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Grado en Odontología

TREATMENT OF INCREASED OVERBITE IN NON GROWING PATIENTS

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ABSTRACT:

Introduction: Increased overbite is characterised by the excessive overlap of the maxillary incisors over the mandibular incisors. Aetiological factors that contribute to its development include dental, skeletal and acquired factors. Dentofacial and skeletal characteristics are used to classify and diagnose increased overbite. The management of increased overbite in non-growing patients must consider the lack of growth potential and dentofacial aesthetics. The selection of treatment method and appliance depends on patient characteristics and treatment objectives.; **Objectives**: (1) Describe different treatment methods and their indications and (2) appliances for the treatment of increased overbite in non-growing patients.; **Material** and **Methods**: 514 longitudinal, retrospective and comparative studies published from 1990 onwards were collected using Pubmed, Google Scholar, and ResearchGate. 11 articles were selected according to inclusion and exclusion criteria.; **Results**: Incisor intrusion and proclination and posterior segment extrusion are methods commonly used for treatment. Their indication depends on the patient's characteristics and objectives. Intrusion arches, clear aligners, and temporary skeletal anchorage devices are commonly used appliances for treatment.; **Conclusions**: Incisor intrusion is indicated for the majority of non-growing patients while posterior segment extrusion is limited to patients that require an increase in vertical dimension. Fixed orthodontic appliances, extrusion and intrusion arches and wires with extraoral anchorage or TSADs, lingual orthodontics, clear aligners systems and surgical interventions can be used for effective treatment of increased overbite in non-growing patients. The options are selected according to the patient characteristics and treatment objectives.

KEYWORDS: Dentistry; overbite; deep bite; adults; non-growing.

RESUMEN:

Introducción: Sobremordida aumentada caracterizada por la superposición excesiva de los incisivos superiores sobre los incisivos mandibulares. Los factores etiológicos que contribuyen a su desarrollo incluyen factores dentales, esqueléticos y adquiridos. Las características dentales, esqueléticas y faciales se utilizan para clasificar y diagnosticar el tipo de sobremordida aumentada. El manejo de la sobremordida aumentada en pacientes que no crecen debe considerar la falta de potencial de crecimiento y la estética dentofacial. La selección del método de tratamiento y del aparato depende de las características del paciente y de los objetivos del tratamiento.; **Objetivos**:(1)Describir diferentes métodos de tratamiento y sus indicaciones y (2) aparatos para el tratamiento de la sobremordida aumentada en pacientes que no crecen.; **Material y Método**: Se recopilaron 514 estudios longitudinales, retrospectivos y comparativos publicados a partir de 1990 utilizando Pubmed, Google Scholar y ResearchGate. Se seleccionaron 11 artículos según criterios de inclusión y exclusión.; **Resultados**:La intrusión y proinclinación de los incisivos y la extrusión del segmento posterior son métodos comúnmente utilizados para el tratamiento. Su indicación depende de las características del paciente y objetivos. Los arcos de intrusión, los alineadores transparentes y los dispositivos de anclaje esquelético temporal son aparatos comúnmente utilizados para el tratamiento.; **Conclusiones**: La intrusión de los incisivos está indicada para la mayoría de los pacientes que no crecen, mientras que la extrusión del segmento posterior se limita a los pacientes que requieren un aumento de la dimensión vertical. Los aparatos de ortodoncia fijos, los arcos y alambres de extrusión e intrusión con anclaje extraoral o TSAD, la ortodoncia lingual, los sistemas de alineadores transparentes y las intervenciones quirúrgicas se pueden utilizar para el tratamiento eficaz de la sobremordida aumentada en pacientes que no crecen. Las opciones se seleccionan según las características del paciente y los objetivos del tratamiento.

PALABRAS CLAVE

Odontología; sobremordida; mordida profunda; adultos; sin crecimiento

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1. INTRODUCTION

1.1. DEFINITION OF OVERBITE AND INCREASED OVERBITE

The intermaxillary relationship that develops between the maxilla and the mandible during physiological development influences the parameters that categorise different types of dental occlusions (1). As the maxilla is larger than the mandible, a vertical relationship, termed overbite (OB), is formed as the maxillary anterior teeth overlap the mandibular anterior teeth (2). Overbite is a normal characteristic of human dentition and its presence in itself is not an indication of malocclusion or pathology and therefore, variations in overbite can be aesthetically and functionally acceptable (2). Overbite can be the focus for treatment objectives and its correction can be used as a measure of evaluating the success of orthodontic treatment outcomes (3). The ideal overbite in a healthy occlusion may range from 2 to 4 mm with one third of the clinical crown of the mandibular incisors being covered by the maxillary incisors (4). Ideally, the incisal edges of the lower teeth should contact slightly at or above the cingulum of the upper teeth (5). Regulated by genetic control, overbite can be influenced by growth discrepancies between the two arches which can result in dentofacial and skeletal variations (6, 7). Overbite can also be influenced by environmental factors acting on aspects of the craniofacial complex and the stomatognathic and masticatory systems including the bone, teeth and muscles(8). Muscular habits, tooth movement, tooth loss and tongue habits such as lateral tongue thrust, finger sucking and lipsucking can continue to influence those systems for the entirety of the patient's life (1,4,6). Generally, an increased overbite, or deep bite, is an excessive vertical overlapping of the mandibular incisors by the maxillary incisors in centric occlusion with severe cases considered to be overbites of ≥5 mm (9). Uncorrected deep bite causes ulceration of the gingival tissues, attrition of lower incisors and abnormal mandibular function and movement (10,11).

1.2. ETIOLOGY OF DEEP BITE

Understanding the aetiology of deep bite and its functional implications is crucial for creating treatment plans and maintaining stable results (4). Deep bite aetiological factors can be categorised into two groups according to whether the factor is inherent to the patient or if it is an acquired factor (4). Inherent factors such as skeletal patterns,

condylar growth patterns, tooth morphology and eruption and acquired factors such as muscular habits and tongue position all contribute to the development of deep bite (12,13). Normally, the eruption of the permanent mandibular central incisors occurs labially towards a normal balanced position between tongue, lip and facial musculature (14). However, if there is a premature loss of the mandibular teeth, the anterior segment becomes less stable which may result in lingual tipping due to the hyperactivity of the mentalis muscle (14). If the mentalis muscle activity is strong, it creates a retracting force on mandibular incisors which results in the supraeruption of the incisors (14). Soft tissue factors such as the length of the lower lip can also contribute to deep bite by causing the retroinclination of the upper or lower incisors or both (13). In turn, the maxillary anterior segment uses the mandibular incisors as a functional stop against the maxillary incisor eruption (14). If this stop is not provided by the mandibular incisors due to their own abnormal eruption, the maxillary incisors erupt further increasing the deep bite (14). The deep bite malocclusion is also the result of the growth patterns of the face (14). Patients with an upward and forward growth of their mandibular condyle tend to have a reduced anterior facial height and as a result, a reduced vertical dimension which can manifest into a deep bite (13). The forward rotation of the mandible, in the direction of mouth closing, is due to an increased posterior vertical facial height growth in comparison to the anterior vertical facial height growth (13, 15). In severe cases of upward and forward growth, skeletal deep bite is common and in combination with a reduced lower face height, it also results in the absence of the occlusal stop of the lower incisors which contributes to overeruption of the maxillary incisors leading to an increased overbite (14).

