CASE REPORT

Interdisciplinary diagnosis and treatment planning for Class III malocclusion and determining the appropriate anterior tooth positions for individual patients

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Abstract
Patients presenting with Class III malocclusion often present significant challenges for the orthodontist and restorative clinician. The characteristic anterior crossbite is commonly associated with a maxillo-mandibular skeletal base discrepancy leading to both functional and esthetic issues. Three potential incisal tooth positions are discussed using clinical examples including implants.

KEYWORDS
anterior tooth positions, class III malocclusion, interdisciplinary diagnosis, treatment planning

1 | INTRODUCTION

The management of Class III malocclusion is one of the most challenging treatments in orthodontics. For patients with any form of severe Class III skeletal base relationship, orthognathic correction is required to effectively correct the dental and skeletal malocclusion. In contrast, carefully selected mild to moderate Class III malocclusion can be treated with orthodontic camouflage. Camouflage is achieved through planned dentoalveolar compensation, which reduces the overall appearance of the underlying skeletal problem while improving the patient’s occlusion, function, and dental esthetics.

Where possible, a Class I incisal relationship should be the primary treatment objective, allowing for a positive (1–2 mm) overjet and overbite for the purposes of occlusal stability. However, there is a limit to the amount of horizontal dentoalveolar compensation (i.e., maxillary incisor proclination and mandibular incisor retroclination), which is acceptable in the anterior region, due to the potential for esthetic and/or periodontal compromises. Therefore, if orthognathic surgery is declined in a moderate to severe Class III case, a zero overjet incisor relationship may be deemed acceptable, yet certainly not ideal. Such a relationship may be less stable due to reduced anterior contacts and may allow teeth to drift undesirably without indefinite orthodontic retention. Anterior and lateral guidance may also be absent due to a lack of vertical overbite, thus increasing the risk of wear on the posterior teeth.

The objective of this article is to investigate the three possible incisal relationships for Class III orthodontic patients and to identify the combination of clinical factors which would justify a post-treatment positive overjet, zero overjet, and negative overjet. These recommendations aim to facilitate the clinical decision-making process when planning the final occlusal relationships, dentofacial esthetics, and any future restorative needs for individual patients presenting with Class III malocclusion.

1.1 | Etiology and treatment objectives

Class III malocclusion has been shown to have a both a genetic and environmental etiology. A reported incidence
of 5% in Caucasian populations and 9%–19% in Asian populations, is suggestive of a significant genetic contribution.\textsuperscript{4,5} Treatment is challenging for these patients, due to the potential for an ongoing aberrant growth pattern and complex interaction between genetic and environmental factors.\textsuperscript{6} Recent studies have also shown that the frequency of bilateral congenitally missing maxillary lateral incisors is 12.5% in skeletal Class III patients,\textsuperscript{7} therefore, orthodontic treatment of these cases must also accommodate for the likely future restorative needs.

If the skeletal discrepancy is not severe, non-surgical orthodontic treatment generally involves proclining the maxillary anterior teeth and retroclining the mandibular anterior teeth. This form of planned dentoalveolar compensation can achieve a Class I incisal relationship and eliminate the anterior crossbite. The amount of maxillary incisor proclination and mandibular incisor retroclination which can be provided is limited by esthetic, functional, and biological factors. Significant maxillary incisor proclination leads to a flared incisor appearance with esthetic flattening of the smile arc.\textsuperscript{8} Studies show laypeople overwhelmingly prefer a consonant smile arc and that the smile arc has a more significant impact on dentofacial esthetics than buccal corridors.\textsuperscript{9} In addition to these esthetic issues, excessively proclined maxillary incisor teeth will not have functional forces of mastication applied through the long axis of these teeth. This non-ideal angulation could be hypothesized to increase the risk tooth mobility and the likelihood of orthodontic retention issues. In the mandibular arch, excessive mandibular incisor retroclination may result in bony dehiscence and the potential for periodontal compromises.\textsuperscript{10}

### 1.1.1 Treatment planning

Treatment planning for Class III patients is often associated with clinical dilemmas, as the definitive surgical-orthodontic management may be extensive. Treatment approaches should not be initiated until the exact diagnoses and etiologies (i.e., dental, skeletal, or a combination of both) of the malocclusion are elucidated\textsuperscript{11} (Table 1). For skeletally mature Class III patients, the primary objective of treatment planning is to determine the viability of orthodontic camouflage as opposed to a combined surgical-orthodontic approach. Systematic evaluation of the skeletal discrepancy in all three-dimensions, the pre-existing inclination of the maxillary and mandibular incisors and the appearance of the soft-tissue profile are all required for appropriate clinical decisions to be made.

