Research Article

Deep bite: A treatment planning decision support scheme

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Abstract

Deep bite malocclusion is one of the most common malocclusions that have a multifactorial nature; with a multitude of underlying components, while various dental and facial parameters could affect the decision making process. This study aimed to customize a step-wise systematized diagnostic tool that could aid the clinician in the decision making process for deep bite cases. We used the data provided by 124 deep overbite cases to elucidate the most eminent underlying components of deep bite malocclusion, moreover a literature review was done that clarified the various contributing factors to the decision making of deep bite. Using this data a systematic diagnostic sheet is presented to aid the orthodontist in designing the treatment objectives of deep bite malocclusion.

Introduction

Orthodontists are required to make decisions regarding treatment on an everyday basis. However, under higher time pressures (as is typical in a busy orthodontic clinic), or with increased ambiguity, experts use intuitive decision making rather than structured methods to arrive at a satisfactory course of action without due regard to all factors and alternatives.

Deep overbite is one of the most common malocclusions in orthodontic practice [1]. Severe deep bite (overbite ≥ 5 mm) is found in nearly 20% of children and 13% of adults, representing about 95.2% of the vertical occlusal problems [2].

Deep bite malocclusion (DBM) overlies a multitude of hidden skeletal and/or dental discrepancies. Hence, the mechano-therapy should be directed to resolve the underlying discrepancy. The orthodontist should treat deep bite not as a disease entity; instead as a clinical manifestation of an underlying skeletal and/or dental discrepancy. This was clarified in a study conducted by El Dawlatly *et al.* [3] in which a group of 124 non-growing deep bite patients were analyzed and they concluded that deep bite malocclusion underlies a multitude of skeletal and dental components that should be all considered during the treatment planning process, accordingly a customized treatment mechano-therapy should be tailored for every individual case in order to resolve the underlying discrepancy.

Materials and methods

As a clinical application of the above mentioned, the aim of this study is to aid the clinical orthodontist in following a thorough stepwise systematic diagnostic approach in the decision making process of deep bite treatment. A systematic diagnostic sheet is proposed as an aid to the orthodontist in designing the treatment objectives. The causative factors (components) were extracted from lateral cephalometric radiographs and study models of 124 non-growing deep bite cases [3]. The age of the included subject was 14 to 22 years and the selection of the subjects was based on following criteria:

a)   Deep overbite more than 5 mm.

b)   Absence of missing teeth

c)   Complete eruption of the 2nd molars

d)   No history of orthodontic treatment

e)   No restriction regarding the sagittal discrepancy (all Angle's classifications were included)

f)   Absence of severe craniofacial disorders.

The following measurements were assessed in order to extract the most important causative factors (Figures 1 and 2) that may contribute to the malocclusion:

a)   Dental cephalometric measurements:

i)   Maxillary anterior alveolar and basal height (Mx-AABH,mm)

ii)   Maxillary posterior alveolar and basal height (Mx-PABH, mm)

iii)   The inclination of the upper incisors (U1/SN)

iv)   Mandibular anterior alveolar and basal height (Md-AABH, mm)

v)   Mandibular posterior alveolar and basal height (Md-PABH, mm)

vi)   The inclination of the lower incisors (L1/MP)

b)   Skeletal cephalometric mesuements:

i)   Mandibular plane angle (MndP-FH)

ii)   Gonial angle (Ar-Go-Me)

iii)   Maxillary plane angle (SN-MaxP)

c)   Dental cast measurements:

i)   The length of the clinical crown of the upper central incisors.

ii)   The length of the clinical crown of the lower central incisors.

iii)   The curve of Spee

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Causative factors of DBM

(Skeletal component)

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Mandibular plane          Combination          Maxillary plane
discrepancy                                     discrepancy
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FMA (27°±5)

SN-Mp (32°±3)

Y-axis angle (60°±5)

SN-Mxp (10°±3)