1.3. CLINICAL CHARACTERISTICS OF DEEP BITE & DIAGNOSIS

Classification of overbite malocclusion pathologies are broad due to their multiple etiologies and their multifactorial characteristics and this is why it is considered to be one of the most challenging malocclusions to treat successfully without relapse (16). A deep bite malocclusion produces various skeletal and dental characteristics which are used to diagnose a skeletal or dental deep bite (13). Deep bite can be observed in different skeletal and dental malocclusions (Class I, II, and III) but is mostly associated with skeletal hypo-divergence typically found in Class II, division 2 (17). In a skeletal

deep bite, common characteristics include a horizontal pattern of growth, convergent jaw bases, decreased ramal height, and reduced anterior facial height (18). Sometimes, these patients can also present with mandibular deficiency (19). Dental deep bites are generally characterised by incisor supraocclusion (overeruption), infraocclusion of the posterior teeth (underruption) , lingual tipping of the anterior teeth and other intraoral features (Table 1, 2) (13). According to a 2014 study conducted by Dinkova and Yordanova, deep bite is also very closely associated with crowding of the lower anterior teeth with 73.3% of patients presenting with crowding (20).

Table 1. Intraoral and Extraoral Features of Deep Bite in a Non-Growing Patient (5)

Extraoral Features	Intraoral Features
Brachycephalic face with straight to mild convex profile	Maxillary dental arch is broad
Short anterior face height	Gummy smile
Diminished nose chin distance	Palatal vault is flat
Deep mento-labial sulcus	Small teeth prone to abrasion
Lips are usually thin with a curled appearance	Crowding of lower incisors

Table 2. Skeletal and Dental Factors of Deep Bite in a Non-Growing Patient (5)

Skeletal Factors	Dental Factors
Overgrowth or undergrowth of one or more alveolar segments	Loss of posterior teeth
An excess growth of the ramus of the mandible	Mesial tipping of posterior teeth
Convergent upper and lower jaw bases	Early loss of teeth
Horizontal growth pattern of lower jaw	Lingual collapse of anterior teeth
The four facial planes are horizontal and nearly parallel to each	Diminished posterior dental height
Forward rotation or anti-clockwise rotation of the lower jaw	Over-eruption of incisors
The four facial planes are horizontal and nearly parallel to each other	Periodontal disease

Through the evaluation of dental study casts and cephalometric analysis, an orthodontist is able to measure important diagnostic factors such as the mandibular plane angle, the gonial angle, interlabial gap and the curve of Spee in the mandibular arch (9, 21). Facial profile and photo assessment can also be used to diagnose deep bite (22). An orthodontist must analyse the interlabial gap, the smile ratio of the patient, the level of gingival display during smile and upper incisor display (14,22). A more complete analysis can be made when the information is interpreted with other smile factors such as degree of elevation and the compression of the upper lip during smile (22). All of these characteristics should not be analysed in isolation but rather, as part of a comprehensive analysis that interprets the information as a whole to achieve an accurate diagnosis (22).

1.4 Treatment Planning with a Non-Growing Patient

One of the most crucial patient characteristics in orthodontic treatment planning is the patient's growth potential, development and age (23). Due to the wide variation that can be seen in patients at the same age, orthodontists prefer to assess growth potential and skeletal maturation using the Cervical Maturation Method (CVM) (24). The CVM measures skeletal maturation by analysing the relationship between the changes in the shape of the cervical vertebrae in the hand-wrist and the age of the patient using lateral cephalometric radiographs (LCRs) (C24). The CVM's accuracy has been independently confirmed and is considered to be the gold standard in determining pubertal growth (24, 25). The CVM method measures the peak in mandibular growth based on the analysis of the shape of the inferior border of the bodies of the second (C2), third (C3), and fourth (C4) cervical vertebrae (26). This is further categorized in six maturational stages (cervical stage 1; CS1 to cervical stage 6; CS6) based on the timing of the ossification and union of the skeletal centres (26). CS1 and CS2 are prepeak stages and CS3 and CS4 are the peak stages of growth (26). CS6 is recorded at least 2 years after the peak and indicates a non-growing patient (26). The CVM method can be used to determine the optimal timing for the treatment by predicting if there is any remaining growth potential in the patient (27).

This is important to know because growth modification procedures using interceptive orthodontic appliances can only be used to treat malocclusions in growing patients (28). Non-growing patients are more complex due to lack of growth potential and “habit-related sequelae” becoming permanent (28). Therefore, treatment options are restricted in non-growing patients which in turn limits treatment appliances that can be used (29). In addition, other factors of a non-growing patient that must be considered besides the lack of growth are perio-restorative problems, facial aesthetics, psychological factors, treatment duration, and medications(30,31). For some patients, deep bite can hinder adequate oral hygiene practice or cause occlusal trauma which can cause greater susceptibility to periodontal disease as such it is recommended that periodontal analysis and therapy should occur two to six months before treatment of overbite (32). Over time, the force of gravity affects upper and lower lips as ageing decreases the elasticity of perioral tissues causing the flattening of the integumentary profile (22). Root resorption and other perio-restorative problems must be evaluated and assessed before and monitored after treatment to reduce the chances of treatment failure (29). A patient's compatibility for an extensive treatment must be considered as patient involvement and collaboration is often required (33). External factors such as social and work life and personal relations must also be considered when planning treatment (33).As people age, the likelihood of systematic illnesses increases and therefore, tolerability, length and maintenance burden of the treatment should be discussed with the patient (33).

1.5 TREATING OVERBITE IN NON-GROWING PATIENT

Mild increased overbite typically requires no correction, unless the patient desires a correction for aesthetics (34). However, severe deep bite is considered to be a clinical problem that can affect the temporomandibular joint, cause periodontal problems, affect the incisive papilla and interfere with masticatory function (4). Extreme deviations from the ideal incisor relationship can result in unsatisfactory oral and facial function and aesthetics and as such, it is often sought out for correction and management in orthodontic offices (35). In non-growing patients, deep bite is normally corrected by the intrusion of the incisors, extrusion of the posterior segments, or a combination of both (36). Conventional treatment appliances and more

recent modern developments have been utilised to successfully treat overbite in non-growing patients for decades (13, 14). Increased overbite is related to dentoalveolar and morphological features of both jaws and determining the influence of all factors is key to an accurate diagnosis and the difference between the success or failure of treatment (37). Many considerations must be taken into account for the management of deep bite and depending on the diagnosis and treatment objectives, a deep overbite in a non-growing patient can be treated through various methods and appliances.