Three therapeutic incisal tooth relationships are possible for the Class III orthodontic camouflage patient. These include the following: a positive overjet with minimal overjet and overbite; a zero-overjet relationship, with effectively no overjet and overbite; or to intentionally remain in a negative overjet.

Kokich and Spears discussed idealistic treatment and treatment goals for the non-restored, patient with a complete dentition, and contrasted this concept with realistic goals in a patient requiring future restorations.\textsuperscript{12} Therefore, when the sizes of all teeth are compatible, a positive overjet incisal relationship with complete interdigitation should be the objectives of ideal treatment (Table 2). However, where further restorative treatment is necessary, it may be advantageous to orthodontically position teeth to facilitate such treatment. In cases where teeth have irregular morphology, are absent or demonstrate evidence of significant wear, the restorative clinician should provide input regarding how the orthodontic plan may facilitate the esthetics, function, and prognosis of the planned restorations, along with the overall occlusal scheme.

### Positive overjet incisal relationship

Class III malocclusion patients who would benefit from a positive overjet in the incisal relationship, present with unworn anterior teeth and sufficient anterior tooth display that is deemed acceptable.

Cephalometric limits of dentoalveolar compensation have been determined to be 120 degrees (Upper incisor to Frankfort Horizontal angle) and 80 degrees (Lower incisor to Mandibular Plane angle)\textsuperscript{16} (Figure 1). A positive overjet incisal relationship is far more likely, if the severity of the underlying Class III skeletal base relationship is within a mild to moderate range (Figures 2 and 3). The ANB angle is a measure of the horizontal difference between the maxillary and mandibular basal positions using the SNA-SNB angular differential.\textsuperscript{13,14} Where the ANB difference is 0 degrees or less, it is indicative of a Class III skeletal base relationship. While the ANB angle is a useful general indicator of the anteroposterior skeletal relationships, its applicability reduces in cases where the SNA and SNB angles are located outside the norms.\textsuperscript{17} A commonly used alternative measurement is the Wits appraisal.\textsuperscript{15} This appraisal compares the relative positions of A and B points projected perpendicularly onto the occlusal plane. A negative value is recorded when the B point lies in front of A point, which is an important diagnostic measurement for Class III malocclusion patients. A large negative value (e.g., more than -5 mm) generally indicates that the amount of tooth movement required to camouflage the skeletal discrepancy will be more complex and involve very significant root re-angulation. In severe cases, non-surgical orthodontic camouflage becomes impractical or impossible to achieve, with orthognathic surgery often being recommended. It has been reported that
the Wits appraisal is the most decisive measurement to determine whether camouflage or orthognathic surgery is more appropriate, predictable, and effective for an individual Class III patient.16

**Case 1**

Mild Class III malocclusion with unworn teeth. A incisal relationship with positive overjet has been achieved through conservative orthodontic treatment.

It is reasonably common for Class III malocclusion patients to be concerned over a vertically deficient smile. Where diagnostic assessment confirms the presence of a vertically under-developed maxilla, orthognathic surgery to advance and down-graft the maxilla may be an ideal treatment option to increase the maxillary tooth display. Other instances of under-sized maxillary anterior teeth (i.e., where the central incisor measures less than 9 mm in length) may include worn incisal edges, excess gingival coverage (gingival hyperplasia, altered passive eruption), hypodontia and/or anatomically short clinical crowns.18

**Table 1**

**Class III diagnostic problem List**

| Skeletal Features |  |
|-------------------|--|
| Horizontal: |  |
| Diagnosis of the severity of the horizontal Class III skeletal base relationship (cephalometric analysis of the ANB angle, WITS measurement15,16) |  |
| Determination of the horizontal maxillary position: Retrusive, normal, protrusive (unlikely) |  |
| Determination of the horizontal mandibular position: Retrusive (unlikely), normal, protrusive |  |
| Determination whether there any significant horizontal facial growth remaining (i.e., assess the skeletal maturity, chronological age of patient and family history) |  |
| Vertical: |  |
| Determination of the vertical facial morphology: Brachyfacial, mesofacial, dolichofacial |  |
| Cephalometric analysis |  |
| • Mandibular plane angle |  |
| • Facial axis angle |  |
| • Lower facial height |  |
| Determination of the severity of the vertical facial morphology |  |
| Determination of the vertical maxillary position: Deficient, normal, excessive |  |
| Determination of the vertical mandibular position: Deficient (unlikely), normal, excessive |  |
| Transverse: |  |
| Facial symmetry: Within normal limits or significantly asymmetric |  |
| Determination of any specific maxillary and/or mandibular asymmetry (e.g., Chin point deviation) |  |
| **Any Other Contributing Factors** |  |
| Metabolic: e.g., acromegaly |  |
| Structural: e.g., craniofacial anomaly or cleft lip/palate |  |
| Previous trauma |  |
| Functional problems: e.g., stomatognathic/TMJ parafunction, which has the potential to result in therapeutic complications and affect the stability and/or longevity of prosthodontic restorations |  |
| Other: e.g., condylar hyperplasia |  |