-

+

Increased upwards and forwards

growth

Increased downwards growth of the

Anterior maxilla
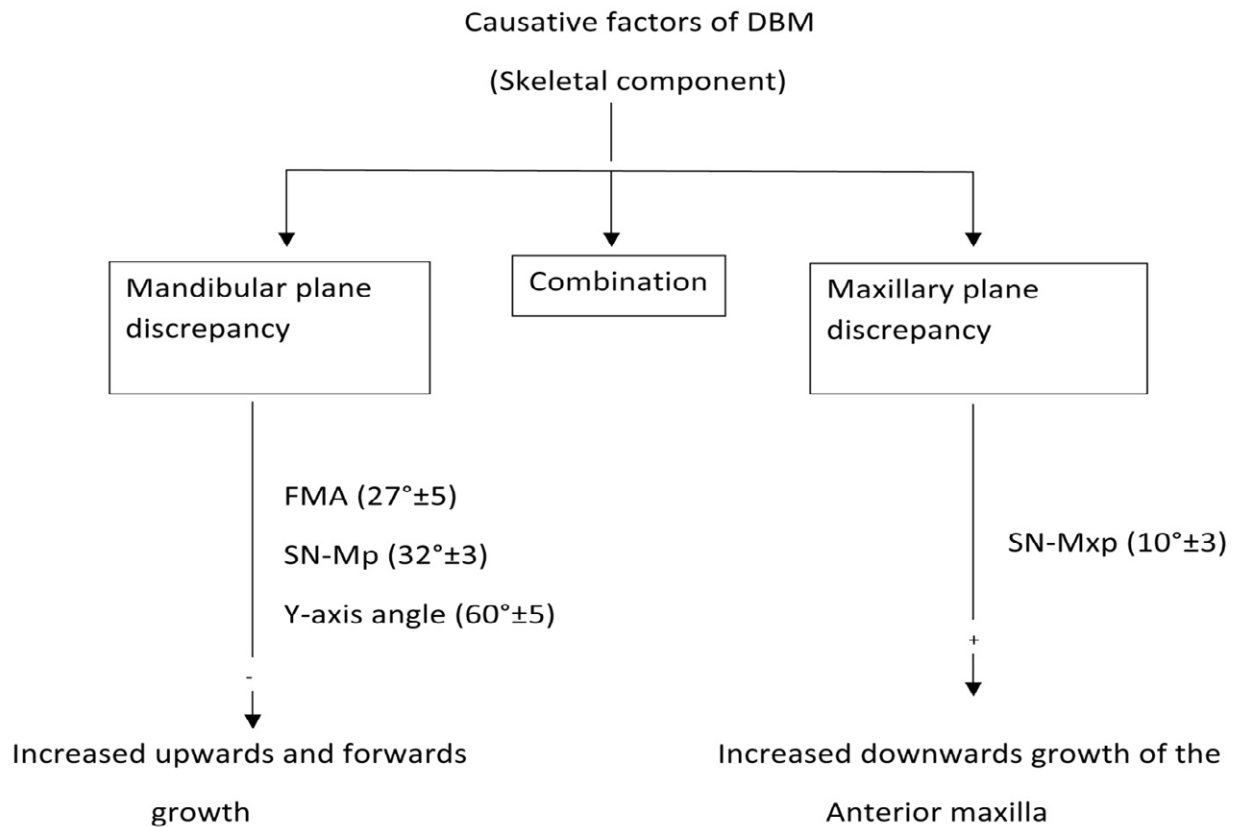
Figure 1. Skeletal causative factors of deep bite malocclusion.

Causative factors (dental component)

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Anterior vertical dento-          Previous                 Posterior vertical dento-alveolar
alveolar discrepancy             extractions              discrepancy
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MxABH
(21±3mm)   Combination   L1 clinical   MdABH
                                       crown   (35±3mm)
                                       length (7-
                                       9mm)

Lower incisors   Posterior teeth   U6-Centriod-PP   L6-Centriod-
                                                                         PP

+   Maximum depth of the
                                                curve of Spee
        U1 clinical   (1.5±0.2mm)
        crown   +   Teeth inclination   Upper Posterior   Lower Posterior
        length (9-   discrepancy   teeth under-   teeth under-
        11mm)   eruption   eruption
Increased
upper   Increased   +
anterior   lower
alveolar   anterior
base   alveolar
height   base height   Exaggerated curve of
(over-   (over-   Spee   U1-SN (104°±6)   L1-SN (104°±6)
eruption   +   eruption of
of upper   Combination
anterior   +
teeth)   +   -   -