2. OBJECTIVES

Principal Objective

1. Describe the different treatment options for the treatment of increased overbite in non-growing patients and their indications.

Secondary Objective

2. Describe the different treatment appliances and their efficacy in the treatment of increased overbite in non-growing patients.

3. MATERIALS AND METHODS

3.1. Information Sources & Literature Search

In this review, a systematic electronic web search was conducted using keywords related to the topic of treating increased overbite in non-growing patients. Pubmed, ResearchGate, Science Direct, and Google Scholar web searches were performed from October 20, 2022 April 10, 2023. Search results were limited to randomised and non-randomized controlled trials (RCTs), literature reviews, longitudinal studies, comparative studies, retrospective studies and case reports published during the years of 1980-2023. The search equations were employed as listed (((Adult) AND (Overbite)) AND (deep bite) AND (orthodontic treatment) AND (non-surgical treatment) AND (temporary skeletal anchorage devices) AND (Incisor intrusion) AND (molar extrusion) AND (incisor proclination) AND ((extra oral anchorage)) AND (surgical treatment) AND (clear aligners)).

3.2 Inclusion Criteria

In order to review different treatments of increased overbite malocclusion in non-growing patients, search inclusion and exclusion criteria were selected. Due to the focus on non-growing patients, case reports conducted on patients listed as older than average age of 18 years were included. If an age was not specified, case studies and reviews focused on 'adult' or 'non-growing' patients were included. Studies were excluded if the patients were on average, younger than 18 years. There was a language restriction in which only the articles written in English, Spanish and Portuguese were included. The PICOS scheme was as follows:

- **Participants**: Orthodontic patients with an increased overbite (>3mm) older than 18 years, "non-growing", "adult without gender predilection
- **Intervention**: incisor intrusion and proclination, posterior segment extrusion using intrusion or extrusion wires and arches and extra-oral anchorage, lingual orthodontics
- **Comparison**: incisor intrusion and proclination, posterior segment extrusion using temporary skeletal anchorage devices (TSADs) and the Invisalign® system or clear aligners
- **Outcomes**: Treatment methods, treatment method indications, treatment appliances, effectiveness in overbite reduction, effectiveness in incisor intrusion or proclination, effectiveness in posterior segment extrusion
- **Study Types**: Comparative Reviews

3.3 Exclusion Criteria

All retrospective and cohort studies, clinical trials and reviews conducted before 1990 were excluded. Studies that did not factor age were excluded. Any studies with an average mean age of less than 18 years were excluded. Studies about "growing patients'' were excluded. Studies about functional appliances were excluded.

4. Results

4.1 Study Selection

A total of 85 studies relating to the treatment of increased overbite in non-growing patients were selected through the database search engines including Google Scholar, Pubmed and ResearchGate after reading the full text. These 85 case

reports were further divided depending on the basis of the treatment modality (intrusion, extrusion, proclination, retroclination), the appliance used (TSADSs, extraoral anchorage, Invisalign® or clear aligners (CAs), intrusion arches and wires) and space acquirement method (interproximal reduction (IPR), extractions). Out of these 85 publications, 74 case reports were excluded for this review on the basis of a lack of relevant information regarding treatment modality and appliances used. In total, 1 cohort and 10 comparative studies were used in this literature review. A total of 397 patients were examined (Figure 1).

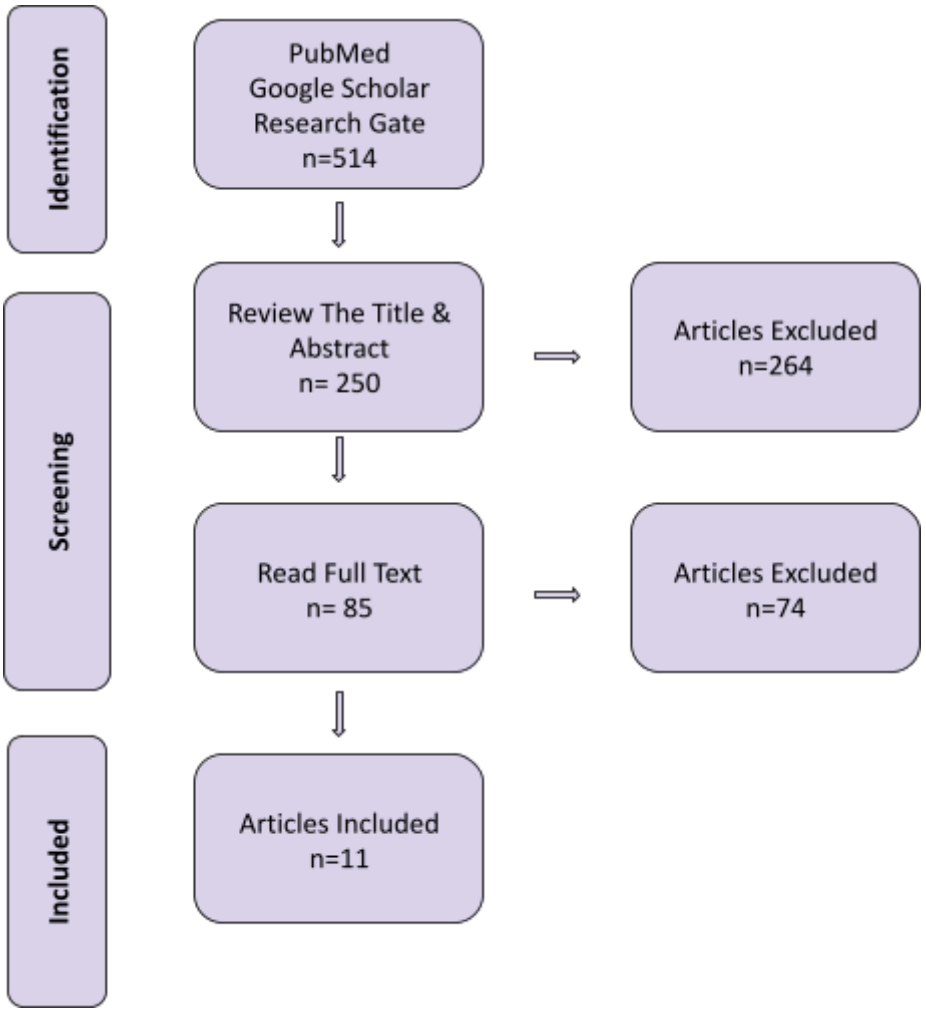

Figure 1: PRISMA Flow Chart of Study Selection Process (38)

4.2 Data Extraction

The data of the selected articles were extracted which included the names of the authors of the study, the countries in which the studies were conducted, the year of

publication of the articles, type of study, population characteristics, treatment interventions, increased overbite diagnosis and treatment results (Table 3).