**Dental Features**

| Horizontal: |  |
| RHS: Assess the molar and canine relationship |  |
| LHS: Assess the molar and canine relationship |  |
| Significant mandibular functional shift upon closure from RCP to MIP: (Yes or No) |  |
| Measure the negative overjet (anterior crossbite) |  |
| Cephalometric analysis of the pre-existing maxillary and mandibular incisor angulations: (i.e., proclined, normal, retroclined) |  |

(Continues)
TABLE 2  Class III treatment objectives

|Corrections of negative overjet |
|--------------------------------|
|Establishing a Class I skeletal relationship |
|Attaining/maintaining an ideal positive overbite and overjet |
|Improving the soft tissue profile |
|Positioning teeth to facilitate restorative treatment |

For cases where the esthetic diagnosis indicates the need for anterior restorations, sufficient intra-arch space must be provided. The use of an intra-oral mock-up may be readily achieved by the restorative clinician during orthodontic treatment and provides valuable information for the detailing of tooth movement in the finishing stage of orthodontic treatment. This serves to assess the esthetics of the maxillary teeth, as well as an analysis of the occlusion and guidance. A zero overjet incisal relationship in these cases is contraindicated as the essential vertical space cannot be acquired.

Where a positive overjet incisal relationship and anterior restorations are planned, clinicians should provide the patient advice regarding likely soft tissue changes, as the resultant lip positions are dictated by the incisal and buccal positions of the maxillary central incisors.¹⁹ The splayed appearance of the maxillary anterior teeth may be corrected in addition to other concerns by bulking the mid-portion and continuing to the cervical third of restorations (Figure 4). Patients need to be aware of the oral hygiene issues and plaque entrapment which the cervical “shelf” may cause (Figure 4C). It is expected that glazed porcelain restoration would allow for greater cleanability over a direct resin restoration long-term. The use of provisional restorations to accurately estimate the likely final lip position and to assess overall anterior smile esthetics is recommended for patient input and approval prior to bonding the final restorations.

Functionally, orthodontic and occlusal goals should include the principles of mutually protected occlusion with protrusive guidance from the central incisors and lateral guidance from the canines.

Case 2  Mild–moderate Class III malocclusion patient with a brachyfacial vertical morphology who was unhappy with a vertically deficient smile, requested an increase in the maxillary tooth display. Previous adolescent orthodontic treatment resulted in an edge-to-edge bite with labial frenum removal to assist in closing the midline diastema. Esthetic analysis revealed the incisal edge position of the maxillary central incisors are superior to those of the lateral incisors and canines, creating a negative smile arc (Figure 5).

A composite mock-up revealed insufficient space for the proposed increase in length, without producing severe proclination of the incisors (Figure 6) which was unacceptable to the patient. The patient underwent orthodontic re-treatment with intrusion and lingual tipping (in conjunction with interproximal width reduction) of the mandibular anterior teeth to create the necessary space for the maxillary incisors to be lengthened with porcelain veneers (Figures 7–9).

Zero overjet Incisal relationship

The zero overjet incisal relationship is ideal for patients requiring restorative implant treatment to replace missing or traumatized teeth. In contrast, the positive overjet Class I anterior position may be contraindicated for these patients for a number of reasons. Implants and implant-supported restorations fare better with forces directed along the long axis of the implant. Due to the maxillary anterior anatomy, implants placed in this region are often subject to horizontal forces which may be detrimental to the implant and mechanics of the implant restoration. Mechanical overloading, especially in directions other than the long axis of the implant, may result in screw loosening and to a lesser extent, damage to the implant, and/or surrounding bone. In addition, the fixture size is often narrow or very narrow due to the available mesial-distal space, shown to be on average 6.8 mm for the maxillary permanent lateral incisor¹⁷ (Figure 10).