        Long clinical   Long clinical
        crown length   crown length   Retroclination of   Retroclination of
        of upper   of lower   the upper incisors   the lower incisors
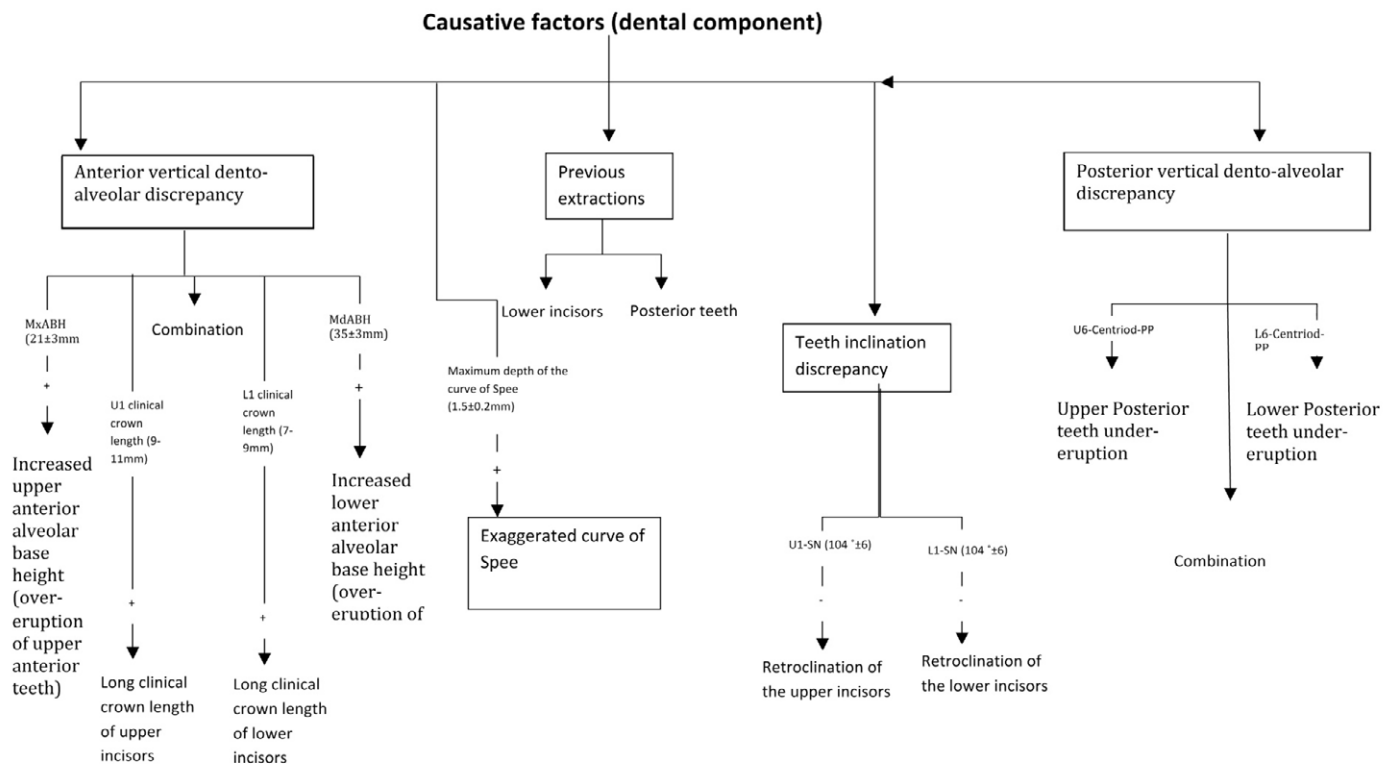   incisors   incisors

Figure 2. Dental causative factors of deep bite malocclusion.

Cephalometric and cast measurements of 10 cases were both repeated by the same observer and by a second observer to measure the intra- and inter- observer reliability.

