilize the arch after orthodontics, without the need for a wire retainer (Case 2), in contrast to two separate two-unit all-ceramic bridges, where in most instances a wire retainer should be used together with the bridges.

Case 7: The patient lost both maxillary central incisors early in life (Fig 20). After orthodontic aligning of the remaining teeth, a ridge buildup was performed with soft tissue augmentation alone. The pontic area was conditioned with an RPD, and a four-unit adhesive PFM bridge was inserted, which also serves as a retainer in the maxilla (Figs 21 and 22).
Fig 20  Case 7  Initial situation and site development with soft tissue buildup.

Fig 21  Case 7  Micropreparations for adhesive bridge; metal framework (nonprecious alloy).

Fig 22  Case 7  Final result.
3. Gap distribution

Restorative compensation with direct composite restorations, etched pieces or porcelain veneers

Case 8: The young female patient presented with a Bolton discrepancy (Fig 23). The anterior tooth forms were restored using a direct approach with composite. Diagnostics include a direct mock-up with the respective composite, allowing the clinician to test the correct layering to achieve the aspired colors and the optimal shape, and also to test whether this is realizable in the hands of the clinician. The mock-up is photographed and further analyzed. In addition, optical or analog impressions can be taken for documentation, before the planned alterations were realized definitively with the direct composite technique (Figs 24 to 26). It can also be helpful during the orthodontic treatment to evaluate the esthetic potential of the repositioned teeth by an interim mock-up.

4. Gap shifting

Restorative compensation with all-ceramic adhesive bridges, composite, etched pieces or veneers

This is an interesting alternative to avoid problems in the esthetic zone. Either a gap is shifted away from the esthetic zone, or multiple gaps are reduced to one gap, and an additional anterior tooth is inserted with an all-ceramic adhesive bridge. Thus, multiple restorations or reconstructions to enlarge teeth that are too
small can be avoided in favor of one single reconstruction on one single abutment tooth, be it a pontic or a veneer, or simple direct composites on the teeth adjacent to the opened gap.

Case 9: This is an instructive example. The mandibular small anterior teeth that all presented gaps were grouped to one side, and a fifth anterior tooth was added adhesively with a bonded bridge (Fig 27). This is an elegant option for the mandibular anterior area, where five instead of four incisors are not obvious to the eye of the beholder (Fig 28).

Fig 25  Case 8  Final result: soft shapes for an airy delicate look.

Fig 26  Case 8  Final smile.

Fig 27  Case 9  Initial situation after orthodontic treatment; direct mock-up.

Fig 28  Case 9  Final result of glass-ceramic adhesive bridge, with the addition of a fifth anterior tooth.
5. **Gap compensation by reconstructive compensation without orthodontics**

A case may not be indicated for a combined orthodontic-reconstructive approach if major reconstructive interventions are needed anyway to compensate for missing or a major amount of malformed tooth substance. If minimally invasive interventions are still feasible, this can be an attractive option – firstly, because it is efficient and effective, and secondly to avoid problems with the potential relapse after orthodontic treatment.

Case 10: The patient presented with a pronounced Bolton discrepancy and an equally pronounced amelogenesis imperfecta (Fig 29). In view of the large amount of missing tooth structure, the patient was reconstructed in full by veneers with no-to-minimal preparation, all-ceramic partial crowns, and adhesive full-veneer crowns without orthodontic intervention. The very small mandibular teeth were enlarged with slightly overlapping shapes to hide the dimensions and achieve a believable appearance (Figs 30 and 31).
Final remarks

Adhesive dentistry today offers outstanding potential to resolve even complex cases with minimally invasive techniques, be they direct or indirect. This enormous potential for reintervention places adhesive dentistry at the forefront of restorative and reconstructive dentistry. There is also the possibility for the patient to choose between different valuable and sustainable options for comparable clinical situations. However, in the light of the increasing complexity of optimally managing materials and techniques used in current restorative and reconstructive dentistry, the individual levels of knowledge and manual skills of the involved clinicians and dental technicians are the key factors for success.

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References

Essay IV

Ongoing alveolar growth, continuous tooth eruption, and implants

Literature evidence and clinical interpretation

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Abstract

It is common knowledge that dental implants should not be inserted in adolescents, before completion of skeletal growth, because they behave as ankylosed teeth and remain in a fixed position while the surrounding bone and teeth are still developing, with consequential worsening esthetic damage. However, there is growing evidence that this phenomenon may continue throughout life in a large number of adult patients, although with a great variability in onset, progression, and extent. Infraocclusion and interproximal contact loss are the more common complications, and the majority of clinically significant cases are located in the anterior maxilla. The esthetic impact is mostly minimal, but in some cases the patient’s smile may be severely compromised. Therefore, adult patients need to be informed when dental implants are considered to replace anterior missing teeth.