When restoring congenitally missing lateral incisors in Class III malocclusion cases, the implant restoration may be opposing the mandibular canine in one or both quadrants and thus, be unintentionally involved in lateral guidance. Prior to debanding, the restorative dentist should assess the canine position and suggest intrusion and/or tipping of the crown in the labio-lingual dimension to reduce or remove lateral guidance contacts on the future lateral incisor implant crown. Where canine guidance cannot be achieved, the orthodontic practitioner should aim to provide partial group function, thus sharing the occlusal load with the premolars and molars on the working side.

Clinicians should also take care when placing implants in a positive overjet incisal relationship following orthodontic treatment. A cantilever effect may be created due to the lingual position of the fixture platform, compared
with the final incisal edge position. Where possible, sufficient grafting to ensure that the buccal bone is of adequate volume will improve the mechanics of the restoration. Soft tissue grafting may also be performed to enhance the volume of the gingival tissues, thus improving esthetics. Congenitally missing teeth cases almost always require an additional bone grafting procedure to correct the deficient labial bone volume. These processes are vital to the overall esthetics and angulation of the final implant. Inadequate bone and soft tissue grafting may result in flattening of the soft tissue, visibility of the titanium implant, and poor overall smile esthetics.

Case 3  Implant restorations for congenitally missing lateral incisors in a Class III skeletal patient with completed orthodontic treatment.

A 23-year-old female patient endured 5 years of orthodontic treatment, had subsequent implant placement, and then presented for the implant restorations for the congenitally missing maxillary lateral incisors (Figure 10). A positive overjet incisal relationship had been achieved, however, non-ideal occlusal forces will be applied on the fixtures and crowns. Note that the 33 is directly under the implant placed in the 22 site (Figure 10C). Orthodontic intrusion of the 33 would allow a reduction of the occlusal forces for the implant placed in the 22 site. The buccal surface of the crowns appear proclined at the first try-in (Figure 11), and composite mock-up bulking the cervical third is applied for addition of further porcelain prior to insertion (Figure 12).

Another critically important factor to consider is the age of the patient. Implant restorations for congenitally missing teeth have been reportedly placed as early as 15 years of age in females and 18 years of age in males when skeletal growth has apparently ceased. Unexpected and variable change in the functional and esthetic outcomes of an implant restoration may certainly occur over the patient’s lifetime and must be outlined during the informed consent process. Meticulous planning is required to achieve appropriate timing, treatment predictability and high quality outcomes, especially when gingival display upon smiling is evident.

Therefore, many contemporary clinicians would recommend delaying implant placement into the middle of the third decade if possible and practical. If no skeletal changes are noted through superimposition of sequential cephalometric radiographs taken at least 6 months apart, this may indicate that facial growth is complete.

Instructions to the technician are also critical to achieve optimal esthetics. Adjacent teeth will show a proclined appearance, and an inexperienced technician may follow this angulation for the implant crown. An alternative approach is to add bulk to the middle and cervical region to create the illusion of a vertical first place for improved esthetics (Figure 4C). However, care must be
taken to avoid bulking the cervical porcelain excessively, as this may force the valuable remaining soft tissue more superiorly.

Complications arise when the adjacent teeth require additional restorations to increase the incisal length along with implant restorations. For this clinical scenario, the

FIGURE 2 (A, B) Pre-treatment photographs of a patient with a Class III malocclusion. (C, D) Progress photographs taken 6 months into active treatment. (E, F) Deband photographs taken at the completion of 12 months active treatment. (G, H) Post-treatment photographs taken 2.5 years following the completion of active treatment.

FIGURE 3 (A) Pre-treatment lateral cephalograph of the patient shown in Figure 1. (B) Progress lateral cephalograph taken 6 months into active treatment. (C) Post-treatment lateral cephalograph taken 2.5 years following the completion of active treatment.
FIGURE 4  (A) Incisors of Class I/II skeletal patients showing the buccal first plane to be vertical. (B) In Class III malocclusion patients, the maxillary incisors are often proclined to achieve a Class I anterior relationship via orthodontic camouflage, which more severely angulates the buccal first plane. (C) Restoring the buccal surface with increased bulk at the cervical half and third of the tooth recreates the vertical first plane, however, this creates a cervical shelf where plaque may accumulate.

FIGURE 5  (A–D) Extra-oral images pre-orthodontic treatment (adult) with composite added to the maxillary central incisors.

FIGURE 6  (A) Pre-treatment maxillary display in full smile (B–D) Addition of resin to the 11, 21 incisal edges to assess the proposed incisal edge position
FIGURE 7  (A–C) Progress photographs taken 6 months into active treatment.

FIGURE 8  (A–C) Extra-oral images at debanding after 12 months of active treatment. (D) Cephalometric imaging at finish, showing an acute inter-incisal angle (E–G) Post-treatment intra-oral images with the proposed position of the maxillary incisal edges.