While the contributing factors (Figure 3 and Table 1) and the mechanical parameters (Table 2) were extracted from a thorough literature review. Five electronic databases were searched till January
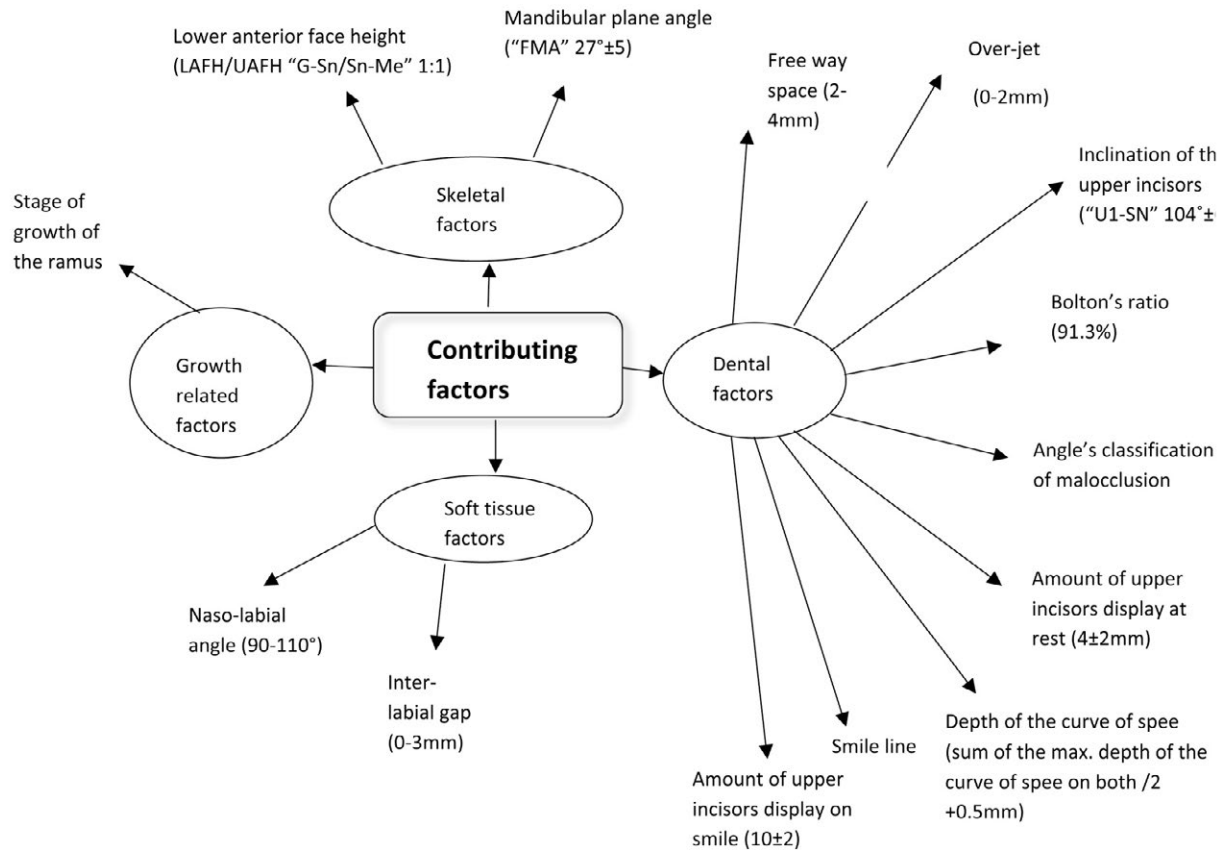

Figure 3. Contributing factors to the decision making process in the treatment planning phase.

Table 1. Effect of the variation of the contributing factors on designing DBM treatment mechanics.

