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Literature review

Late Mandibular Anterior Crowding

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SUMMARY

The objective of this literature review is to provide a comprehensive overview of late mandibular anterior crowding, with a focus on its etiology, management and treatment. In the first part of the review, we will cover the principles associated with this malocclusion scheme, including the various contributing factors. We will also explore the topic of mandibular third molar involvement and its relationship to anterior crowding.

In the final part of the review, we will examine modern strategies for managing and treating late mandibular anterior crowding in the dentist's office. This will include a discussion of various treatment modalities, such as clear aligners and traditional braces, as well as the importance of ongoing patient education and monitoring.

By providing a comprehensive overview of the topic, this review aims to equip practitioners with the knowledge and expertise necessary to effectively manage patients presenting with complaints of late mandibular anterior crowding. Improved outcomes and oral health will result in a combination of modern treatment strategies and patient education.

KEYWORDS:

Malocclusion; Late Mandibular Crowding; Class I; Adulthood; Third Molars; Etiology; Aligners.

I. INTRODUCTION:

In modern orthodontics, one of the most commonly referred concerns of the patient is the misalignment of the mandibular front teeth. The general practitioner is usually in the first line position to assess, discuss and articulate this issue with the patient. Therefore, an educated and up to date knowledge of the etiology, mechanisms and factors related to late mandibular anterior crowding is a primordial attribute in any dental clinic, as well as the possession of adequate treatment strategies.

As it was found that 67% of adolescents will develop mandibular anterior crowding by early adulthood (1), the relevance of the topic is accentuated by the increasing need of aesthetically pleasing dentition in the general population (1).

It is habitual for the general dentists to follow patients over an extended period of time, usually starting when the patient is still a child. It gives the general dentist a key position to observe and evaluate the evolution of the dentition, including orthodontic changes.

As we will understand later, anterior crowding, or the overlapping of the canine to canine teeth, do not represent any pathological or functional issues(3), in the most severe cases, achieving a proper hygiene could be more challenging, but overall, the general and dental health is not at risk (3).

According to Van der Linden, the latter stage of crowding (tertiary), the one on which we will focus here, develops between the ages of 15 and 20 years old (2) and concerns a slight majority of men, as mandibular growth rates differ between sexes (1). Dressing the profile type of the patient seeking orthodontic treatment as teenage or young adult men, with primarily aesthetic concerns. In this time period, physical appearance, including dental occlusion and misalignment is a major factor in building self-confidence. The psychosocial impact of mandibular crowding is an important preoccupation for the patient and should not be overlooked or minimized by the clinician (4). And it is just as important that each patient presenting a case of mandibular crowding understands that it is a “normal” phenomenon occurring naturally (3).

In this review, we will first take a look at the basic principles, etiology, concepts and biological implications of late mandibular crowding, then we will have a discussion on the role and the effects of mandibular third molars, as well as their extraction on the anterior crowding. And finally we will analyze the current treatment options and strategies as well as the tools put in place to facilitate the management of late mandibular crowding.

II. METHODOLOGY:

This literature review was redacted using the PubMed Central database with the initial research method: ((systematic review[Title]) AND (malocclusion[Title] OR Class I[Title])) AND (Etiology[Title]) OR (Third Molar[Title]) OR (Treatment[Title]). The limit was set to ten years originally and grafted with ressources issued from the original findings.

III. UNDERSTANDING LATE MANDIBULAR ANTERIOR CROWDING

Definition

Before we even begin to touch on various theories and concepts, it is necessary to have in mind what teeth crowding is, and in our particular case, late mandibular anterior crowding. In a straightforward fashion, we will break down the term into separate words to better understand their meaning all together.

"Late": implies a time period. Introduced by Van der Linden in 1974 (5), this terminology, still well accepted in modern orthodontics, belongs to a three, time based, classification: Primary, secondary and tertiary (also referred to as late) crowdings. In his classification, Van der Linden describes the tertiary crowding as being the last time-sensitive period where crowding can be observed. This time period being between the ages of fifteen and twenty years old, therefore comprising adolescent and young adult patients with permanent dentition.We should also note that tertiary, or late crowding can occur in patient presenting a previously ideally arranged dental arches, as well as in patients with a history of primary and/or secondary crowding. (3)

"Mandibular anterior": self explanatory, it denotes the area of interest. Here the canine to canine region of the lower jaw and in particular the intercanine width of the permanent dentition. Which as we will see, shows some relevance in the etiology and treatment strategy.

"Crowding": the core of this discussion, is a term that could be interchanged with "overlapping" or "misalignment". Crowding, or "to crowd" is defined as the result of the forces pushing the subjects together in a tight or confined space, implying that space is per definition insufficient for comfort or natural placement. It is a perfect reminder that the dentition is in a constant dynamic phase and evolves throughout life (6). The forces, vectors and equilibrium that play a role in the mandibular anterior crowding are multiple and not necessarily equal to each other, as we will now understand in a comprehensive overview of the different etiological factors and their implications in the resulting crowding.

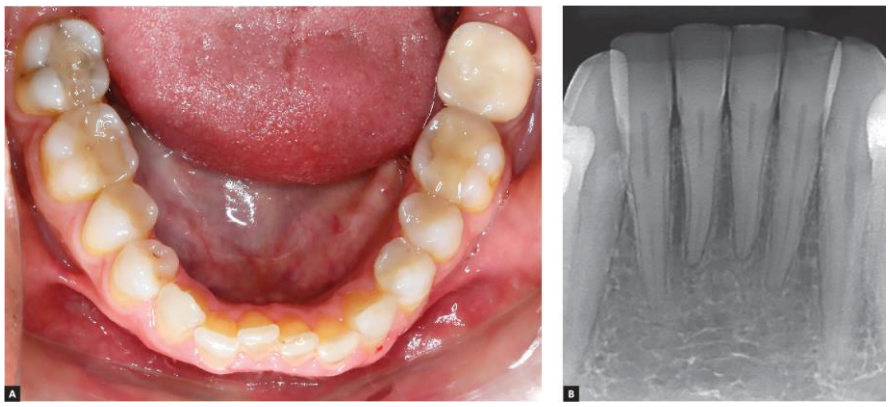

Figure 1: - Mandibular anterior crowding, highlighting the proximity of the teeth (roots), maintaining their structures, without inflammatory resorption, dental ankylosis, nor concrescence. (3)

Etiology

In 1979, Richardson ME. found a correlation between mesial migration of the lower posterior teeth, including first, second and third molars (in particular the first molar), and anterior mandibular crowding (7). Mesial migration of the posterior teeth can be explained by different theories: physiological mesial drift; the anterior component of the force of occlusion on mesially inclined teeth; the mesial vectors of muscular contraction; the contraction of the trans-septal fibers of the periodontal ligament or the presence of a developing third molar (6). The role and implications of these vectors will individually be discussed in this piece with a special emphasis on third molars.