Keywords: adult alveolar growth, dental implants, infraocclusion
Introduction

The replacement of anterior missing teeth (either due to agenesis, severe dental pathologies, or trauma) has always been a challenge for dentistry. For a long time, the only options available were removable appliances, too often offering poor functional and esthetic outcomes, or crown and bridges, inevitably too demoli-
tive in the case of intact abutment teeth.

The discovery and evolution of the principles and techniques of dental adhesion offer a better, more conservative option: a resin-bonded prosthesis, the Maryland bridge. However, this has often been consid-
ered by many to be a temporary solution due to the low predictability of the adhesive performance and the unesthetic grayish appearance given to the supporting teeth by the metal framework.

After the advent of modern implantology, the use of artificial roots to replace anterior missing teeth has rapidly become the preferred choice among patients and clinicians, being considered more ‘natural’ than a traditional crown and bridge restoration, and more functionally reliable than an adhesive bridge. Howev-
er, when dental implants began to be used in anterior tooth replacement, the negative impact of this treat-
ment option in young patients was initially underesti-

dated. It was the demonstrated by animal studies5 that a dental implant has an ankylosic connection with the bone and does not follow the natural eruption of the adjacent teeth. Therefore, the implant-supported crown remains stationary while the surrounding alve-
olar bone and teeth will ‘move,’ mostly in a forward and downward direction in the anterior maxilla. This is an analogy of what happens when, in children and ad-
olscents, a traumatically avulsed anterior tooth is reimplanted too late to restore a vital periodontal attach-
ment and so it becomes ankylosic to the bone, soon showing a progressive infraocclusion which, in time, becomes an increasingly severe esthetic problem.

Following this evidence, it became clear that skele-
tal maturation and chronological age needs to be considered,6 and it is commonly recognized and rec-
ommended to delay implant placement until the end of adolescence, when alveolar growth has ceased. However, as it will be demonstrated by this essay, based on the scientific literature and clinical evidence, infraocclusion of anterior implant-supported teeth (to-
gether with other related alterations) may also occur in a large number of adult patients, affecting the long-
term results of implant treatment, sometimes mildly (Fig 1) and sometimes severely (Fig 2). Considering that more than two thirds of dental implants are insert-
ed in the anterior maxilla,7 it is important to improve our knowledge of this topic and review our concepts in the treatment planning of the replacement of ante-
rior missing teeth.

Literature evidence

It is quite surprising that so little is known within the dental community about this complication of implant treatment, as it if far from rare. Even more surprising is the fact that the term ‘infraocclusion,’ associated with dental implants, cannot be found in the latest edition of the glossary of terms sponsored by the world’s leading scientific organizations dedicated to implant-
ology, the Academy of Osseointegration (AAO), and the European Association for Osseointegration (EAO), as it is in other similar publications. Moreover, only in the latest edition of the most comprehensive textbook on complications in implant dentistry,8 has a new chapter been included: ‘Craniofacial growth in adults and its implications for implant reconstruction.’ And again, recently, a detailed article8 analyzing 50 years of osseointegration from different perspectives did not mention this problem at all, including in the ‘final open questions.’

It therefore appears necessary to review the litera-
ture on the topic. But before that, it may be useful to briefly review some basic knowledge on craniofacial growth, which is indeed a very complex topic. Beyond sutural growth, which is responsible for most of cranial development, facial growth happens through appo-
sition and resorption of the maxilla and mandible (the latter also comes from condylar growth). Donald En-
low’s V principle postulates that the bones of the cra-

niofacial area, which have a V-shaped configuration, show bone resorption occurring on the outer side of the V of the bone, while bone deposition occurs on the inner side of the V. Therefore, the movement of bone during growth occurs toward the open end of the V. Then, to accommodate tooth eruption, the
maxilla and mandible grow together in a downward and forward direction (counterpart principle).

It is a common knowledge that the growth of the bones supporting the dentition increases from childhood to adolescence, then decreases and almost completely stops with the cessation of skeletal growth. For this reason, it has been suggested that, when indicated, implants should be placed only after the age when skeletal growth is thought to be completed.\textsuperscript{11-14}

The end of adolescence and the beginning of adulthood coincides with the exhaustion of growth potential, but adaptive changes of the jaws continue. The amount of growth decreases steadily after the second decade of life; however, some studies in the orthodontic literature indicate that growth of facial skeleton continues throughout life, progressing in a timespan of over 60 years.\textsuperscript{15-20} In particular, it has been demonstrated that maxillary tooth eruption does not stop after skeletal maturation. While the anterior maxilla of males remains straight, females show a tendency for the incisors to incline their apex in a palatal direction. Therefore, males are said to be ‘forward rotators,’ while females are more ‘backward rotators.’ Also, posterior teeth, molars, and premolars tend to erupt to an even lesser extent than canines and incisors; therefore, a posterior implant crown may also become infraoccluded\textsuperscript{21} (Fig 3).