Factor (Norm)	variability	Effect on the mechanics
Inter-labial gap (0-3 mm)	increased	Contraindicates extrusion of posterior teeth.
Mandibular plane angle (FMA 27° ± 5)	Steep	Contraindicates extrusion of posterior teeth.
Free way space (2-4 mm)	increased	Provides a room for extrusion of posterior teeth
Lower anterior facial height /upper anterior facial height (1:1)	increased	Contraindicates extrusion of posterior teeth.
Smile line (parallel to the curvature of the lower lip)	flat	Contraindicates intrusion of anterior teeth
Amount of upper incisors display at rest (4 ± 2 mm)	increased	Favours intrusion of anterior teeth.
Amount of upper incisors show on smile (10 ± 2 mm)	increased	Favours intrusion of anterior teeth
Inclination of the upper incisors "U1-SN"(104° ± 5)	proclined	If intrusive arch used, Intrusive force should be applied posterior to the centre of resistance of the anterior segment/ If anterior bite plate used, should not touch the palatal surface of the upper incisors
	retroclined	If intrusive arch used, Intrusive force should be applied anterior to the centre of resistance of the anterior segment If anterior bite plate used, should touch the palatal surface of the upper incisors.
Naso-labial angle (120 ± 5)	decreased	Further proclination of the upper incisors is contraindicated.
Bolton's ratio (91.3%)	Low ratio (increased Maxillary teeth mass)	Stripping of upper anterior teeth.
	High ratio (increased mandibular teeth mass)	Stripping of lower anterior teeth.
Stage of growth of the ramus	Growing ramus	More stable results after extrusion of posterior teeth
Class II Angle's classification	Division 1	intrusion of lower incisors is required
	Division 2	Usually proclination of the upper and lower incisors is required

Table 2. Effect of parameters change on the amount of overbite.

Parameter	Change in the parameter	Consequent change in overbite
U1-SN	+1°	-0.05 mm
L1-MP	+1°	-0.05 mm
Curve of Spee	0.8 mm leveling of the curve of spee	-0.05 mm
Extrusion in the posterior buccal segment	1 mm extrusion	-1.5 mm
Over-jet	+1 mm	-0.5 mm
Intrusion of upper anterior teeth	A maximum of 1.5 mm (non-growing individuals)	-1.5 mm
Intrusion of lower anterior teeth	A maximum of 1.9 mm (non-growing individuals)	-1.9 mm

2014, these were MEDLINE, EMBASE, OVID, LILACS and THE COCHRANE LIBRARY. Hand searching of orthodontic journals; American Journal of Orthodontics and Dentofacial Orthopedics, Angle Orthodontist, European journal of Orthodontics, Journal of Orthodontics.

The search resulted in 984 citations, and after removal of duplicates and irrelevant articles only 117 articles were used to extract the above mentioned factors and parameters.

Results

Regarding the dental causative factors, the exaggerated curve of Spee showed the highest contribution in DBM (78%) followed by the over eruption of the upper incisors (66.1%). On the other hand considering the skeletal components, the decreased gonial angle was found to be the most skeletal component contributing to DBM (37.1%) followed by the maxillary plane clock-wise 3 rotation (32.2 %). While all the other dental and skeletal factors shared with variable percentages in the malocclusion. Where, the least contributing dental causative factor was the increased clinical crown length of the lower incisors (12.1%). While the least contributing skeletal factor was the mandibular plane angle (19.3%).The intra-observer and inter-observer reliability analysis was calculated using concordance correlation coefficient (CCC), recording high CCC value; indicating reliable measurements

Accordingly, since all the tested causative factors shared with variable percentages in developing the malocclusion, they were all included in the created decision support sheet (Figure 4 a and 4b).

Regarding the contributing factors and mechanical parameters, the search done resulted in designing the most important:

a)   14 contributing factors (that doesn't cause deep bite but they do affect the decision making process when planning the treatment mechanics) (Figure 3).

b)   7 mechanical parameters (that are some treatment mechanics that are built to resolve other problems during treatment but eventually they have a direct effect on the anterior over-bite) (Table 2).

The created deep bite decision support sheet was designed to include all the above mentioned causative, contributing factors, and mechanical parameters. In every deep bite case all the measurements included in the scheme should be filled in order to design an individualized treatment plan for every individual case without missing any of the above mentioned factors. Two cases are presented as an example of the technique of using this diagnostic protocol for defining the treatment objectives (Figure 5 and 6).

Discussion

Causative factors

Skeletal deep bite (Figure 1) could result from a discrepancy in the

vertical position of the maxilla, mandible, or their cant [4]. If there is an increased maxillary downward and backward growth and/or an increased mandibular upward and forward growth, this would result in DBM. It has been shown that the vertical component of mandibular growth has a more remarkable effect than the rotational component [5,6], and that the mandibular skeletal changes are twice as important as the mandibular dental changes and about 2.5 times as important as the maxillary changes in inducing overbite change.