A well established phenomenon decreasing the lower arch length, is retroclination of the anterior teeth; such a situation can be due to the application of distal forces on the dentition (8). For example, the growth pattern of the jaws greatly influences the position of the dentition relative to the maxilla and mandible. During the teenage years, when the body undergoes significant changes, the inter-incisal angle will

naturally increase (8). This can result in retroclination of the lower incisors, causing them to tilt backwards, and reducing the overall arch length. This phenomenon, known as incisor uprighting, occurs as the mandible grows forward relative to the maxilla, leading to a straightening of the profile (6).

The differential nature of late skeletal growth is responsible for incisor uprighting. Meaning that the mandible experiences more growth in a forward direction than the maxilla, resulting in a forward shift of the mandible relative to the maxilla. Additionally, the B point on the alveolar bone, which supports the teeth, grows less in a horizontal direction than gnathion on the basal bone. This disparity in growth between the alveolar and basal bone suggests that the growth of the alveolar bone does not keep pace with the skeletal growth, leading to incisor uprighting. (9)

In patients with a tight anterior occlusion before late mandibular growth occurs, the contact relationship of the lower incisors with the upper incisors will change if the mandible grows forward. In such a situation, one of three things must happen: 1- the mandible is displaced distally, which can lead to a distortion of temporomandibular joint function and displacement of the articular disc; 2- the upper incisors flare forward, creating space between these teeth; or 3- the lower incisors displace distally and become crowded. In most cases, distal displacement of the lower incisors with concomitant crowding and a decrease in the lower intercanine distance is the typical response. (9)

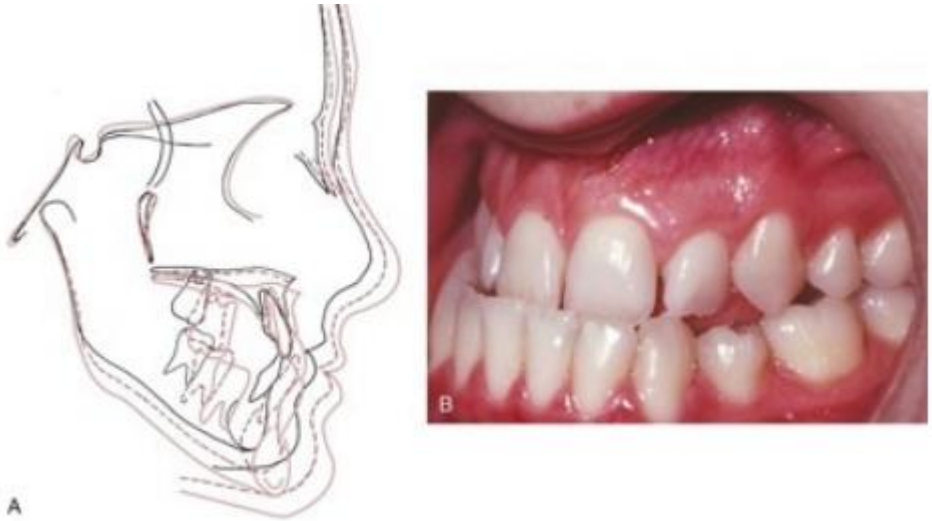

Figure 2 : patient with a prolonged pattern of excessive mandibular growth (A), the lower incisors were increasingly tipped lingually as the mandible grew forward and were noticeably retroclined (B) by the end of adolescent growth (9).

Moreover, severe rotation of the mandible in a forward or backward direction could lead to heightened dental crowding. (6) If the mandible rotates upward and forward, the eruption paths are shifted towards the midline, causing Björk to describe it as "packing of the lower anterior segment." (10). In contrast, extreme downward and backward rotation of the mandible results in retroclination of the lower incisors due to their functional relationship with the upper incisors. This can result in a lack of guidance for the posterior teeth during eruption, causing them to become crowded (6).

Another component of distal forces applied to the lower mandibular anterior teeth would be the maturation of the soft tissues as it is generally recognised that tooth position can be modified in relation to the oral soft tissues. If M.E. Richardson did not find a direct evidence of soft tissue maturation affecting lower anterior crowding (11), It remains interesting to take a look at some indirect evidence of this phenomenon, for example, it has been found that Frankel's functional regulators helps in the sagittal development of the mandibular arch by removing the forces applied from the external oral muscles (12). As we have understood, the role of mandibular arch development is key in lower anterior crowding but it we should keep in mind that these observations were made in mixed dentition patients presenting class II malocclusion and that such results might not be reproducible for the class 1 malocclusion patient of older age. We can still take into consideration that the changes associated with late mandibular growth

can bring the dentition into a different soft-tissue environment, that skeletal growth does not necessarily coincide with soft tissue growth, that self conscious adolescent might keep their lips close, affecting the lip pressure on lower anteriors and that orthodontic treatments can impact the overall pressure environment on the teeth. (6)

Forces originating from the occlusion can also be accounted responsible for late anterior crowding. Changes in the functional occlusion can deviate masticatory forces or create premature contact points. such changes can be due to the development of parafunctional habits, orthodontic treatments, restorations or even tooth loss. (6)

The presence of continuous periodontal force has been shown to play a role in maintaining interproximal contacts in a state of compression in humans (13). This has led to a significant correlation between interproximal force and lower arch crowding. While it may be difficult to attribute crowding solely to periodontal forces, they may contribute to the development of lower arch crowding when combined with other factors. (6) Transseptal fibers, which extend from one tooth to adjacent teeth and even other teeth, play an important role in the dynamics of this process. These fibers serve as biological splints, maintaining tooth contacts and keeping the teeth together. In order to maintain interproximal contacts, transseptal fibers must also have a role in moving teeth. The contractile mechanism of the transseptal ligament has been shown to be responsible for the mesial drift of the teeth when interdental space is created (14). This is demonstrated in the study by Moss and Picton (15) where the teeth moved mesially to reestablish contact when occlusal surfaces were ground out of occlusion and interproximal surfaces were ground to create interdental space. Thus, the transseptal fibers are essential for maintaining tooth contacts and playing a role in tooth movement.

In addition to forces exercised on the dentition, it is commonly accepted that the mesio-distal width of the crowns to the length of the mandibula ratio is a key factor to anterior crowding and a pattern that tends to express itself in the tertiary stage of crowding in particular (16). As described by Puri et al. , tooth width is determined by hereditary, ethnicity, sex and secular trend (17). In their study the relationship between the size of teeth in crowded, spaced, and normal dental arches was investigated. They found that the dimensions of teeth were larger in crowded arches compared to normal dental arches, while the total tooth material and dimensions of teeth were smaller in spaced arches. In addition, there was a positive correlation between the dimensions of

incisors with those of canines and premolars. The study also showed that there was a significant difference in the size of teeth between crowded and spaced arches. Finally, it was found that lateral incisors size varied significantly across all three groups. Proving that discrepancy in the arch length and tooth width have a direct effect on anterior mandibular crowding.