Author, Year, Country	Type of Study	Population Characteristics	Diagnosis	Control Group	Intervention	Results
Al-Zoubi and Al-Nimri, 2022, Jordan	CS	- 42 Patients - Group I: 18.4 ±2.8 years) - Group II: 18.2 ± 3.1 years	- Increased OB (more than half of the lower incisors) - Mild skeletal discrepancy - Group I: overbite=5.8 ±0.6 mm) - Group II: overbite: 5.2 ± 0.4 mm)	Lower reverse curve of Spee archwire (Group I); 21 Participants	Metal Anterior Bite Turbos (Group II); 21 Participants	- Lower incisors proclined more in Group I - All cusps of both lower molars showed more extrusion in Group II - The duration of OB correction was shorter using the ABTs by 1.7 months
Chhibber et al., 2011, India	CS	- 55 patients; 41 (F), 14 (M) - Group Begg: 18.25 ± 3.2 years - Group PEA: 18.03 ± 3.5 years	- Angle Class I bimaxillary dentoalveolar protrusion on an underlying Class I - Mild Class II skeletal base (0 degrees < ANB <5 degrees) - Overbite 0–4 mm, with 2–3 mm of crowding or spacing. - Proclined upper and lower incisors	Group Begg; 27 Participants	Group PEA; 28 Participants	- No significant difference was found between the Begg group and PEA group on vertical dimensional changes
Deguchi et al., 2008, Japan	CS	- 8 Patients; 16 (F), 9 (M) - Group J-HG: 20.7 ± 2.5 years - Group: Implant: 21.5±3.7 years	- Group J-HG; OB (mm): 4.4 ± 2.1 - Group Implant; OB (mm): 5.0 ± 1.9	Group J-HG: 10 Participants	Group Implants; 8 Participants	- Group J-HG; OB (mm): 1.0 ± 1.5 - Group Implant; OB (mm): 0.5 ± 1.0 - Significant reductions in OB after intrusion of the incisors in implants & J-hook headgear group - Significantly greater reductions in OB in the implant group than in the J-hook HG group.
El Namrawy et al., 2019, Egypt	CS	- 30 Patients, 21 (F), 9 (M) - Average Age Group I: 19.5 ± 2.5 Average Age Group II: 22.6 ± 5.3"	- ≥ 4 mm overbite - Class I or Class II malocclusion - Excessive gingival display on smiling	Mini-Screw (Group I); 15 Participants	Group II (Intrusive Arch); 15 Participants	Group I: OB (mm): -2.6 ± 0.8 - Group II OB (mm): -2.9 ± 0.8 - No statistically significant difference was found in maxillary incisor intrusion
Goel et al., 2014, India	CS	- 30 Patients - Average growth pattern - No growth remaining	-Requiring intrusion of 2.0-4.0 mm of maxillary incisors	Ricketts utility arch (Group I); 10 Participants	K-SIR arch (Group II); 10 Participants and RCS arch (Group III); 10 Participants.	**- True incisor intrusion:** - utility arch: 1.6 mm - K-SIR: 1.25 mm - RCS: 0.70 mm **- Rate of intrusion** - utility arch: 0.44 mm/month -K-SIR: -0.33 mm/month -RCS: -0.35 mm/month -the difference was not statistically significant

Henick et al., 2021, Canada, USA	CS	- ODI: ≥80.5 ° - 48 Patients - Group Invisalign®: 37.2 ±17.7 years - Group FFA: 27.1 ± 10.4 years	- Class I or Class II DIV. 1 and 2 - Group Invisalign®: OB (mm): 4.49 ± 1.0 - Group FFA: OB (mm): 4.60 ± 1.12"	Invisalign® (Group I); 24 Participants.	Full fixed appliance (FFA) (Group 2); 24 Participants	**Invisalign®**: - Mean change in ODI was -1.58° - Mean decrease in OB: 1.3 mm; significantly different FFA - Mean change in DOI: -2.08°; - Mean decrease in OB: 2.0 mm; significantly different
Pamukçu and Oͤzsoy, 2021, Turkey	CS	- 26 Patients; 19 (F), 7(M) - Group Lingual: 35 ± 12.07 years - Group Labial: 32 ± 13.77 years	- Angle Class I or mild Class II malocclusion - Initial overbite of >3.7 mm - ANB angle between 0° and 4°	Group Lingual; 13 Participants	Group Labial; 13 Participants	- Proclination of the upper incisors was higher in the labial group. - Significant lower incisor proclination in the labial group. - The lower incisors were intruded (-1 mm) in the lingual group but lower incisors were minimally extruded (0.3 mm) in the labial group. - Less protrusion in lingual orthodontics than the labial treatment
Proffit et al., 1992, USA	CS	- 42 patients; 17 (M), 25 (F) - Group I: 22.2 ± 6.1 years; OJ(mm): 6.6±3.0; ANB(°): 5.1±1.4 - Group II: 30.5 ± 9.8 years; OJ(mm): 9.0±2.4; ANB(°): 5.8± 2.0	- Group I: Skeletal Class II malocclusion, OB(mm): 3.9 ± 2.2 - Group II: Only Mandibular Advancement Surgery; OB (mm): 4.9± 2.8	Orthodontics Only (Group I); 33 Participants	Surgery - Orthodontics (Group II); 57 Participants	- Group I: OB (mm): 2.8 ±1.1 - Group II: OB(mm): 2.8 ± 1.1 - Both groups had improved the malocclusion - Surgery resulted in greater reduction of overbite and greater improvement in most cephalometric skeletal, dental, and soft tissue criteria.
Rozzi et al., 20122, Italy, Albania	CS	- 62 patients, 25 (M), 37(F) - Average Age: 24 years 5 months ± 19 months"	- Group F: Curve of Spee 3.5 ± 0.83 - Group I: Curve of Spee 3.7± 0.82"	- Fulled Fixed Appliances (Group F); 32 Participants	- Invisalign® (Group I); 30 Participants	- Group F: Curve of Spee 1.2 ± 0.86 - Group I: Curve of Spee 1.5± 1.02 - F group presented a statistically significant extrusion of posterior teeth with flared mandibular incisors - I Group presented a statistically significant intrusion of mandibular incisors with excellent flare control
Vela-Hernández et al., 2020, Spain	CS	– Non-growing patients, mean age: 36.6 ± 4.9 years - 42 Patients; 24 (F), 20 (M)	- Skeletal class I (ANB 2° ± 1) - ≥ 3mm Gummy smile – Incisor inclination smaller than 110° (U1-PP). – Increased overbite - Group I; OB (mm): 5.17 ± 2.47; CR-SN (mm): 77.47 ± 4.29; IE-SN (mm): 86.89 ±	- One Mini Screw between Central Incisors (Group I); 16 Participants	- Bilateral Microscrews Between Lateral Incisors and Canines (Group II); 28 Participants	-Group I; OB (mm): 2.42 ± 1.93; CR-SN (mm): 71.78 ± 3.99; IE-SN (mm): 81.31 ± 4.06 - Group II; OB (mm): 2.40 ± 1.68; CR-SN (mm): 66.41 ± 3.73; IE-SN (mm):76.13 ± 3.72 - More OB reduction in the