In the vertical dimension, average changes are small, but there is large interindividual variability, so that some patients manifesting maximum growth may show 2 to 3 mm of vertical increase in the natural teeth and a corresponding infraocclusion of the implant crown, while others, with little or no growth, may show no vertical change and no infraocclusion.\textsuperscript{16}

Less relevant modifications take place in arch dimensions. For example, the maxillary intercanine width is thought to increase significantly up to approximately 16 years of age\textsuperscript{22} and then tends to decrease a
little, no more than 0.5 to 1.0 mm over a 20-year span. Nevertheless, there are some clinical cases which contradict this fact and show, for example, the progressive formation of a diastema between a central incisor implant-supported crown and the contralateral lateral central incisor. In a similar case reported in a recent article, a left central incisor was replaced by an implant crown which then developed a mesial and distal open contact. At a later stage, the implant-supported crown also started to show infraocclusion, together with a further increase of the diastemas; after replacing the crown, the mesial open contact reappeared, and also a barely visible infraocclusion returned (Fig 4). These modifications developed during a 16-year period, demonstrating the persistence of the phenomena also during mature adulthood.

Due to the effects of all the above subtle but continuous modifications taking place in a large number of adult implant patients, there have been a growing number of clinical observations and articles on this topic in the dental implant literature. Most articles are only a retrospective analysis of the outcome of implants placed in the anterior maxilla of adult patients. In order to draw a short summary of the results reported by these publications, it can be useful to consider some parameters that may help to interpret the infraocclusion phenomenon.

Firstly, the prevalence of infraocclusion varies in different studies, from a minimum of 40%25 up to 100%24 of cases. With regard to patient age as a predisposing factor, only one study20 reported a three times greater probability of infraocclusion for patients under 30 years, while others23,24,26-28 found no differences.

Regarding sex as a predisposing factor, one author29 reported that females had a significantly greater chance than males of developing infraocclusion, but the sample size was limited to 28 crowns (20 in males, eight in females). All the other studies found no difference.23,24,26-28

Patients showing an anatomic pattern defined as long-face syndrome were considered at higher risk28 but only one article found a weak association with infraocclusion.30 Moreover, Aarts et al31 demonstrated that facial growth cessation is not influenced by the shape of the face.

Another possible contributing factor is the state of occlusion; namely, a lack of occlusal contacts of the anterior maxilla. However, a correlation was suggested in only one study,32 which was conducted on a small group of ten adolescents (15 to 19 years old). On the contrary, the lack of posterior occlusal contact in the case of posterior free-end implant restorations in both arches can result in the loss of their bearing capacity if they become infraoccluded. This will put the remaining anterior dentition under stress, with mechanical consequences.33

At the moment, there is the only one very recent publication with a prospective design.34 In total, 31 patients (18 women and 13 men, with a mean and median age of 23.8 and 18.8 years; range 17.8 to 52.8 years) received single anterior maxillary implants. A slight (< 0.5 mm) infraaposition was found in 36% of cases, but with a mean follow-up of only 4.5 years (range 3.3 to 6.6).

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Fig 3 Premolar (tooth 25) at time 0 (a) and after 10 years (b and c): infraocclusion is clearly visible.
For the sake of completeness, another clinical consequence of ongoing adult facial growth must be mentioned: the interproximal contact loss (ICL). This is the formation of a space, usually between the mesial aspect of an implant-supported crown and the adjacent tooth (Fig 5). The frequency of this complication – related to the spontaneous mesial drift of teeth, generating anterior crowding in the maxilla but mostly in the mandible – ranges from 34% to 66%. It is more precocious and more disturbing for patients than infraocclusion, generating problems like food impaction, caries, and peri-implant mucositis.35

A recent extensive retrospective study36 on 4325 implants reported a much lower incidence (17%) of ICL, although it showed an increase over time (28% at 8 years). No difference was found between males and females. The possible role of occlusal forces as a contributing factor has been dismissed.
Clinical interpretation

From the above synthetic analysis of the scarce available literature, it appears that the only proven fact is the relevant incidence of the ongoing modifications of jaws in adult implant patients. So, why is the topic still rarely included in the program of scientific meetings, and unknown to the large majority of dentists? The simple answer is that these modifications take place over years – at least 3 to 5 – but with a large interindividual variability and also with some notable exceptions.