Although, Raymond Begg conducted studies that suggested the modern diet and attributed attrition may contribute to the prevalence of anterior crowding in contemporary populations. Begg hypothesized that the Australian aborigines' diet, which caused significant occlusal and interproximal wear, meaning smaller width of anterior teeth, led to less crowding in their population. This theory is commonly found in the literature and is often presented as a main etiological factor of anterior mandibular crowding (18). However, subsequent evidence has refuted this theory as Australian aborigines who adopted a modern diet still presented less crowding than the average contemporary population (9). It can be concluded that the natural width of teeth is indeed creating a discrepancy with the length of the mandibular arch but lack of attrition in the modern diet cannot be considered as a definite cause of crowding.

Furthermore, degenerative changes in the bone and periodontal membranes are known to be susceptible to hormonal fluctuations during adolescence and may be exacerbated by periodontal disease. (6) These changes can cause clinical crown elongation, gingival recession, and bone loss, which can weaken the supporting tissues and render teeth more susceptible to pressures that were previously resisted (6). Orthodontic tooth movement can also contribute to root resorption and reduced bone levels, resulting in premature aging and post-retention crowding (6). The condition of the periodontium plays a critical role in the stability of lower incisors, with a balance between the forces of the tongue, lips, and cheeks usually present (19). Destructive changes in the periodontium can lead to unbalanced muscular forces and subsequent pressure on the lower incisors, with age being a primary factor in increased periodontal destruction due to natural bone resorption (19).

Which will lead our interest to the complex equilibrium of forces applied together at different degrees that will rearrange the occlusion. The concept of tensegrity can now be introduced to our discussion. Consolaro A. (3) introduces and correlates the

mechanism of tensegrity to dentistry as the balance and stability of any system of forces, including the dental arch. The dental arch must maintain tensegrity, which can be analyzed in one tooth, a group of teeth, the dental arch, or across the face. The teeth, antagonistic teeth in stable occlusion, forces generated by soft tissues, and bone tissue's adaptive and functional dynamism contribute to the tensegrity of the dental arch. When one of these factors changes, the tensegrity is broken, and the tooth tends to change position gradually, leading to crowding. From this description, one should understand that crowding should be considered a loss of tensegrity of teeth in the dental arch and not simply a lack of space.

Biological status of crowded teeth

Finally, we can wonder how the biological status of the periodontium of the crowded teeth reacts and adapts to the different forces applied and orthodontic changes. As comprehensively described by Silva BSE et al. in their 2017 article (20) , the periodontal ligament is an essential structure for tooth anchorage, and its maintenance is crucial for proper dental function. The epithelial rests of Malassez (ERM) are the only odontogenic epithelial structures that persist in the periodontal ligament in adulthood and play a vital role in maintaining homeostasis and promoting regeneration of the periodontal ligament space. Epithelial growth factors and prostaglandins released from bone resorption of the alveolar surface trigger the regeneration of periodontal tissue by assisting in the renewal of cells that have suffered damage. ERM also contributes to the regeneration of the cementoblastic process, allowing the root surface to regenerate and return to its normal state. The balance maintained by ERM prevents the occurrence of dentoalveolar ankylosis and contributes to the reorganization of the periodontal ligament during orthodontic tooth movement and resorption. Furthermore, the constant release of EGF by ERM maintains the periodontal space at a thickness of 0.2 to 0.4 mm, preventing inflammatory resorption, ankylosis, or dental concrescence. This peptide permeates between the fibers and cells of the periodontal ligament, stimulating bone

resorption if new layers of fasciculate bone get too close to the tooth(3). As a result, resorption of hard tissues occurs only on the bone surface of the periodontal ligament, allowing the maintenance of the periodontal thickness as new layers of cement slowly build up. In conclusion, crowded teeth cannot be considered in a pathological periodontal status as they do not result in ankylosis or concrescence and will not interfere with a healthy periodontium.

It has now become obvious that there is no consensus on the origin of lower anterior crowding and that none of the factors mentioned above can be solely considered as a causative agent but rather their complex combination in association to the particular environment that makes mandibular anterior crowding a natural occurrence in most adults. In conclusion, the causes of lower jaw anterior crowding are multifactorial and one can agree that each of the factors do not act or influence in the same manner according to the individual's age or gender (3). But the common denominator is a decrease in arch length, which will inevitably, if the teeth remain at their normal and natural sizes, result in tooth crowding. Lower arch length can be decreased by a forward migration of the lower posterior teeth, a retroclination of the anterior or a combination of both (3, 6).

IV. THE ROLE AND INFLUENCE OF MANDIBULAR THIRD MOLARS ON ANTERIOR CROWDING

A contoversial topic

Purposefully, one factor has been omitted from the first part of our discussion, as it is probably the most controversial thematic of the subject. This second part will provide an updated overview on the role and attribution of third molars to lower anterior crowding.

The influence of third molars on lower anterior crowding has been a subject of controversies in the orthodontic field for the past decades and mentions of it can be traced as early as 1907 with Angle's descriptions of occlusion(22). Nonetheless, over time and with the evolution of scientific standards and means of studies, the opinions of dental and orthodontic specialists have diverged, creating this ambiguous status on the role of third molars on anterior mandibular crowding.

We can now take a look at this evolution, starting with the general opinion of specialists on the subject. Indeed, in 1971, about 65% of oral surgeons and orthodontists believe that unerupted mandibular third molars was the etiological factor responsible for anterior crowding due to mesially directed forces (19) . Yet, more recent studies on the opinion of specialists show a switch in tendency as the majority of oral surgeons and orthodontists now seem to agree on the non ability of mandibular third molar eruption to cause lower anterior crowding (21). It was concluded that more recently graduated orthodontists were less likely to advocate prophylactic removal of third molars to reduce crowding, whereas surgeons who graduated in the 1970s or 1980s were more likely to recommend removal (22).

So what is the driving factor of this change in opinion? In 1979, a consensus in the regard of third molars concluded that there is little motive, based on present evidence, for the extraction of third molars solely to minimize present or future crowding of lower anterior teeth, either in orthodontic or non-orthodontic patients (6). Yet, it did not rule out the implication of erupting third molars on lower anterior crowding as proven by M.E Richardson the same year (19).