			3.81 - Group II; OB (mm): 6.20 ± 1.50; CR-SN (mm): 74.60 ± 3.49; IE-SN (mm): 84.51 ± 3.65"			group II - More intrusion in group II, statistically significant.
Verma and Jain, 2020, India	CS	- 12 patients - Average Age: 29.5±2.1 years	- Angle's Class I or Class II Division 1 malocclusion - Overbite of >4 mm - >3 mm gummy smile - Lower lip coverage of maxillary central incisors: >4mm	Orthodontic Mini Implants (Group A); 6 Participants	K-SIR Loop (Group B); 6 Participants	- Rate of intrusion for Group A: 0.38 mm/month - rate of intrusion for Group B: 0.31 mm/ month - The amount of intrusion was significantly more in Group A - TSADS have a higher rate and amount of intrusion - There is no difference in vertical control between the two modalities

Table 3: Summary of Data Extraction of Treatment Methods and Appliances used to Treat Increased Overbite in Non-Growing Patients

SR = Systematic Review, CS: Comparative Study, RCS: Retrospective Comparative Study, ODI: Overbite Depth Indicator, PEA: preadjusted edgewise appliance, HG: Headgear, OJ: Overjet, OB: Overbite

5. DISCUSSION

The successful management of increased overbite in non-growing patients involves an accurate diagnosis and a treatment plan based on the treatment methods indicated for each individual patient and their treatment objectives in order to provide aesthetic, occlusal and functional harmony with long-term stability (39). Orthodontists must evaluate their patients clinically by assessing dentofacial aesthetics such as angle class, missing teeth, teeth positioning, facial profile, gingival exposure, and appearance of the smile (14). In a non-growing patient, the convexity of the facial profile must be taken into consideration because specific treatment options and appliances can not only worsen facial appearance but can also potentially affect long term stability (391). Generally, there are three ways to correct increased overbite in non-growing patients: absolute intrusion of the incisors, relative intrusion of the incisors, extrusion of the posterior segment or a combination of all three (36).

5.1 Treatment Methods Used for the Correction of Deep Bite in Non- Growing Patients

5.1.1 Incisor Intrusion and Proclination of Incisors

Intrusion of the maxillary and mandibular incisors is considered to be one of the most recognized methods in the treatment of deep bite in non-growing patients (Jadhav et al., 2021). It is a multi-functional treatment option that can be used to target not only an increased overbite but other common associations of deep bite such as excessive gingival display and a deep mandibular curve of spee (40). During intrusion, the vertical intrusive force passes through the centre of resistance of the anterior segment which intrudes the anterior teeth more than the posterior teeth causing the bite to open, and therefore, reduces the increased overbite (41). Light force is required as the force is concentrated through a small area at the tooth apex (42). In addition, low forces are generally recommended because heavier forces do not exponentially increase the rate of intrusion but can increase the chance of unwanted side effects such as root resorption (43, 44). When the intrusion force passes directly through the centre of resistance of the tooth without tipping or inclination, this is considered to be "true" or "genuine" intrusion (4, 40). When intrusion forces pass away from the centre of resistance of a tooth, tipping or inclination (flaring) of the incisors occurs which is normally not desired unless treatment objectives require the proclination of the incisors (45). However, true intrusion is difficult to achieve in clinical practice because it is difficult to accurately determine the direction of force through the centre of resistance (17, 41, 46). The proximity of the roots to the cortical bone is a theoretical limit on the amount of possible incisor intrusion (46). Incisor intrusion must be monitored during treatment to preserve proper dentofacial aesthetics while correcting the deep bite (47).

The position of the maxillary incisors are often used as an indication for specific treatment methods for increased overbite in a non-growing patient (48, 49). Intrusion of the maxillary incisors is indicated if a patient with a normal or increased lower facial height also displays an excessive distance between the incisal edge and the cephalometric landmark stomion or a large interlabial gap (17). If there is minimal incisor display, using maxillary incisor intrusion would flatten the smile arc and worsen aesthetics (48). In such cases, mandibular levelling and mandibular incisor intrusion is indicated instead (47). Mandibular incisor intrusion is indicated for adults with normal incisal and gingival display and a normal or high mandibular plane angle (50). The

upper lip line during a smile can also be used to determine if incisor intrusion or other treatment methods should be used (17). As cited in the systematic review by Ng et al. (46), mandibular incisor intrusion is more readily achieved in adults compared to maxillary incisor intrusion (46). The correction of the inclination of maxillary and mandibular incisors can also reduce overbite (17). The proclination of maxillary and mandibular incisors usually occurs as a sometimes undesired side effect of intrusion but can also assist in decreasing the amount of overbite if the patient presents lingually tipped incisors as commonly seen in Class II, division 2 or Class III cases of deep bite (17, 51)

There are traditional appliances that produce intrusive movements such as fixed oral appliances (FOAs), intrusion arches and reverse curved archwires(40). In order to select the appropriate intrusive appliance, the potential side effects must also be considered (17). With traditional appliances, a lack of vertical control increases the likelihood of posterior extrusion which can be contraindicated in deep bite patients with skeletal vertical hyperdivergence (17). Extraoral anchorage and modern anchorage appliances such as temporary skeletal anchorage devices (TSADs) should be used for more successful treatment outcomes (17)

5.1.2 Extrusion of Posterior Segment

Like the intrusion method, deep overbite correction using the extrusion of the posterior segment depends on individual patient characteristics, diagnosis and treatment objectives (52). Reduced lower anterior facial height is a contributing factor to the development of increased overbite and can be caused by underdeveloped molar heights in combination with normal growth of mandibular length, and counterclockwise rotational growth (53). Posterior extrusion invades the freeway space due to lack of vertical growth which stresses the TMJ muscles resulting in downward and backward movement of the mandible (30). This downward and backward movement has been reported to facilitate substantial anterior bite opening with every 1 mm of posterior extrusion reducing the overbite by 1.5mm-2 mm (54). However, the use of the extrusion method applies to a narrow group of non-growing patients with reduced lower facial heights and even then, there are strict therapeutic limitations

(55). When the mandible rotates clockwise as the posterior teeth extrude, the skeletal relationship can worsen and create a more retrusive chin depending on the patient (55). In a patient with a deep mandibular curve of spee with a long lower facial height, it is advised against to increase the vertical dimension by extrusion of the posterior teeth (40). Extrusive mechanics in a patient with skeletal deep bite can increase the difficulty of treatment and prolong treatment time because it must counter large occlusal forces and work against the jaw muscles (55). Molar extrusion is not recommended in non-growing patients and is considered to be a more appropriate treatment in growing patients to increase vertical dimension and correct the deep overbite (56,57). Extrusion of the posterior segment can be carried out using continuous or segmented archwires, reverse curve of spee and/or maxillary exaggerated curve of spee wires, step bends, or anterior bite turbos and bite plates (58, 59). Careful planning is required because most traditional appliances have an extrusive component which must be carefully controlled in all cases regardless of whether it is indicated for treatment or not (30). As such, incisor intrusion is usually the indicated treatment in adults with an excessive overbite alongside the use of strict anchorage control (4).