An example is the case of a 35-year-old female patient whose implant-supported maxillary left central incisor developed a remarkable infraocclusion of 1.2 mm after only 15 months5 (Fig 6). The treatment required intrusion of the natural tooth 11 and splinting of the two crowns. After 5 years, there was no further complication (Fig 7).

Basically, most patients with infraocclusion (and also many dentists) do not notice this initial minimal discrepancy, and if they do, they tend to disregard it in the majority of cases. In a recent study,28 the patient’s “awareness and perception” of the problem was analyzed through a questionnaire that produced a score for each patient. As expected, most patients with infraocclusion (71.8%) either failed to notice it or consider it an esthetic problem, but 18.2% of them expressly requested to be treated. In particular, 22.2% of the female patients in the study requested treatment. Four out of six of them presented a high smile line, so that the more apical the gingival margin (very often associated with infraoccluded crowns), the more the negative esthetic effect of the incisal margin discrepancy.

It is true that in many cases the esthetic problem generated by infraocclusion can be easily resolved, ie, elongating the incisal margin or making a new crown, if needed. Therefore, the implant prosthetic design should be planned to facilitate crown retrievability. Screw retention must be preferred, and if a cement-retained crown is used, a low adhesion luting material is indicated.

Patient age at time of implant insertion has not been confirmed as a contributing factor for infraocclusion. Nevertheless, if a patient is in the first half of the third decade, and later develops infraocclusion that requires a first corrective intervention, it must be expected that – as reported in the literature50 – infraocclusion will probably emerge again at a later time. This may well become a reason to maintain natural abutments as far as possible before declaring a tooth hopeless and a candidate for extraction, as too often happens.

If possible, it makes sense to delay the use of implants in the esthetic zone in young adults as they are not always the best solution to replace missing teeth. Moreover, it is important to bear in mind that, in some cases, the result of infraocclusion can be severely disfiguring and may require very complex and invasive treatments. Such treatments include surgical implant repositioning by segmental osteotomy combined with osteodistraction or submergence, or the removal of
If more than one adjacent implant is involved, the treatment may become very difficult and its outcome unpredictable. For these reasons, especially when replacing an anterior tooth, alternative treatment options should be considered and discussed with the patient. For example, traditional crown and bridge offers a well-documented long-term efficacy and should be considered the first choice when the teeth adjacent to the edentulous site are already prosthetically restored. In case of intact dentition, the functional and esthetic performance of resin-bonded fixed restorations have greatly improved in recent years.

It is advisable to also apply the approach of Patient Reported Outcome Measures (PROMs) to this specific area of treatment, as has been suggested for other fields of implant dentistry.

Finally, when the implant option has been chosen, it is mandatory to thoroughly explain to the patient that the restoration might need to be modified in the future in order to adapt it to possible subtle anatomical changes, the development and amount of which cannot be anticipated. This explanation should be included in the informed consent form that the patient will sign. It is equally important to define the liability issue when different professionals are involved in the treatment (oral surgeon, periodontist, prosthodontist) to avoid future legal disputes. Future well-designed studies (ie, prospective studies) are necessary to improve our knowledge of this relevant aspect of implant treatment.

Fig 6  A 35-year-old female patient with one implant-supported crown in position 21 (a), and 15 months later (b).

Fig 7  (a to c) The situation is stable 5 years after orthodontic intrusion of tooth 11 and splinting of the two crowns.
Conclusions

1. Adult craniofacial growth is a proven clinical fact.
2. It may become a problem when implants are placed adjacent to the natural teeth.
3. Infraocclusion and ICL are the most common complications.
4. The majority of clinically significant cases are located in the maxillary esthetic zone.
5. It evolves very slowly over time but with a large variability in onset, progression, and extent.
6. It has been weakly associated with females and long-face skeletal types.
7. The clinical relevance is mostly minimal but in some cases serious esthetic problems may arise.
8. It should be better studied and considered with attention in treatment planning to the esthetic zone.
9. Alternative and predictable treatment modalities should also be reconsidered.
10. Patient information is mandatory, and forensic liability issues need to be clarified.

References


Discussion

Moderator: Hadi Antoun
Discussion Editors: Aris Petros Tripodakis and Stefano Gracis

The implant-supported restoration option – growth and infraocclusion

Hadi Antoun: At what age is it indicated to place an implant, and in which situations?

Marco Rosa: There are two types of bone: the basal bone and the alveolar bone. Craniofacial changes are related to the basal bone, which is above the alveolar bone, and it stops growing when the body stops growing, between 18 and 20 years of age. It has nothing to do with infraocclusion. Changes related to the implant position occur due to the growth of the alveolus. Aging involves abrasion of the tooth surfaces and continued growth of the alveolar process. There is weak scientific evidence that females and patients with long faces may be more at risk of infraocclusion.