Recent studies seem to follow this idea. In a 2018 study conducted by AMG Gonzales (2), 74 patients, selected for having no previous orthodontic treatment, over 15 years old and a complete permanent dentition, were observed over the course of one year, using clinical records, models, panoramic and lateral head film radiographs. Crowding was evaluated using Little's Index. It was found that the prevalence of late mandibular crowding was 83.7%; the most common types were severe 26% and very severe 27%. Seventy percent of the patients showed more dentoalveolar discrepancy on the lower arch. Twenty six percent of patients with crowding showed reduced mandibular length. The horizontal growth pattern predominated in 49% of the case groups and in 58% of the

controls. It was concluded that no patient with crowding had a diminished mandibular body or a vertical growth pattern and that crowding can occur regardless of whether or not the lower third molars are present. However, this study also proved the etiological role of mesiodistal width of the crowns and crowding. It should be noted that the sample used in this study is not representative of the general population and that the position of lower third molars is not taken into account.

Yet, M.Žigante reached a similar conclusion (23), this time, considering unilateral or bilateral extractions, hypodontia, eruption and/or impaction.

These findings are in accordance with the previous works of NW Harradine (24), who established from a randomized control sample and using Little's index, that the influence of third molar eruption does not represent a significant etiological factor to justify their prophylactic extraction.

In order to be a controversy, there needs to be conflictual opinions on the subject. As such, several studies, even if less frequent nowadays, still find and defend the theory that the third molar eruption is directly accountable for lower mandibular crowding.

In 2021, S. Hussein conducted a study (25) aimed to investigate the relationship between the presence or absence of mandibular third molars and mandibular lower incisor crowding using cone-beam computed tomography (CBCT) images. A retrospective collection of 40 CBCT images was obtained from a university database, divided into two groups: one in which third molars were present and the other in which they were absent, with 20 images in each group. The CBCT images were reviewed, and the amount of crowding was calculated using Little's irregularity index. The results showed that there was a significant positive correlation between mandibular third molars and mandibular lower incisor crowding. The researchers came to the conclusion that " there is a positive correlation between the mandibular third molar and mandibular incisor crowding, establishing the role of third molars as one of the etiological factors for crowding if not the only one." This conclusion appears to be disconcerting, especially after having educated ourselves on the many etiological factors affecting lower anterior crowding. It is important to note that the study does not take into account any previous orthodontic treatment followed by the patient, nor mentions the eruption status of third molars, the reason for their absence (agenesis or extraction), or their location

(unilateral or bilateral). Due to all these omissions, this conclusion can hardly be considered reliable.

However, H. Emmad also reached the conclusion that third molars have a role in late mandibular anterior crowding (26), but with more reserves this time. Indeed, the study is this time also using Little's index, the position of the third molar and only patients with no previous orthodontic treatments were selected. The study involved 131 volunteers aged 18-25 years, divided into three main groups according to the status of their mandibular third molars. The severity of their crowding was also asserted into five gradual categories. The results showed that the most prominent severity of crowding was "mild irregularity" which was their lowest grade of severity after "perfect alignment", and the group in which crowding was the most often observed was the one with impacted third molars. But the study failed to inform about the prevalence of the severity categories according to each group of third molar status. Leaving the reader clueless about which third molar eruption status causes the most severe crowding. Also, the study failed to notice that no patient presented "perfect alignment", including the ones with third molar agenesis, proving the evidence that factors other than third molars and their eruption status play a role in anterior crowding.

These articles by their lack of consistency and scientific accuracy can hardly prove their point and seem to correlate the simple concomitance of lower third molar eruption and anterior crowding.

A common observation to the vast majority of studies made on the subject is the improper or total lack of control of the many additional etiological factors inducing crowding. Both for the ones defending the solid etiological implications of third molars and for the ones opposing this theory. The most indolent studies isolate the role of third molars and draw conclusions merely on correlations.

Nonetheless, deferring the results of these studies would be counterproductive as the abundance of evidence they provide helps us to affirm what is probably the final conclusion to this debate until proven otherwise. Third molars and their eruption pattern can be a vector provoking crowding of the lower anterior teeth but not significantly enough to assert that they are the sole or even one of the main etiological factor.

Only when extensive studies controlling the other etiological factors will be performed, then a clear statement can be drawn. Longitudinal studies on twins could provide more

accurate results, acknowledging that it would seem realistically complicated to conduct such studies in compliance to ethical standards.

Extraction of mandibular third molar and anterior crowding

Consequently to the previous beliefs regarding the role of third molars in lower anterior crowding, extraction of third molars was lavished (27). But with modern findings, it becomes natural to wonder if extracting the third molar to prevent crowding is a relevant or justifiable practice. Harradine (24), raised the question in a previously mentioned study, aimed to investigate the effect of third molar extraction on late lower incisor crowding in patients with Class I dental malocclusion. A randomized controlled trial was conducted on 82 participants who were randomly assigned to two groups: one group underwent third molar extraction, while the other group served as a control. The participants were followed up for four years, during which their dental casts were analyzed to evaluate changes in lower incisor crowding, using Little's index. The study found that there was no significant difference in the amount of late lower incisor crowding between the two groups, suggesting that third molar extraction does not have a significant impact on late lower incisor crowding in patients with Class I dental malocclusion.

After conducting a cross sectional study to assess the role of mandibular third molar position in lower anterior crowding, RB Shah (28) concluded that " The recommendation to extract third molars in the lower jaw has to have a justifiable reason and cannot be solely based on the doubtful rationale to minimize present or future crowding of the lower anterior teeth." (28)

A frequently cited study by B. Lindqvist (29) emits the hypothesis that extraction of third molars could have a positive effect on limiting anterior crowding. However, the researchers performed the observation on a limited size sample who only presented "anticipated crowding", but did not specify precisely the criterias for this selection. Also, the researchers expressed some reserves as to indicate lower third molar extraction, considering that they were not able to predict which patient would benefit

from the procedure and that they would potentially only perform the extraction on patients already presenting severely crowded anterior teeth.

To conclude, both older and more recent studies in orthodontics have not yet provided a comprehensive approach to the etiological factors leading to crowding. However, there is a general consensus that the eruption pattern of third molars can contribute to anterior crowding, although the degree of involvement is not significant enough to justify their extraction as a means to reduce or prevent crowding.
It is worth noting that this shift in thinking about third molar extraction represents a departure from the previous belief that prophylactic extraction of third molars was an effective method to prevent crowding.

V. *CLINICAL MANAGEMENT OF LATE MANDIBULAR CROWDING*

Patient's motivations

With a better understanding of late mandibular crowding, it is time to analyze its management in the clinical conditions. But as we have seen earlier, in our focus cases of adult patients presenting class 1 malocclusion, anterior crowding itself, does not represent a pathological process. The questions of should it be treated and why do patients seek treatment in the first place now come to the discussion.