5.2 Treatment Appliances Used for the Correction of Deep Bite in Non- Growing Patients

5.2.1 Fixed Orthodontic Appliances

As cited in the case report by Ongelina & Narmada (60), fixed orthodontic appliances (FOAs) are indicated for multiple tooth movements such as intrusion, controlled space closure, torque control and extrusion (60). Various types of preadjusted edgewise bracket systems, like the MBT appliance, can be used to ensure successful treatment results (60). Nickel Titanium (NiTi) wires are often used because of their advantageous properties such as high flexibility, resistance to fatigue, strength, production of constant small forces and shape memory (61). These properties result in fewer archwires required to achieve a successful outcome and as a result, there is less chairside time and patient discomfort (62).The bracket position of a fixed orthodontic appliance affects the direction of force on the tooth and therefore its movement (41). In a labial system, the force passes through the centre of resistance anteriorly which can cause teeth to protrude or flare as intrusion occurs (41). In lingual systems, the

bracket is placed closer to the centre of resistance and therefore, intrusion can occur with less flaring (41). The Begg technique developed by Begg and Kesling in 1977 is considered to be a superior method in increasing vertical dimension by opening the bite using intrusion of the mandibular incisors and extrusion of the posterior segment with anchorage bends and light forces using FOAs (63). However, according to a retrospective study by Chhibber et al (64), there was no significant difference in changes in vertical dimension between the Begg mechanotherapy compared with normal preadjusted edgewise appliances (64). Continuous fixed appliances use unquantified force systems which makes the specific force levels and vectors difficult to control or determine (65). Other intrusive and extrusive appliances such as a reverse curve of spee, vertical steps, Ricketts' utility arch, or segmental techniques such as the Burstone's intrusion arch can be used alongside fixed appliances to generate increased desired forces (17).

5.2.2 Intrusion Arches and Reverse Curve of Spee Wire

Intrusion arches can intrude the incisors, extrude the posterior segment or perform both movements simultaneously (66). The utility arch appliance was developed to intrude incisors by Dr. Ricketts using a 0.016 x 0.016-inch, square-edged, non-heat treated blue elgiloy wire for the purpose of axial inclination control during intrusion (67). The arch functions in three separate segments simultaneously, in the anterior and posterior segments of the mouth, to activate desired movements (40). Using utility arches has been proven to effectively level deep curves of spee and produce incisor intrusion in a short duration of time (68). It can correct increased overbite and minimally increase mandibular plane angle and anterior facial height (68). Segmental intrusion arches, such as Burstone or Connecticut intrusion arches, are ligated to a base arch wire on the anterior teeth (69). The three piece base intrusion arch was created as a modification of the Burstone intrusion arch and was designed to produce true intrusion while providing maximum control of posterior extrusion (40). This intrusion appliance controls the intrusive force through an attachment of the intrusion arch to the anterior arch instead of brackets (40). This provides the three pierce arch with simultaneous control of tooth movement in the vertical and sagittal planes (70). The light force that acts on the anterior segment of the three piece arch is able to change

the direction of the intrusive force through the centre of resistance of the anterior teeth which allows for true intrusion without a change in the axial inclination of the teeth (40). Depending on the patient, utility arches may not be the optimal choice because they require anchorage and may produce movements like proclination which can be contraindicated (71). In addition, the key to successful intrusion is 160 grams of continuous intrusive force; however, the magnitude of forces of the utility intrusion arch can not be accurately determined (45, 65). Bardideh et al reports that segmental intrusion arches have less unwanted effects on the anchorage teeth and are more effective for anterior teeth intrusion than utility arches which extrude anchorage teeth more than other methods (69, 72). According to a multiple case reports study authored by Goel et al. (73), the utility arch produces the highest true incisor intrusion, followed by the segmented K-SIR intrusion arch, with the reverse curve of spee producing the lowest amount. However, there was no significant difference in the rate of intrusion using the utility arch, K-SIR arch and the reverse curve of spee (73). Like the utility arch, the reverse curve of spee wire can be used for levelling an increased curve of spee, a manifestation commonly seen in deep bite patients (74). The use of the reverse curve mechanism facilitates the intrusion of the mandibular anterior teeth and extrusion of the premolars and molars (74). However, the use of the reverse curve of spee can cause unwanted changes in the axial inclinations of the posterior segment and flaring in the anterior segment(75). Through their comparative study, Al-Zoubi and Al-Nimri (59) reported that anterior bite turbos produced greater mandibular posterior segment extrusion and a more efficient greater increase in the lower facial height ratio in comparison to reverse curve of spee archwire (59).

Intrusive arches such as Ricketts utility arch, segmental intrusion arches and three piece intrusion arches that use the posterior teeth as anchorage to intrude the incisors tend to have posterior extrusion as a side effect which is not usually indicated in non-growing patients (45, 49, 70). The use of traditional appliances for intrusion can result in molar extrusion and incisor buccal tipping due to proper lack of anchorage (70). In patients with a high mandibular plane angle, the counteracting forces on the posterior segment results in increased clockwise rotation of the mandible (76). To cancel this effect, effective anchorage control alongside the incisor intrusion is required

for correction and this can be provided by using extraoral appliances, such as headgear or the J-Hook (71). It has been reported that J-hook headgear used as reinforced anchorage can produce intrusion of the anterior segment while avoiding extrusion of the posterior teeth (77) . Quintão et al. (78) successfully reported a 7 mm decrease in the overbite due reduction through the use of a J-Hook appliance(78). Despite the ease in use, extraoral anchorage requires high compliance and patient cooperation to achieve the desired result and it is considered difficult to convince adult patients to consistently wear their headgear (76).