Aris Petros Tripodakis: The phenomenon of infraocclusion of an implant can definitely be related to skeletal alterations over time, such as aging and growth. We as dentists, however, deal with problems intraorally and occlusion is a major clinical issue. The mechanical forces of occlusion over time definitely play a role in the overeruption and labial migration of the natural anterior teeth, which will not be followed by an ankylosed adjacent implant. These forces increase over time when mutual occlusal protection becomes ineffective due to the loss of posterior support. The occlusal factors should also be taken into consideration in order to evaluate why these anterior teeth migrate, even though occlusion is irrelevant in certain cases. Occlusion may become relevant when there is loss of posterior support combined with anterior flaring and periodontal involvement.

Beatrice Vilabo: Tooth wear might also be related to implant infraocclusion, as eruption occurs in order to compensate for the wear. Signs of posterior tooth wear may be another risk factor for the early positioning of an implant in the anterior area.

Renato Cocconi: Prospective studies can help to better clarify which factor plays the major role. Unfortu-
nately, at this moment, there are not sufficient available data to draw a definitive conclusion regarding the etiology.

Aris Petros Tripodakis: There is a school of thought indicating that implant restorations should be under-occluded with respect to the natural teeth that possess the natural periodontal resiliency. In as much as such an approach is wrong (when applied), all the anterior horizontal forces are directed on the anterior natural teeth, and thus it is expected that they will migrate or overerupt in time.

Marco Rosa: Infraocclusion is completely unpredictable; sometimes it occurs and sometimes not. If you want to avoid infraocclusion, you need a lifelong retention involving the implant restoration and the adjacent teeth. I saw the first case of infraocclusion in 1998, and for this reason stopped using implants immediately. I remember two 20-year-old females with one CMLI – same malocclusion, same treatment modality, same orthodontist, same oral surgeon, same implantologist, same implants, same laboratory. One was infraoccluded by 8 mm after a few years, while the other had no infraocclusion. If you want to be sure, you need lifelong retention with the implant included, but this solution may create other negative side effects.

Roberto Cocchetto: When orthognathic and orthofacial surgery is applied, a significant static advantage for the patient is provided. The static advantage refers to function and not just cosmetics. Of course, relapse always occurs, but the issue is to what extent will the relapse affect the quality of the result. We have had cases of double jaw surgery and, after some years, there was some relapse. It does not matter to the patients since they function adequately. What is relevant is to maintain the result to the best of our ability. On the other hand, a significant infraocclusion of an implant in the lateral position in a high smile line case will affect the quality of our result.

Carlo Marinello: If we have an infraocclusion of an implant, is it possible to intrude the natural teeth as a solution?

Roberto Cocchetto: What we can do is a surgical block sectioning of the implant and coronally reposition the implant and tooth rather than intrude the entire arch against one implant. On the other hand, in selected cases, intrusion of a single adjacent tooth may be considered, but a permanent post-intrusion retention must be provided, as I have shown in a published case report (see reference 37).

Carlo Marinello: It needs to be considered that the alveolar bone moves down together with the teeth.

Marco Rosa: The whole periodontal support together with the soft tissue moves together with the tooth. An infraoccluded implant restoration becomes evident because not only the incisor margins but also the gingival margins are on different levels.

John Orloff: We all agree that there will be changes over time in these patients. Is splinting the natural teeth with the restoration a lifelong option? Does retention refer to prevention of growth or maintenance of the tooth alignment? Can retention be used as a security that the implants will not be found in infraocclusion over time?

Roberto Cocchetto: Splinting will not prevent the eruption of the adjacent natural teeth. It is important to identify the high-risk patients, for example, those with a high lip line who are obviously more demanding esthetically. Then, it is very helpful to plan a retrievable type of connection, namely screw retention, and to use materials that can be easily replaced or repaired, such as composite resins. However, at the moment, we cannot state anything clearly as far as risk factors such as age, gender, face type, and occlusion are concerned because clear scientific evidence does not exist.

Carlo Marinello: Are small-diameter implants a transitional solution for bypassing all the negative growth aspects? Mini- or micro-implants are ankylosed onto a smaller osseointegrated area. With larger implants, the impact on the surrounding bone is much bigger.
Marco Rosa: An implant is an ankylosed foreign body in the alveolar bone. There is no reason to expect less ankylosis if the implant is small.

Hadi Antoun: Changes are not influenced by the volume of bone, but by the growth of bone. The narrower the diameter of the implant, the less probable growth interruption will be.