It has been observed over the last decades that the profiles of patients seeking orthodontic treatments are less and less limited to children and adolescents and more frequently adults with concerns reach out for orthodontic treatment (30). As a particularly interesting trend, these mainly self-reported patients, most often have concerns regarding late anterior crowding treatment and aesthetic appearance enhancement (31). In a study by McMorrow, aimed at understanding the adult patient receiving orthodontic treatment in the Republic of Ireland, the obtained results (Figure 3, Figure 4) gives us a good overview on the current situation. (31)

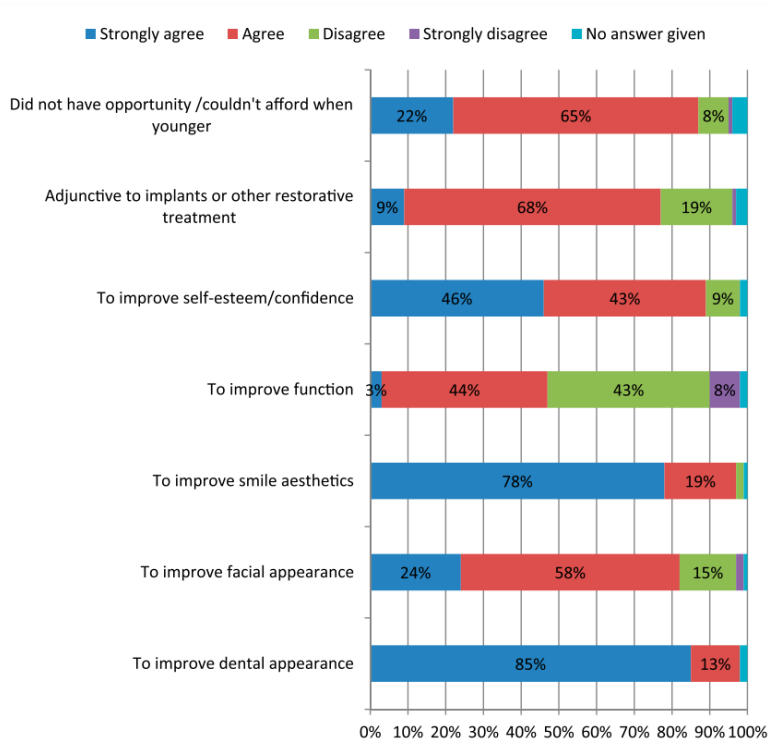

Figure 3. . Specialists' perceived reasons why adults seek orthodontic treatment. (31)

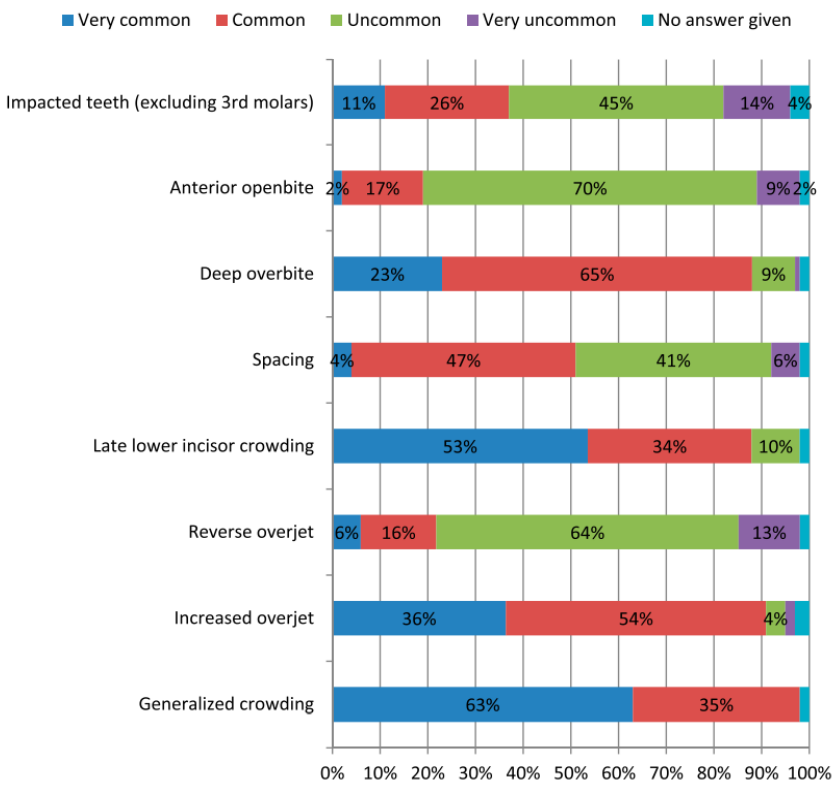

Figure 4. . Specialists' estimates of dental and occlusal anomalies in adults. (31)

It should be noted that in the modern days, the internet allows the general population to have easy access to information and to educate themselves on possible treatment options, which could be a reason for this increasing flow of adult patients seeking orthodontic solutions (32 , 33). These observations comply with the general opinion that misaligned teeth can have severe psychological implications, translating on the self-esteem and social life of the patient as it presents a discriminating factor (30 , 34 - 37). Additionally, the British orthodontic society, in their Index of Orthodontic Treatment Needed (IONT), established crowding, and its various severity degrees, as a legitimate condition requiring treatment.

This brings us to the conclusion that late anterior crowding, due to its prevalence and impact on the patient's well-being, especially psychosocial concerns, is a condition that, even if considered physiological, necessitates to be addressed and treated, including in the later stages of life.

Management strategies

Various management techniques become relevant in the clinical environment. Traditionally, orthodontic treatment is postponed until all oral diseases have been resolved and the restorative treatment plan has been finalized. (34).

Initially, the dental practitioner responsible for the patient must diagnose and determine the patient's anterior crowding and overall orthodontic condition. To accomplish this task, numerous instruments and techniques can be utilized. Commencing with an orthodontic diagnostic set-up, which is beneficial for arriving at a correct diagnosis and will also aid during the treatment phase (34 , 38);

After creating the diagnostic set-up, the clinician can employ various methods to determine the degree or scope of the crowding. One such technique is arch space analysis, which enables the orthodontist to calculate the difference in millimeters between the total available arch length and the combined width of the teeth (34).