5.2.3 Temporary Skeletal Anchorage Device (TSADS)

Multiple studies and case reports have shown that extraoral appliances can provide reliable anchorage but only if the patient is compliant (53). Temporary skeletal anchorage devices (TSADs) have been suggested as a superior alternative to traditional anchorage appliances for incisor intrusion mechanics due to their ability to minimise undesired reciprocal effects on posterior segments (71, 79, 80). Additionally, TSADs are more comfortable for the patient than traditional anchorage and there is no requirement for patient compliance(81). With the development of TSADs, clinicians can now move teeth with control and precision without anchorage loss (53). TSADs are able to successfully treat overbite through controlled light continuous forces which results in less external apical root resorption (82). TSADs provide the required strong anchorage for root movement of the maxillary incisors and correction of overbite (53). Currently, two types of TSADs are used, specialised bone screw implants or bone plates (79). One or two TSADs can be placed between the central incisors, the central and lateral incisors, or between the lateral incisors and canines (76, 83, 84). Bone quality, the geometry of the TSADs, the operator's skill and experience, and insertion technique determine the success of a TSAD (85-87). It is recommended that TSADs are placed obliquely to the bone surface for better positioning of the head of the TSADs, reduction in the chance of root contacts, as well as allowing for wider space for the apex of the TSADs in the apical root area (53). In a comparative study by Vela-Hernández et al. (88), it was reported that upper incisor intrusion and the correction of overbite is greater when treated with bilateral miniscrews placed between the upper lateral incisors and canines instead of one placed between the

central incisors (88). Poggio et al. (87) reported that in the mandible, the bone thickness decreases towards the anterior area and therefore, the interradicular areas are not considered safe for TSADs placement due to the higher risk of root resorption and TSAD failure (87). Similarly, Wang et al.(89) also reported that the placement of TSADs is not advised if there is a limited labial plate and a pathological periodontal state (89). Intraoral periapical radiographs or 3D reconstruction of computed tomography scan images can show the placement and inclination of the TSADs and their position to adjacent roots (53,90). TSADs can be immediately loaded and placed in various sites through simple placement and removal procedures (91). In contrast, it has also been reported that after implantation, loading should be postponed for two weeks to allow healing and a focus on oral hygiene (85). Tekale et al. (81) reported that less invision during placement and less pain and discomfort after placement are among some of the reasons why TSADs have a 80-95% success rate (81). The insertion of mini-screws is considered to be less surgically invasive than mini plates because a mucosal flap is not required for placement, and therefore, it is more preferred (81). However, according to a comparative study by Yao et al. (92) reported that there was more efficiency in the intrusion of the maxillary dentition using miniplates than screw-type bony anchorage (92).

According to the study by Deguchi et al. (76) reported that TSADs produce higher amounts of intrusion in comparison to the J-Hook appliance due to the flexibility of choosing a placement location as it relates to the centre of resistance, movement control and the control of undesirable movements and side effects (76). Deguchi et al. (76) also reported that while there were significant reductions in overbite in groups that used TSADs or an extraoral appliance such as the J-Hook, there were significantly greater reductions in overbite in the TSADs group than in the J-hook headgear group (76). In the systematic review by Bardideh et al. (69) reported that mini-screws reduce overbite and produce higher true intrusion compared to other methods of maxillary incisor intrusion such as segmented intrusion arch, utility arch, J hook headgear (69). Yao et al. (92) also reported that appliances such as TSADs had less anchorage loss and greater control in anteroposterior and vertical directions than traditional headgear appliances (92). The case study by Quintão et al. (78) also reports that there is no

significant difference in treatment time when using TSADs or J-hook headgear for anchorage (78). Additionally, the effect of TSADs produces less extrusion of the molar teeth than the previously mentioned appliances (69) In a comparative study, Verma and Jain (93) reported that TSADs have a significantly higher rate of intrusion in comparison to the K-SIR segmented intrusion appliance while the K-SIR intrusion appliance resulted in greater molar extrusion (93). El Namrawy et al. (94) conducted a study comparing the effects of miniscrews and intrusive arches in non growing patients and reported that both groups can produce an effective intrusion reducing the deep overbite but more true intrusion is seen in the micro screws (94).

In contrast, a systematic review article published by Sosly et al. (95) concluded that weak evidence supports the idea that miniscrews are more efficient in treating deep bite correction in comparison to intrusion arches (95). Similarly, Al Maghlouth et al. (96) reported in a 2021 systematic review that there was a low to medium level amount of evidence to support the hypothesis that TSADs were more effective for incisor intrusion than other orthodontic intrusion appliances such as J-hooks and utility arches (96). TSADs do not eliminate the concern of anchorage loss because the force on the traction hook will cause deformation and coupling of the archwires which induces mesial tipping of the molars and lingual tipping of the anterior teeth (71). Compensatory curves in the archwire can be used to counteract the deformation of archwire, provide torque control and assist in correcting the deep overbite (71, 81).

5.2.4 Invisalign® and other Clear Aligner Systems

The Invisalign® appliance system, like other clear aligners tray systems (CAs), function by moving teeth to their preferred position through incremental movements of 0.25-0.3mm, or two degrees of rotation, per tooth (97). Depending on the prescription, patients usually wear each tray for a minimum of 20 hours a day, advancing to the next tray every two weeks (98). CAs tends to be a preferred option for orthodontic treatment especially in non-growing patients due to its pleasing aesthetics in comparison to FOAs (99). Invisalign® initially treated increased overbite by removing the occlusal cover of the second molars but has more recently developed bite ramps and the designing of composite attachments placed on buccal surfaces of the teeth (40). These attachments allow for tooth movement, increased retention and the

delivery of forces (98). The design of the attachments are important in ensuring correct force application on the teeth (100). When these attachments are placed on premolars, they act as anchorage and provide effective control for the intrusion of the incisors (100). A retrospective study by Khosravi et al. (101) reported that proclination of mandibular incisors, maxillary incisor intrusion and posterior extrusion were the principal modalities of DBM correction using the invisalign system (101.). Similarly, it is reported that the best method to treat deep bite cases using Invisalign® is through the intrusion of mandibular incisors (98).

Invisalign® is considered to be effective in patients with deep bites due to the predictable nature of intrusion and other levelling and aligning mechanics using the ClinCheck* procedure (100). A 2011 modification to the system with the G4 SmartForce platform more effectively supported and increased the predictably of movements (98). This new platform upgraded the attachments to improve control of tooth movements thereby increasing the success of deep overbite correction in cases with moderate to severe crowding (47). The G4 platform used 1-mm thick buccal-lingual horizontal bevelled rectangular attachments on premolars (98). In 2014, the G5 platform modification was launched with new standard 4mm and 5mm horizontal rectangular attachments on the premolars and canines respectively (100). For extrusion of the premolars, the attachment design was changed to horizontal gingival bevelled attachments (100). The G5 platform can create pressure areas to any tooth that requires intrusion (40).