Marco Rosa: Implants placed in the alveolar bone will not follow the normal growth of the alveolar process and the adjacent teeth. The type of implant you choose to place, big or small, does not make any difference.

Hadi Antoun: Bear in mind that extra-narrow-diameter implants, that is, between 1.8 and 2.5 mm, can only receive cemented, not screw-retained, superstructures. The manufacturers of the 3-mm implant do not recommend its use for a central incisor, only for a lateral incisor.

Kony Meyenberg: It seems that the implant fracture risk is pretty high in the long run for implants that are below 2.9 mm, which defines them as transitional tools. Also, crown retention by screws is technically almost unfeasible, and this makes the prosthetic management very difficult. There are 3-mm-diameter implants where a screw-retained restoration can be applied.

Hadi Antoun: Odman et al. noted on pigs that at some distance from the implants the tissues developed normally; however, further development was slowed in their immediate vicinity. This means that small-diameter implants may interfere less with alveolar growth; this was confirmed in a clinical study by Lambert et al. on extra-narrow-diameter implants. The authors showed a minor complication related to passive eruption, but these results have to be interpreted cautiously due to the limited power of the study. The authors also recommended that, in order to minimize the risk of complication related to passive eruption, the implant should be placed in a more coronal position, leading to a more cervical limit of the gingiva compared with the neighboring teeth. Can we or can we not say that implant placement is indicated at around 25 years of age?

Roberto Cocchietto: There is not enough scientific evidence to clearly support this. It is not possible to define a proper age for implant placement. It is unknown at any given moment if and when the eventual changes are going to take place. On the other hand, expert opinion may have a certain value. Based on my personal observation alone, in a patient with a short face, horizontal discrepancies such as interproximal contact loss are more likely to occur in the esthetic zone, while in a patient with a long face it is much more probable to have vertical discrepancies such as infraocclusion. A young patient requiring implant therapy, therefore, needs to be informed that age-related modifications can occur. This does not mean that implant therapy should be excluded. The patient needs to be properly informed before consenting to the treatment.

Wael Att: Some guidelines should be considered in terms of high-risk patients. Females younger than 25 years of age and with a long face are identified as such, and an informed consent should be applied. Age-related changes and growth do not occur quickly and cannot be evaluated or measured when making a decision to place an implant. Superimposing two hand radiographs taken 6 months to 1 year apart is considered a valid method to evaluate the growth process.

Renato Cocconi: This protocol was proposed by Kocich. If no vertical changes are detected, Kocich claimed that the implant could safely be placed in a 17- to 18-year-old female and an 18- to 21-year-old male. The superimposition of 3D intraoral scans could be an alternative, since it introduces an error that is acceptable.

Devorah Schwartz-Arad: Inasmuch as it is impossible to predict these changes precisely, while there is still a need, an indication or even a request from the patient for an implant placement is always possible, and it is easy to replace a crown after some years, if that is required. The patient needs to be informed; if the patient
agrees, the implant can be inserted even at the age of 20 to 25 years. Then, if needed, at the age of 30 to 34 years, the replacement might take place. On the other hand, if the patient can wait for the implant to be placed at a preferred age, the treatment can be postponed until then.

Marco Rosa: My answer to the question as to when to place an implant in the esthetic area is after 30 years of age. And if the patient shows the gingival margins during speech and smiling, I would never plan for an implant-supported restoration.

Roberto Cocchetto: Contraindications for implant placement should be evaluated. Considering the long-term potential changes, a more appropriate term would be ‘limitations of the field of intervention’ within implant therapy, rather than the word ‘contraindications.’ Considering the patient’s age, the need for a restorative solution to replace missing teeth has to be determined early enough. The absence of a lateral incisor does not have the same indications for treatment as that of a central incisor. On the other hand, a strong indication for implant placement would be deep bite occlusion, which precludes an adhesive restoration.

Conservative minimally invasive adhesive restorative options

Kony Meyenberg: When an adhesive solution is contemplated, the orthodontic treatment should be properly coordinated so that occlusal space is preserved palatal to the tooth on which the prosthetic wing is going to be bonded. Also, the width of the edentulous space is crucial. In situations where the span is wider than 7 mm, it is riskier to choose an adhesive bridge. Parafunctional habits also represent contraindications to this approach. If an implant is chosen, it should be of a diameter that allows screw-retained superstructures, that is, over 3 mm. This is preferable to cemented restorations. Pin-like implants introduce prosthetic limitations. Preestablished cervical crown margins on the prefabricated implant often end up being located deep under the soft tissue, and cement removal becomes extremely difficult and uncontrollable.

Roberto Cocchetto: The possibility of using a one-wing resin-bonded bridge for replacing a lateral incisor can be applied even on teeth with convergent roots. The only issue might be the amount of space, as one wing becomes less reliable when it supports more than 7 mm.