Dental deep bite (Figure 2) may be caused by an anterior dento-alveolar vertical discrepancy. The over-eruption of the upper anterior teeth or the lower anterior teeth causes dental deep bite [7]. DBM may be also caused by the under-eruption of the upper or the lower posterior segments [8].

The exaggerated curve of Spee is a main factor in DBM [9,10], where the lower incisors are retroclined and over-erupted.

The extraction of teeth could also deepen the bite because of the loss of the vertical holding wedges after the extraction of posterior teeth [11]. The extraction of lower incisors leads to a collapse of the lower arch with a consequent deepening of the bite [12].

Discrepancy in the inclination of the anterior teeth has an effect on bite depth. Retroclined upper anterior teeth cover a greater length of lower anterior teeth [13], while the retroclined lower anterior teeth lead to a collapse of the lower arch [14].

Contributing factors

These are factors that do not cause DBM, but affect the decision making process in designing the treatment mechanics. They are categorized into growth-related, skeletal, dental, and soft tissue factors (Table 1 and Figure 3).

The growth factor: In a growing patient with a skeletal deep bite, growth modification is the treatment of choice. The stage of growth can be determined using the cervical vertebrae maturation index (CVM) [15]. It was proven that the growing deep bite subjects attain their peak pubertal growth changes 2 years after the open bite subjects [16]. Therefore, growth modification should be attempted late, in the terminal period of the pubertal growth spurt.

The vertical growth of the ramus increases the free way space between the jaws. Therefore, the growth status of the mandibular ramus is of great importance in case of extruding the posterior teeth. If the ramus is still growing, this provides room for the extrusion procedure, a better neuro-muscular adaptive capability and the long term stability of the extruded teeth is more secured [17].

Skeletal contributing factors: Evaluating lower anterior facial height is important, since in a long face extrusion of posterior teeth should be avoided in order not to aggravate the problem [18].

Dental contributing factors: The display of the upper incisors

a

DBM Diagnostic procedure:

Amount of overbite: _____

- o **Aimed overbite:** _____
- o **Correction required:** _____

Step 1 (Growth status):

- o Age: ____
- o Sex: ____
- o CVMI stage: ____

Step 2 (skeletal status):

Mandiblular measurements:

- ➤ FMA (27 +/- 5): _____
- o increased
- o normal
- o decreased
- ➤ Y-axis angle (60 +/-5): __
- o Increased
- o Normal
- o decreased
- ➤ SN-Mp (32+/-3): _____
- o Increased
- o Normal
- o Decreased

Maxillary plane measurements:

- ➤ MMA angle (27+/-5): _____
- o Increased
- o Normal
- o decreased
- ➤ SN-Mxp angle (10+/-3): _____
- o Increased
- o Normal
- o Decreased

Step 3 (Dento-alveolar status)

Anterior teeth vertical discrepancy:

- ➤ "MxABH*" (21 +/-3 mm) : _____
- o Increased
- o Normal
- o decreased
- ➤ "U1 crown length"(10.5±1mm)
- o Increased
- o Normal
- o Decreased
- ➤ "MnABH**" (35 +/- 3 mm): _____
- o Increased
- o Normal
- o decreased
- ➤ "L1clinical crown length" (9±1mm)
- o Increased
- o Normal
- o Decreased
- ➤ "U6 _PP mm" (26±3): _____
- o Over-eruption
- o Normal

- o Under-eruption
- ➤ "L6_MP mm" (35±3): _____
- o Over-eruption
- o Normal
- o Under-eruption
- ➤ "U1-SN" (104 +/- 6) : _____
- o Increased
- o Normal
- o decreased
- ➤ "L1-MP" (95 +/- 5): _____
- o Increased
- o Normal
- o Decreased
- ➤ **Extracted and/or missing posterior tooth no.** _____
- ➤ **Extracted and or missing lower incisor no.** _____

Step 4 (Contributing factors)