A retrospective study authored by Henick et al (102) reported that the average decrease in overbite and the amount of maxillary and mandibular incisor intrusion is larger in FOAs use than it is with the G5 Invisalign® system (102). Traditional FOAs are more useful in cases where the curve of spee must be levelled because aligners have difficulty executing levelling due to the 'bite block effect' which can prevent posterior tooth extrusion (100). As cited in the case study by Pasciuti et al., (100) this effect can be minimised by using precision bite ramps on the lingual side of the maxillary anterior teeth (100). Henick et al. (102) also reported that there was less flaring of lower incisors during intrusion with the G5 technology which may indicate that the

Invisalign® system is better at producing true intrusion in comparison to FOAs (102). In addition, a study by Rozzi et al.(103) concluded that equivalent results could be achieved in the levelling of the curve of spee when using either FOAs or the Invisalign® system, however, less mandibular incisor flaring and posterior extrusion was seen with Invisalign® (103) . Pasciuti et al. (100) further elaborated that if the deep bite requires only incisor proclination and intrusion for correction, aligners like the Invisalign® system perform similarly to FOAs (100). However, Pasciuti et al., (100) also cites that if the treatment objectives indicate the intrusion of lower incisors and extrusion of posterior teeth, aligners perform worse than FOAs (100). The Khosravi et al. (101) retrospective study also revealed in their retrospective study that the use of Invisalign® in patients with more severe deep bites were not corrected to normal overbite values with their results suggesting that only 1.5 mm of overbite improvement can be expected when using Invisalign to treat deep bite (101). With Invisalign® , it is not possible to add curve archwires to determine the amount of overcorrection needed to treat the deep bite as it is with FOAs (100). However, it is possible to design a virtual setup called “frog staging” in order to overcorrect anterior teeth intrusion and extrusion of posterior teeth (100). The success of treatment in cases using CAs can also be attributed to increased compliance in patients (47). There is less mucosal irritation and tooth soreness and in general, less patient discomfort, in comparison to fixed orthodontic appliances (104).

5.2.5 Lingual Orthodontics

Lingual orthodontic treatment can open the bite with less protrusion of incisors (105). It produces bite opening when the lower incisors come into contact with the upper brackets on the lingual surface (106) When the lower incisors touch on the upper incisor lingual brackets, extrusion of the posterior teeth takes place (106). According to the comparative study by Pamukcu and Ozsoy’s (105), the improvements in overbite that can be seen between lingual and traditional labial orthodontics had no statistical difference(105). However, lingual orthodontics did have a higher amount of vertical movement of the incisors and more intrusion than in comparison to labial orthodontics (105). It has been reported that higher rates of mandibular incisor intrusion in lingual orthodontics can be attributed to the shorter distance of force application between the

centre of resistance of the incisors and the lingual bracket (105). A case report by Fukui et al. (107) concluded that the intrusive force being closer to the centre of resistance of the mandibular incisors in lingual orthodontics would cause more intrusion than conventional labial bracket appliance (107). A Finite-Element-Measurement (FEM) study conducted by Jost-Brinkmann et al. (108) concluded that lingual force application generates more optimal tooth movement in intrusion (108). However, lingual orthodontics can be difficult to use in specific patients due to their placement on the lingual surface of the maxillary anterior teeth which can prevent proper occlusion of the teeth (107).

5.2.6 Surgical Intervention

Many cases of increased deep bite in non-growing can be successfully treated with nonsurgical orthodontic treatment, however, some patients have severe skeletal discrepancies that require orthognathic surgery or a combination of orthodontic and orthognathic surgery (33). A cephalometric analysis using specific measurements of anatomical landmarks can provide a specific diagnosis of deep bite (22). A decreased gonial angle was found to be the most common skeletal component with the highest correlation to deep bite (37.1%) followed by the maxillary plane clockwise rotation (32.2 %) (21).

Patients begin with an initial phase of FOA treatment with brackets and wires to align the arches and to correct any dentoalveolar compensation that has manifested due to the discrepancies (decompensation)(109). Decompensation may initially exaggerate the problematic features of the patient's case but it is required in order to achieve the correct occlusal relationships after surgery (110). Orthodontic treatment in combination with surgery decreases the total treatment time and lowers the risk of posterior open bite (55).

In patients with severe skeletal discrepancies, mandibular advancement is usually performed alongside other surgical treatments such as genioplasty , Le Fort I osteotomy, symphyseal osteotomy, anterior mandibular subapical osteotomy, body osteotomy, total mandibular subapical and osteotomy, submental lipectomy, and

rhinoplasty (55). These additional surgical procedures are done simultaneously with the mandibular advancement surgery to correct any skeletal discrepancies and create anteroposterior, vertical, and transverse facial harmony (55). The bilateral sagittal split osteotomy (BSSO) is the most common surgery procedure for mandibular advancement and is indicated for minor to moderate mandibular setback in patients with horizontal mandibular excess, deficiency, and/or asymmetry (111). BSSOs facilitate mandibular advancement and clockwise rotation (112). Vertical abnormalities manifesting in the maxilla presenting as a decreased lower anterior facial height can be corrected by Le Fort I osteotomy with interpositional bone grafting (Bell). Horizontal osteotomies of the inferior border of the mandible genioplasty provide a very predictable means of increasing the lower anterior facial height when mandibular chin height is disproportionately small (55).

In a comparison study by Proffit et al 1992 (113), it was reported that both orthodontic treatment and surgical-orthodontic treatment improved the malocclusion, however, surgery resulted in greater reduction of overbite and improvement in most skeletal, dental, and soft tissue criteria(113). In contrast to Ruf and Pancherz's (114) comparison study of non-growing patients that were surgically treated, those treated with the Herbst appliance saw similar reductions of overbite between the two groups although skeletal and soft tissue and facial profile convexity was reduced significantly in the surgery group(114). The success and predictability of the Herbst appliance indicates that it can be considered an alternative to orthognathic surgery in borderline adult skeletal Class II malocclusions where facial aesthetics are not of a great concern (114).

6. CONCLUSIONS AND LIMITATIONS

Taking into account the limitations of this review, the conclusions are as follows:

1. The different treatment methods for treating increased overbite in non-growing patients are incisor intrusion and proclination and posterior segment extrusion. Incisor intrusion is indicated for the majority of non-growing patients while posterior segment extrusion is limited to patients that require an increase in vertical dimension. In addition, treatment methods utilised will vary based on individual patient characteristics and treatment objectives and may also be

combined in treatment together. However, all these methods do have the ability to treat overbite reduction in a non-growing patient.

2. The different treatment appliances for treating increased overbite in non-growing patients are fixed orthodontic appliances, extrusion and intrusion arches and wires, extraoral anchorage, TSADs, lingual orthodontics, clear aligner systems and surgical intervention. All these modalities have the ability to treat overbite reduction in a non-growing patient. Depending on the patient characteristics and treatment outcome, the efficiency and success of treatment can vary greatly.

Limitations of this review include the lack of quality assessment method applied in the inclusion of the case reports, retrospective studies, systematic reviews, meta-analysis' and literature reviews. Due to the low number of the included reports, reviews and studies, the conclusions should be interpreted with caution.

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8. ANNEX

ANNEX - FIRST PAGE OF ALL PAPERS CITED?