In order to establish the severity of the crowding, the previously mentioned Little's Irregularity Index is employed (39 , 40). Little's Irregularity Index (LII) is commonly used in Orthodontics to measure the level of crowding of the mandibular anterior arch. It was first introduced by Robert M. Little in 1975 (39). The index is based on the anatomical contact points of the anterior incisors, with a contact point defined by the touching of the edges of two different teeth. The LII measures the horizontal linear displacement of anatomic contact points of each mandibular incisor from the adjacent anatomic point and sums the five displacements together to determine the degree of anterior irregularity (40). The index is not affected by vertical discrepancies, and Dial Calipers are used to measure the distances accurately in millimeters. A score of 0 indicates perfect alignment, and increasing scores indicate increasing levels of crowding as follow:

0 - Perfect alignment
1-3 - Minimal irregularity
4-6 - Moderate irregularity
7-9 - Severe irregularity
10 - Very severe irregularity

As the Index was established five decades ago, several modern studies were conducted to evaluate the accuracy and reliability of the Index (30 , 41). And provided valuable insights into the effectiveness of using Little's Irregularity Index to evaluate crowding in the mandibular anterior arch. It was concluded that LII is a reliable and valid method for assessing crowding and can be used to evaluate the efficacy of orthodontic treatments. The studies also showed that the index can be used for assessing the severity of crowding as well as to measure changes in crowding over time, which can help clinicians assess and measure the success of orthodontic treatments (41).

Which is contradictory with the results found by Macauley et al. (42) in a study aimed to examine the repeatability and precision of LII measurements on the maxillary arch of orthodontic patients by four independent examiners. The results showed significant correlations between all examiner-pairs but also revealed that 86% of the 600 individual

contact point displacement measurements differed by greater than 20% of the mean. The study concluded that the overreliance of LII in assessing different orthodontic appliances' performance must be discouraged.

We can therefore agree that Little's Irregularity Index can be used as a diagnostic tool in order to evaluate and categorize the severity of crowding, precisely enough to establish appropriate treatment options but clinicians should not rely solely on the LII for the reviewing of the treatment evolution.

It should be noted that studies using the little's index, mostly relied on plaster casts analysis, and that in the modern clinical practice, intra-oral scanners are becoming more commonly used, and are generally more accepted than the conventional impression method both by the patients and the operator. Integrated Softwares can allow the clinician to operate measurements digitally with greater accuracy and reproducibility, allowing for faster and more comfortable evaluations of the dentitions. (42-44)

Treatment options

For the adult patient with class I late anterior crowding who did not receive previous orthodontic treatment, several treatment options are available, generally according to the extent of the crowding, and the severity grade of the LII. (30,34)

For patients with minimal and moderate crowding, the use of aligners for mandibular expansion is usually enough (30,34). The patients are usually offered the choice between conventional fixed appliances or a succession of clear aligners, as studies have found no difference in the time of treatment between the two options as well as similar effectiveness in treating anterior crowding. (45,46) a randomized control trial study by Alfawal even concluded that patients treated with clear aligners reported higher oral health related quality of life and shorter treatment duration as compared to those treated with fixed appliances (47). In addition, clear aligners have a good predictability of results, even in cases of more severe crowding, and the use of digital software makes it easier for the clinician to evaluate the progression. (48)

For patients presenting minimal to moderate crowding, space in the arch can be achieved by interproximal enamel stripping (34,30). To evaluate the amount of stripping to be performed, the amount of interdental contact surface of the anterior teeth, simply corresponds to the amount needed to be stripped. Stripping is usually made on the buccal segment, with a general rule of one millimeter maximum by mesial or distal surface (49). By definition, this means that interproximal enamel stripping can alleviate up to eight millimeters of crowding. This treatment option requires an orthodontic diagnosis set-up to evaluate the stripping surfaces and is accompanied by alignment using clear aligners (50). This method has received criticism for its lack of accuracy and dependence on practitioner experience for predictable treatments. (51)

Finally, for patients with moderate to very severe crowding and more, extraction of a lower incisor is prescribed.(34,30) This treatment option is also usually accompanied with a diagnostic set-up to predict the mandibular rearrangement, as well as a succession of clear aligners in order to close the space created by the extraction site, with satisfactory results. (52) It should be noted that extraction of lower incisors permits a maintenance of the occlusal balances and forces, however, there can be a risk of increased overjet in particular cases.(53) This method of extraction is preferred over the first mandibular premolar extraction, which is more invasive and can affect the profile of the patient (54).

Retention is essential regardless of whether clear aligners or a fixed appliance is utilized, until restorative or other treatment has been finished. The retention method could involve the final aligner in a sequence, although this may not provide sufficient stability to be an effective retainer. Other options include a molded thermoplastic retainer after a fixed appliance has been removed, a canine-to-canine clip retainer, or a bonded fixed retainer.(34)

It is a fairly common occurrence that patients who received orthodontic treatment in their earlier childhood or early adulthood end up losing their retainer, resulting in a relapse of crowding.(55) For this particular case, Brezulier suggested that relapse of crowding of less than 2mm should be treated by interproximal enamel stripping, but of the anterior teeth this time. Placement of a wire retainer and rearrangement of the teeth with elastics, and full bonding of the retainer a week later. (56)

It should be noted that in a study led by Shigenobu (57), who took a different approach on the crowding diagnosis by analyzing the patterns in addition to the extent of the crowding. The researchers found that crowding can be classified into three clusters, corresponding to a different pattern as seen on figure 5.

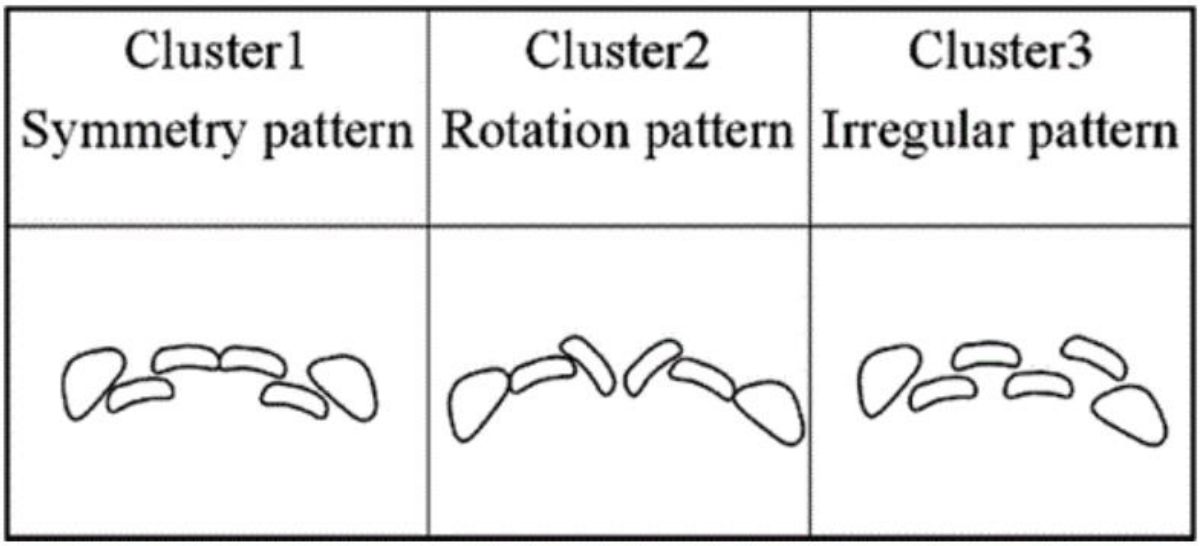

Figure 5. Clusters of mandibular anterior crowding (57)