1) Clinical examination:
- ➤ smile line
- o Flat
- o normal
- o Exaggerated
- ➤ Inter-labial gap "Ustm- Lstm" (0-3mm)
- o Normal
- o increased
- ➤ Upper incisors display at rest "Ustm-U1 incisal edge" (3±2mm)
- o Normal
- o Increased
- o Decreased
- ➤ Free way space "Sn-Me at rest position- Sn-Me at maximum intercuspation" (2-4 mm)
- o Increased
- o Within normal
- o Deficient
- ➤ Upper incisors and gingival display on smile (10±2): _____
- o increased
- o normal
- o deficient

2) Cast analysis
- ➤ Depth of the curve of Spee: ____
- ➤ The amount of over-jet (0-2mm): _____
- ➤ Bolton ratio between upper and lower teeth (91.3 %): _____
- ➤ Angle's classification of malocclusion:
     Class I   Class II div1   class II div2   Class III

3) Cephalometric analysis
- ➤ **Lower anterior facial height "G-Sn: Sn-Me mm" (1:1):** _____
- o Increased
- o Normal
- o decreased
- ➤ **Mandibular plane "FMA"(27 +/-5):** _____
- o Increased
- o Normal
- o Decreased

4) Stage of growth of the ramus: _____

b

Outcome 1 (growth status): _____

Outcome 2 (skeletal status): _____

Outcome 3 (dento-alveolar status): _____

Outcome 4 (contributing factors): _____

Final outcome:

_____

_____

Treatment
objectives: _____

_____

* MxABH: The upper anterior alveolar height (distance in mm between the midpoint of the alveolar meatus and the point of intersection between the palatal plane and the maxillary alveolar axis).

** MnABH: The lower anterior alveolar height "(The mm distance between the midpoint of alveolar meatus of mandibular central incisor and the intersection between symphysial surface and mandibular alveolar axis).

Figures 4a and 4b. The proposed new diagnostic paradigm.

Case 1

Age: 12.
Bite depth: 6.5mm.

Aimed end result of overbite: 1 mm.
Correction required: 5.5mm.

1) Growth status:
- Stage 2 CVMI (cervical vertebrae maturation index).
- Peak mandibular growth spurt is approximately 1 year away.
- Patient is still growing.

2) Skeletal status:
- Slight increase in the downward and backward rotation of the anterior part of the maxilla.
- (A skeletal maxillary component is contributing to DBM).

3) Dento-alveolar status:
- Over-eruption of upper and lower anterior teeth.
- A slight long clinical crown length of the lower central incisors.
- Proclined upper incisors.

4) Contributing factors:
- Normal smile line.
- Increased upper incisors display at rest.
- Increased upper incisors and gingival display on smile.
- Very deep curve of Spee.
- Class II div 1 malocclusion.
- Increased lower anterior facial height.
- Increased overjet.

Treatment objectives:

Control posterior dentoalveolar segments and intrude upper and lower incisors

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Case 2

Figure 5. Clinical application of the new paradigm.

Age: 12.
Bite depth: 9mm.

Aimed end result of overbite: 2 mm.
Correction required: 7mm.

- Peak mandibular growth spurt occurs in this stage.
- Patient is still growing.

2)   **Skeletal status:**
- Increased upward and forward rotation of the mandibular base.
  (skeletal mandibular component sharing in DBM).

3)   **Dento-alveolar status:**
- Under-eruption of upper and lower posterior teeth.
- Retroclined upper incisor.
- Missing 2 lower lateral incisors.

4)   **Contributing factors:**
- Flat smile line
- Decreased upper incisors display at rest
- Decreased upper incisors display on smile
- Deep curve of Spee
- Class II div 2 malocclusion
- Decreased lower anterior facial height

Treatment objectives:

Encourage eruption of upper and lower posterior segments and avoid intrusion of upper incisors

1)   **Growth status:**
- Stage 3 CVMI (cervical vertebrae maturation index).

Figure 6. Clinical application of the new paradigm.

at rest and the amount of upper incisor show on smile influence the treatment decision. Excessive incisor display favors intrusion of upper anterior teeth. Conversely, normal or decreased incisor display favor extrusion of posterior teeth and/or intrusion of lower anterior teeth .The smile arc curvature has a bearing on the treatment of choice for deep bite patients. In case of a flat or nearly flat smile arc, intrusion of upper incisors is contraindicated [19-23].