Tidu Mankoo: Avoiding an implant in the lateral incisor position before the age of 30 means that the resin-bonded bridge becomes the first choice. On the other hand, for a central incisor, the noninvasive solution is less predictable. Metal wings cause an esthetically unacceptable gray shadow and a gray appearance of the abutment tooth. In such cases, zirconia resin-bonded bridges are preferable, as lithium disilicate reinforced adhesive bridges for central incisors are riskier.

Federico Ferraris: Is there a time limit for maintaining composite resin restorations, after which time we need to switch to ceramics? What is the protocol of maintenance for composite restorations?

Marco Rosa: After space closure, generally, we always start with composite noninvasive restorations and a retention strategy for at least 2 years: usually, a mandibular bonded splint on six/eight anterior teeth and a removable appliance on the maxillary arch. Orthodontic appliance removal, composite restorations, and upper retention are performed on the same day. I prefer to avoid ceramic restorations before the end of growth. The composite restorations are no-prep and can be refreshed easily. In my experience, patients are often not interested in ceramic veneers since they are satisfied with composite restorations. After the stabilization of the orthodontic outcome and of the occlusion, when the ceramic restorations are planned, I prefer to first suspend the upper retention and check the patient for at least 4 to 6 months. If some minor movement of the maxillary anterior teeth occurs, it will be fixed by the ceramic restorations. The ceramic work has two main advantages: it is easier to provide a group function, and less maintenance is required. After the final restorations are applied, depending on the original malocclusion, a removable maxillary retainer is advisable.
Facing the infraocclusion of the implant restoration

Giano Ricci: In case a problem occurs, such as infraocclusion or the development of a diastema, what are your recommendations on how to correct it?

Kony Meyenberg: Correcting the problem when you have a screw-retained implant restoration is, in most cases, easily managed. After removal, contact points and shape can be corrected in the laboratory and the restoration is re-placed. This is the reason why screw-retained implant restorations are preferable. Composite alterations or indirect restorations of the adjacent teeth can also help to correct esthetic problems.

Didier Dietschi: Is there an estimated rate of severe complications? Often, the patient asks about the risk involved in order to decide about the treatment. Such an estimate would be a great help for better communication with the patient.

Roberto Cocchetto: To answer that, I would need to process and analyze my clinical data by statistical methods and transform them into numbers. Nevertheless, we cannot continue to ignore the problems that arise from implants over the years because most affected patients do not seem to care. The knowledge that the problem exists is primarily of concern to our colleagues, and it is important that we devise a rational but not intimidating statement.

Virtual imaging and treatment plan

Amelie Manjot: Digital technologies can help to simulate the treatment outcome and the various options. The possible solutions can be shown virtually and discussed with the patient. All the advantages and disadvantages of each plan could also be listed and discussed. On the other hand, the idea of a signed informed consent is an important subject that has not yet been considered.

Hadi Antoun: Is the proposal that one shows the patient the finished result with digital technology? Is the patient capable of understanding the virtual imaging?

Amelie Manjot: The patient has to be informed of what may happen in the future. The importance of putting the patient in the center needs to be highlighted. The practitioner does not choose the treatment plan alone.

Main points

Carlo Marinello and Wael Att:
1. Age-related changes occur throughout life and are unpredictable; there is no literature about them.
2. We have to identify young adults, females with long faces, and those with a high lip line as high-risk patients. These risks are identified through clinical experience. Consult with an orthodontist to make better predictions; proper case selection is essential.
3. Being as conservative as possible is of utmost importance. At a young age, the resin-bonded fixed prosthesis is the option of choice.
4. Space closure is preferable between the ages of 0 to 20 years.
5. In case of a missing lateral incisor, at ages 15 to 30 years, the resin-bonded bridge is an absolute indication.
6. In the position of the central incisor and of the canine, a resin-bonded bridge can be applied, depending on the occlusal risk factors.
7. At the ages of 20 to 30 years, an FPD is an alternative.
8. The implant option should be delayed as long as possible; it can be considered for patients in their mid-20s and older, depending on the risk factors.
Final statements

Kory Meyenberg: It is important to be minimally invasive and conservative in our restorative approach.

Roberto Cocchetto: I agree on being as minimally invasive as possible. Natural teeth are better than implants. Use implants in young adults only when there are no alternatives.

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Conclusions

Replacing the anterior missing tooth and growth

Carlo Marinello

The orthodontically driven closure of a space is followed by a minimally invasive prosthodontic, esthetic, and functional restorative ‘camouflage’ of the situation. In the order of their invasiveness, these interventions are listed as follows: external bleaching, odontoplasty, composite addition, composite refreshing, and veneer or single-crown restorations. They are all evidence-based, efficient, cost-effective, and low-risk clinical procedures, successfully used in many cases.