This study was conducted on patients presenting mixed or early permanent dentition and the researchers managed to associate each cluster with a respective center of gravity of the occlusal force. They concluded that environmental factors during the replacement of teeth contribute to the extended discrepancy in the symmetry pattern. Conversely, functional factors, including the magnitude and center of gravity of the force, may lead to the rotation pattern and the irregular pattern. They also proposed that in cases of a symmetry pattern, it is typically necessary to expand the dental arch or extract the premolar to eliminate crowding. However, for rotation and irregular patterns, it may be helpful to induce the center of gravity of the occlusal force to a stable position in the anterior-posterior right-left dimension and arrange the molars accordingly while considering anterior occlusion. Therefore, it is recommended that the pattern of crowding in the anterior region be considered as a criterion for treatment planning in orthodontic clinics.

It could be beneficial to reproduce similar studies on the adult patients to analyze how the center of gravity of the occlusal force affects crowding over the years.
To summarize, late mandibular crowding is relatively well managed in the clinical situations, mostly due to time tested tools that can provide reliable and predictable results. However, the new abundance of adult patients in orthodontic offices and evolution of the clear aligners call for a possible revision or update of the treatment strategies.

VI. CONCLUSION:

The issue of late anterior crowding continues to be one of the most widely debated topics in modern orthodontics. However, it is apparent that new research and the accumulation of data are essential to achieve a comprehensive approach to managing anterior crowding. It is important to acknowledge the multifactorial nature of the etiological factors and the concept of dental tensegrity, as the loss of this balance is a significant factor in the development of late crowding. This represents a shift from the previous belief that the eruption pattern of third molars was primarily responsible for late anterior crowding. Current studies and modern thinking of practitioners agree that the extraction of third molars as a prophylactic measure has little impact on crowding. While the clinical management of late anterior crowding is effective, and available tools have been shown to be reliable and efficient, the advent of clear aligners offers promising perspectives for conservative treatment options and the democratization of orthodontic treatment for the adult population. Nevertheless, further research is still necessary to explore all the various aspects of crowding and to accurately predict its occurrence for anticipative solutions. The ongoing accumulation of knowledge and refinement of techniques will help orthodontic practitioners to provide optimal care for their patients and manage late anterior crowding successfully.

REFFERENCES:

1) Burnheimer J. Mandibular anterior dental irregularity in a population living a century ago. Dent Oral Craniofac Res 3, 2017; 10.15761

2) González AMG, Rodríguez LLV. Prevalence, types and etiologic factors of mandibular crowding in orthodontic patients in Tabasco, Mexico Rev Mex Ortodon. 2018 ; 6 (1):22-27

3) Consolaro A, Cardoso MA. Mandibular anterior crowding: normal or pathological? Dental Press J Orthod. 2018 Mar-Apr;23(2):30-36.

4) Isiekwe, Ikenna & Sofola, Oyinkansola & Onigbogi, Olanrewaju & Utomi, Ifeoma & Sanu, Tosin & Dacosta, Oluranti. Dental esthetics and oral health-related quality of life in young adults. American Journal of Orthodontics and Dentofacial Orthopedics. 2016; 150. 627-636

5) F. Van der Linden Theoretical and practical aspects of crowding in the human dentition JADA VOLUME 89, ISSUE 1, P139-153, 1974

6) ME Richardson Late Lower Arch Crowding: The Aetiology Reviewed Dental Update VOL. 29, NO. 5 2017

7) Richardson, M E. "Late lower arch crowding facial growth or forward drift?." European journal of orthodontics vol. 1,4 1979; 219-25.

8) William R. Proffit et al. Contemporary Orthodontics fifth edition, 2013, chapter 9

9) William R. Proffit et al. Contemporary Orthodontics fifth edition, 2013 Pages 120-123

10) Björk A. Prediction of mandibular growth rotation. Am J Orthod 1969; 55: 585–599.

11) Richardson, M. E. . Late lower arch crowding in relation to soft tissue maturation. American Journal of Orthodontics and Dentofacial Orthopedics, 1997; 112(2), 159–164.

12) Fränkel R, Loffler U. Functional aspects of mandibular crowding. Eur J Orthod 1990; 12: 224–229

13) Stubley, R. “The influence of transseptal fibers on incisor position and diastema formation.” American journal of orthodontics vol. 70,6 1976; 645-62.

14) Buschang H. Class I malocclusions—The development and etiology of mandibular malalignments; Seminar in Orthodontics VOLUME 20, ISSUE 1, P3-15, 2014 March

15) . Moss JP, Picton DC. Short-term changes in the mesiodistal position of teeth following removal of approximal contacts in the monkey Macaca fascicularis. Arch Oral Biol. 1982; 273-8.

16) Fastlicht, J. Crowding of mandibular incisors. American Journal of Orthodontics, 1970; 58(2), 156–163.

17) Puri, N., Pradhan, K. L., Chandna, A., Sehgal, V., & Gupta, R. Biometric study of tooth size in normal, crowded, and spaced permanent dentitions. American Journal of Orthodontics and Dentofacial Orthopedics, 2007; 132(3), 279.

18) Leighton BC. Aetiology of malocclusion of the teeth. Arch Dis Child. 1991 Sep; 66(9):1011-2.

19) Stanaitytė R, Trakinienė G, Gervickas A. Do wisdom teeth induce lower anterior teeth crowding? A systematic literature review. Stomatologija. 2014;16(1):15-8.

20) 16: 15-8, Silva BSE, Fagundes NCF, Nogueira BCL, Valladares J Neto, Normando D, Lima RR. Epithelial rests of Malassez: from latent cells to active participation in orthodontic movement. Dental Press J Orthod. 2017 May-Jun;22(3):119-125.

21) Gavazzi, M., De Angelis, D., Blasi, S. et al. Third molars and dental crowding: different opinions of orthodontists and oral surgeons among Italian practitioners. Prog Orthod. 2014; 15, 60

22) Lindauer, Steven J et al. “Orthodontists' and surgeons' opinions on the role of third molars as a cause of dental crowding.” American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics vol. 132,1 2007; 43-8.