The ratio between the mesio-distal width of the upper and lower teeth will affect bite depth. According to Bolton a normal acceptable overbite could be attained only if a balanced ratio (91.3%) between the upper and lower teeth is reached [20,21].

Regarding Angle's classification of malocclusion, a deep overbite that is caused by the over-eruption of lower anterior teeth due to the increased overjet is associated with the growth factor malocclusion. While in skeletal contributing factors; deep overbite is the direct result of retroclined upper incisors that cover most of the lower incisors height [22-23].

In case of using intrusive arches, the degree of upper incisors inclination affects the point of application of the intrusive force during incisors intrusion [24]. Also their inclination affects the design of the bite raising device or the anterior bite plate, depending on whether there is a need to flare the upper incisors or not.

The available free way space should be precisely measured. A sufficient free way space would permit the extrusion of posterior teeth and decrease the tendency for relapse [25].

Soft tissue contributing factors: An increased inter-labial gap would be aggravated by extruding the posterior teeth. The naso-labial angle limits the proclination of the upper incisors as a treatment option for DBM. In case of a reduced naso-labial angle, proclination of the upper incisors is contraindicated [26].

The Mechanical parameters

These are some parameters that are built to resolve certain problems during treatment, and at the same time they have a direct effect on the depth of the bite (Table 2).

Changing the inclination of the upper incisors has been found to have a direct effect on the amount of overbite; there is a negative correlation between the inclination of the upper incisors and the amount of overbite where a decrease of 6 degrees in their inclination results in a 0.3 mm increase in overbite. Any change in the amount of overjet during the various treatment procedures affects the amount of overbite; with every 1mm increase in overjet the overbite is reduced by 0.05 mm [27].

Considering the extrusion of posterior teeth, it has been proven that every 1 mm of posterior extrusion opens the bite anteriorly by 1.5 mm [28]. This finding emphasizes that small amounts of molar extrusion can result in significant anterior bite opening.

The intrusion of the upper incisors is proposed in many studies as the ideal treatment option for DBM [29].

According to a recent systematic review it was found that, for non-growing individuals, a maximum of 1.5 mm upper incisors intrusion and 1.9 mm lower incisors intrusion could be attained [30].

In addition to the effect of leveling the Curve of Spee on the vertical position of the incisors, the use of straight wires for leveling causes proclination of the incisors. The degree of proclincation can be calculated from the equation [(the sum of the maximum curve of Spee on both sides/2) +0.5 mm]; for every 0.8 mm required for leveling the curve of Spee there is 1° proclination in the lower incisors with further opening of the bite [31].

Not only the antero-posterior changes affect the bite depth, but also the transverse changes have a remarkable influence [32,33]. Rapid maxillary expansion, attained in growing subjects, was found to cause an increase in the downward and backward rotation of the mandible, increase in the lower facial height and a decrease in the overbite [34].

The proposed decision support scheme

In order to follow the current protocol aiming to customize the treatment plan for deep bite cases, the clinician should:

a) Extract all the measurements listed in the sheet from the patient's lateral cephalogram and study model.

b) Classify the problem list into 4 sections; the growth status, dental, skeletal status and the contributing factors. This is applied in Figure 5 and 6.

c) Specify the treatment objectives and the bite opening mechanics according to what is dictated by the extracted data.

Conclusions

The orthodontist's approach in treating DBM should resemble the physician's approach in managing fever. The physician regards fever as a symptom of an underlying pathological condition. Likewise, the orthodontist should be aware that DBM is not a disease entity, but rather a clinical manifestation of an underlying skeletal and/or dental discrepancy. By following the proposed diagnostic procedure (Figure 4a and 4b), which takes into account all factors that affect DBM, an efficient, factor-based treatment plan is established. Two cases are presented to emphasize the clinical utility of this approach (Figures 5 and 6).

By systematically following the suggested deep bite diagnosis procedures [35,36] the two cases presented were found to be divergent regarding causative and contributing factors. The systematic consideration of all factors could provide individualized treatment objectives for deep bite correction.

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