FIGURE 9  (A–E) Images obtained 12 years post-treatment with increased length and overbite of the maxillary teeth.
recommended treatment plan is to finish to a zero overjet incisal relationship with the mandibular teeth sufficiently intruded. Such intrusion will provide sufficient space to increase the incisal edge length and reduce the forces on the implant restoration.

The second type of patient that would benefit from a zero overjet incisal relationship is the patient with a missing lateral incisor requiring replacement with a Maryland bridge. Reducing forces on the connectors by minimizing any overlap may lead to better success rates, especially when materials such as zirconia are used to enhance esthetics.

The third class of patient to benefit from a zero overjet incisal relationship is the moderate to severe skeletal Class III patient seeking non-surgical orthodontic correction. Such patients often have a Wits measurement more than -5 mm. By attempting correction to a positive overjet incisal relationship, the resultant maxillary anterior teeth proclination would be too severe. Where possible, treatment prediction software should be utilized for the patient to envisage their dentofacial outcome. Patients who are not satisfied with the prediction may need to consider orthognathic surgical options for more ideal dentofacial outcomes.

### Zero Overjet Incisal Relationship

| Indications |
|-------------|
| Implant treatment in the anterior maxilla |
| Bonded all-ceramic fixed prostheses |
| Moderate class III skeletal relationship |

| Contraindications |
|-------------------|
| Limited display of the maxillary anterior teeth where an increase in length would improve the esthetics |

### Negative Overjet Incisal Relationship

This group of patients will most often benefit from orthognathic surgery, due to inherently larger discrepancies in the Wits measurement, which indicates more severe horizontal disharmony in the maxillo-mandibular relationship. Should such patients still decline the surgical option, the goals of orthodontic treatment must be appropriately revised, with a post-treatment reverse overjet incisal crossbite relationship knowingly accepted. It would seem prudent for such patients to avoid irreversible removal of teeth, as this may complicate orthodontic decompensation should the patient subsequently change their mind regarding orthognathic surgery.

Both functional and esthetic restorative challenges will be encountered in this patient group, and primarily include ongoing wear due to the reverse overjet the anterior crossbite and the lack of anterior guidance. Where possible, an incisal overbite should be eliminated thereby preserving the anterior teeth and reducing the incidence of incisal edge wear. The second reason for preserving the maxillary anterior teeth is that visibility may be compromised due to the lingual position of the teeth. Difficulties arise in planning future restorations, due to the lack of vertical space, unless there is a large reverse overjet present which would enable the maxillary teeth to disclude during excursive movements.

Digital prediction software may be used to facilitate the decision-making process in these cases, as the expected soft tissue profile improvement associated with orthognathic surgery may be demonstrated more effectively. Surgical orthodontic treatment has been shown to provide consistently greater skeletal base relationship correction, greater reduction in chin prominence and more favorable lip and chin contours.

### Negative Overjet Incisal Relationship

| Indications |
|-------------|
| Severe Class III skeletal relationship (in the absence of orthognathic surgery) |

2 | CONCLUSION

The orthodontic discipline considers a positive overjet for the incisal relationship as ideal, and strives to achieve this occlusal scheme for patients where possible and practical. Despite this treatment objective, it may be impossible (or inadvisable) for some patients with a moderate to severe Class III malocclusion to attain a positive overjet in the absence of orthognathic surgery.

Meticulous interdisciplinary treatment planning, ongoing communication and careful treatment execution are required for any patient with plans to undergo future prosthodontic procedures. Achieving the most ideal
Position of teeth for each individual case can greatly facilitate the success of the final restorations. Successful treatment should satisfy the following criteria; a significant esthetic improvement, ongoing harmonious occlusal function, and excellent expected longevity. Where implant restorations are planned, the mechanics of the restoration and the lack of periodontal ligament should be taken into consideration when setting up the occlusal scheme. This article presented three potential incisal relationships for Class III malocclusion patients, with detailed discussion regarding the justification for various tooth positions. It is hoped that these clinical guidelines will assist clinicians to determine the most appropriate anterior relationship for patients seeking treatment for Class III malocclusion, particularly when future restorative procedures are required.

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A.K, E.F, and D.O. involved in conceptualization and writing. All authors have read and agreed to the published version of the manuscript.

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CONFLICT OF INTEREST
No conflicts of interest have been declared by the authors.

DATA AVAILABILITY STATEMENT
All data included in this report are accurate and to the best of our knowledge. We will make data available upon request.

CONSENT
Written informed consent was obtained from the patient to publish this report in accordance with the journal’s patient consent policy.

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