The orthodontically driven adequate position and distribution of teeth and their relevant spaces in the maxillary anterior region, and the subsequent use of either an autogenous tooth transplantation or a two-unit cantilever resin-bonded FPD, both followed by a minimally invasive prosthodontic esthetic and functional anterior ‘camouflage,’ are evidence-based procedures. They are indicated as successful solutions in the mid and long term, especially in younger patients. They allow for the strategic postponement of more invasive prosthetic solutions (conventional two-unit cantilever FPD; implant-supported single crown). The innovative use of mini-implant-retained pontics or the use of narrow-diameter implants may act as a short-term alternative in specific cases. They do not seem to notably counteract facial growth; however, longer follow-up is needed.

All evidence-based orthodontic and/or prosthodontic solutions are indication-dependent and clinically successful. However, especially with implant-supported restorations, delayed placement has, as a rule, always been and still is recommended until craniofacial ‘growth’ has ceased (end of adolescence and later). A gummy smile situation demands special caution.

The average changes of ‘growth’ (overlain by maturation, aging, remodeling) are normally small. However, a large interindividual variability and unpredictable clinical manifestation can be expected. Therefore, the placement of implants in the anterior area of the maxilla is a risky treatment throughout life. Possible side effects having an impact on esthetics, function, and biology are infraocclusion, interproximal contact loss followed by potential for food impaction, caries and peri-implant mucositis, mucosal recession, darkening of the labial mucosa, lack of interproximal papillae, and buccal alveolar bone loss.

It is equally important to define the liability issue when different professionals are involved in the treatment (oral surgeon, periodontist, prosthodontist). In order to avoid future legal disputes, it is suggested that the patient signs an informed consent form prior to the start of treatment.
References


Proposed form for Informed Consent for the prosthetic treatment on implants

Roberto Cocchetto and Stefano Gracis

Dear patient

To make you more aware before you consent to the therapy involving the insertion of osseointegrated implants, you are informed of a phenomenon observed in some partially edentulous patients (those missing some teeth), especially in the anterior sector.

1. The jaw bones that support our teeth tend to develop gradually until reaching the maturity of the entire skeleton, that is, at the beginning of the so-called adult age (18 to 20 years). Parallel to the changing of the bone bases, the teeth also undergo small but continuous changes of position that are not normally perceived because all the teeth ‘move’ in harmony with the alveolar processes, i.e., with the bone that surrounds the roots of the teeth themselves.

2. Thanks to numerous studies it has been observed that, where a dental implant is inserted into the bone and osseointegrated (a situation known as ‘ankylosis’), the bone undergoes a localized developmental arrest so that the implant connected to it remains in the position determined at the time of insertion, while the surrounding dentition can change its position. It is thus possible to observe spatial discrepancies between the crown supported by the implant and the natural teeth, which gradually become more evident as the patient’s growth progresses. For this reason, the insertion of implants before adulthood, i.e., in adolescence, is universally discouraged.

3. In some patients, however, this ‘growth’ never stops completely. The jaw and mandible may undergo a very slow growth, the extent of which varies from case to case, and has been observed even in old age. The implants, therefore, do not follow the expansion of the jaws, and thus it is possible that the esthetic disharmonies and functional problems mentioned above can also occur in patients defined as young adults (aged 20 to 30 years), mature adults (30 to 40 years), and even beyond that age.

4. The main problems that can occur are: infraocclusion (where the tooth on the implant appears shorter than the adjacent natural teeth); loss of interproximal contacts (formation of a space between the implant crown and the contiguous natural tooth); or the apparent displacement toward the inside or the outside of the tooth on the implant compared with the dental arch, while, in reality, it is the position of the adjacent dentition that has modified. These phenomena, although they can occur anywhere on both dental arches, are more evident in the maxillary anterior zones because it is easier for the patient to notice them when they result in an alteration of the harmony of the smile.
5. From the analysis of the studies published to date it appears that:

- these phenomena can occur in a considerable percentage of cases (from 40% to 100%, depending on the studies);
- it is not possible to predict in which patients the phenomena might occur or the extent/speed of their development;
- in the vast majority of cases, the phenomena pass completely unnoticed for many years and are almost irrelevant from an esthetic point of view. Only in a few cases will an imperfection manifest itself that requires treatment such as the modification or remaking of the prosthetic tooth to correct the disharmony with the neighboring teeth.

If you have further questions about the indications of osseointegrated implants for tooth replacement and possible therapeutic alternatives, do not hesitate to ask us.