23) Zigante M, Pavlic A, Morelato L, Vandevska-Radunovic V, Spalj S. Presence and Maturation Dynamics of Mandibular Third Molars and Their Influence on Late

Mandibular Incisor Crowding: A Longitudinal Study. Int J Environ Res Public Health. 2021 Sep 25;18(19):10070

24) Harradine, N & Pearson, M & Toth, Ben.. The effect of extraction of third molars on late lower incisor crowding: A randomized controlled trial. British journal of orthodontics. 1998; 25. 117-22.
25) Husain and Rengalakshmi, Correlation between mandibular third molar and mandibular incisor crowding: A retrospective CBCT-based study, J Dent Res Dent Clin Dent Prospects, 2021; 15(4), 247-250

26) Hasan, Labeed & Abdulazeez, Maha & Abdulla, Emad. (2014). The Relationship of the Lower Third Molar to the Anterior Dental Crowding. Journal of Oral and Dental Research. 2014; 1. 29-32.

27) Schwarze, C. W. The influence of third molar germectomy—a comparative long term study, Abstract of Third International Congress, London, 1973; 551–562.

28) Shah RB, Kanzariya N, Goje SK, Kulkarni N, Joshi H, Chellani S. Assessment of role of mandibular third molar position in lower anterior crowding- A cross sectional study. J Integr Health Sci 2018; 6:69-73

29) Lindqvist B, Thilander B. Extraction of third molars in cases of anticipated crowding in the lower jaw. Am J Orthod. 1982 Feb;81(2):130-9

30) Antoszewska-Smith J, Bohater M, Kawala M, Sarul M, Rzepecka-Skupień M. Treatment of Adults with Anterior Mandibular Teeth Crowding: Reliability of Little's Irregularity Index. Int J Dent. 2017; 2017:5057941

31) McMorrow SM, Millett DT. Adult orthodontics in the Republic of Ireland: specialist orthodontists' opinions. J Orthod. 2017 Dec;44(4):277-286.

32) Ustdal, Gokay, and Ayca Ustdal Guney. YouTube as a source of information about orthodontic clear aligners. The Angle orthodontist 2020; 90(3)

33) Yavan, Mehmet Ali, and Gökçenur Gökçe. YouTube as a source of information on adult orthodontics: a video analysis study. Journal of the World federation of orthodontists vol. 11,1 2022

34) Proffit R. Contemporary Orthodontics 6th Edition, 2018 Pages 599-656

35) Baxmann M, Timm LH, Schwendicke F. Who Seeks Clear Aligner Therapy? A European Cross-National Real-World Data Analysis. Life. 2023; 13(1):65

36) Sari, Cinta & Jazaldi, Fadli & Ismah, Nada. Association Between Psychosocial Status and Orthodontic Treatment Needs in Indonesian High School Students. Pesquisa Brasileira em Odontopediatria e Clínica Integrada. 2020; 20. 10.1590

37) Pithon MM, Nascimento CC, Barbosa GC, Coqueiro RD. Do dental esthetics have any influence on finding a job? Am J Orthod Dentofacial Orthop. 2014;146:423–429

38) Telma Martins de Araújo et al. Preparation and evaluation of orthodontic setup, Dental Press J. Orthod. June 2012; 17(3):146-165

39) Little RM. The irregularity index: a quantitative score of mandibular anterior alignment. Am J Orthod. 1975 Nov;68(5):554-63

40) Bernabé E, Flores-Mir C. Estimating arch length discrepancy through Little's Irregularity Index for epidemiological use. Eur J Orthod. 2006 Jun;28(3):269-73

41) Baciu, Elena-Raluca & Budală, Dana & Vasluianu, Roxana-Ionela & Lupu, Costin & Murariu, Alice & Geleţu, Gabriela & Zetu, Irina & Diaconu-Popa, Diana & Tatarciuc, Monica & Giorgio, Nichitean & Luchian, Ionut. A Comparative Analysis of Dental Measurements in Physical and Digital Orthodontic Case Study Models. Medicina. 2022; 58. 1230. 10.3390

42) Macauley D, Garvey TM, Dowling AH, Fleming GJ. Using Little's Irregularity Index in orthodontics: outdated and inaccurate? J Dent. 2012 Dec;40(12):1127-33

43) Christopoulou I, Kaklamanos EG, Makrygiannakis MA, Bitsanis I, Perlea P, Tsolakis AI. Intraoral Scanners in Orthodontics: A Critical Review. Int J Environ Res Public Health. 2022 Jan 27;19(3):1407

44) Brandão MM, Sobral MC, Vogel CJ. Reliability of Bolton analysis evaluation in tridimensional virtual models. Dental Press J Orthod. 2015 Oct;20(5):72-7.

45) Kassam SK, Stoops FR. Are clear aligners as effective as conventional fixed appliances? Evid Based Dent. 2020 Mar;21(1):30-31

46) Hennessy, Joe et al. A randomized clinical trial comparing mandibular incisor proclination produced by fixed labial appliances and clear aligners. The Angle orthodontist; 2016; 86(5):706-712

47) Alfawal, Alaa M H et al. The impact of non-extraction orthodontic treatment on oral health-related quality of life: clear aligners versus fixed appliances-a randomized controlled trial. European journal of orthodontics 2022; 44(6)

48) Fiori A, Minervini G, Nucci L, d'Apuzzo F, Perillo L, Grassia V. Predictability of crowding resolution in clear aligner treatment. Prog Orthod. 2022 Nov 28;23(1):43

49) Chudasama, Dipak, and John J Sheridan. Guidelines for contemporary air-rotor stripping. Journal of clinical orthodontics. 2007; 41(6):315-20

50) Livas C, Jongsma AC, Ren Y. Enamel reduction techniques in orthodontics: a literature review. Open Dent J. 2013 Oct 31;7:146-51

51) De Felice ME, Nucci L, Fiori A, Flores-Mir C, Perillo L, Grassia V. Accuracy of interproximal enamel reduction during clear aligner treatment. Prog Orthod. 2020 Jul 28;21(1):28.

52) Khalid H. Zawawi, Orthodontic Treatment of a Mandibular Incisor Extraction Case with Invisalign, Case Reports in Dentistry, 2014; 2014(8):657657

53) Machado GB. Treating dental crowding with mandibular incisor extraction in an Angle Class I patient. Dental Press J Orthod. 2015 May-Jun; 20(3):101-8.

54) Kokich, V G, and P A Shapiro. “Lower incisor extraction in orthodontic treatment. Four clinical reports.” The Angle orthodontist, 1984; 54(2)

55) Lyros I, Tsolakis IA, Maroulakos MP, Fora E, Lykogeorgos T, Dalampira M, Tsolakis AI. Orthodontic Retainers—A Critical Review. Children. 2023; 10(2):230.

56) Brezulier, Damien et al. A Protocol for Treatment of Minor Orthodontic Relapse During Retention.” Journal of esthetic and restorative dentistry : official publication of the American Academy of Esthetic Dentistry 2016; 28,6

57) Noriko Shigenobu; Masataka Hisano; Sachiko Shima; Nozomu Matsubara; Kunimichi SomaAngle Orthod. 2007; 77 (2): 303–310