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RESEARCH ARTICLE

THE EFFECTIVENESS OF FLEXIBLE ALIGNERS IN THE 3D CONTROL OF TEETH: A A SYSTEMATIC REVIEW

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Abstract

Introduction: Orthodontic aligners are removable, invisible devices implemented to move teeth without a rim, floss or bracket. It is, in fact an alternative therapy to conventional orthodontic techniques in order to move the teeth gradually that involves wearing a series of transparent aligners following the steps. Each aligner takes the shape of a dental splint which is tailor-made, thermoformed medical polycarbonate that can be removable, comfortable, and compatible with the oral cavity. Each splint must be worn for a duration of 300 hours, that is two weeks, day and night, at a rate of 22 hours per day. The aim of this systematic review was to assess and evaluate the effectiveness of aligners in the 3D control of teeth in cases with and without extractions, in particular the control of dental axes during translational motion, the efficiency of the derotation of anterior and lateral teeth, torque control and the ability to intrude and extrude the anterior and posterior teeth.

Equipment and Methods: A literature review search strictly related to publications in English and French was carried out on the following databases: Medline, Ebsco Host, Cochrane Library and Science Direct. This research included, in vivo, prospective, or retrospective research studies published up to 2019. Furthermore, this study was based on the PICO format whose target subjects were patients treated with orthodontic aligners with or without the use of devices with the objective to study the efficiency of aligners in the aforementioned 3D control by the predictability of programmed dental movements after orthodontic treatment by splint only or in comparison with fixed multi-bracket treatments.

Results: Sixteen relevant articles were selected (four prospective studies and 12 retrospective studies). The control of the dental axes in translation (canine retreat, alignment, version) was predictable by orthodontic aligners with the use of attachments. Nevertheless, rotation, torque (control of the root axes) as well as vertical movements (intrusion, extrusion) were difficult to achieve with orthodontic aligners and required the incorporation of attachment to improve the obtained result. Distalization was not possible with orthodontic aligners.

Conclusion: Based on results obtained from various studies carried out on orthodontic aligners, the effectiveness of the latter in the control of dental axes is low. In addition, the variation of the experimental protocols generated a low level of evidence on the predictability of

certain dental movements (version, intrusion, extrusion, rotation, torque) with a certain unpredictability of the distalization movement.

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Introduction:-

Over the years, orthodontic field has been subjected to the emergence of many aesthetic treatment alternatives in order to meet the growing demand of patients in this regard. The fact that adult population is more and more interested in receiving orthodontic treatment has also played a role at this level (1). Some patients consider aesthetics to be as crucial in an orthodontic treatment as cost, pain experienced, overall well-being as well as the duration of the treatment (2). In this sense, different dental malocclusions can be treated not only with conventional multi-braces but currently with various aesthetic options such as ceramic brackets, lingual orthodontics, and flexible transparent orthodontic aligners.

The option of transparent orthodontic aligners was common in the late 1990s, thereby contributing to the improvement of both patient and practitioner comfort (1). Therefore, these diversified and available options make it possible to choose an aesthetic alternative such as aligners while in the process of correcting dental malocclusions. But what about their effectiveness in the 3D control of teeth?

As a matter of fact, the idea of using transparent thermoformed trays to perform orthodontic treatment is not new, starting with the use of manual set-ups and reaching digital techniques for recording and simulating orthodontic movements. Actually, they have been described since 1945 by Kesling (3) for the sake of correcting minor malposition. Nowadays, the evolution of aligners allows a complete orthodontic treatment with and without extractions.

The drawback of this new and rapidly evolving technique (optimized attachment, inter-maxillary elastics.) is the lack of codified biomechanics that may ensure a good occlusal finishing at the end of the treatment. Often practitioners ensure the finishing of their cases by using multi-braces at the end of treatment.

With the help of a recent systematic review of the literature, we will analyze the effectiveness of flexible aligners in the 3D control of teeth. In this sense, the aim of our systematic review being to evaluate the effectiveness of flexible aligners in the 3D control of teeth in cases with and without extractions, in particular the control of dental axes during translational movements, the efficiency of derotation at the level of anterior and lateral teeth, as well as the torque control and the ability to intrude and extrude anterior and posterior teeth.

Equipment and Methods :

The electronic search for the articles that are the subject of this systematic review was carried out using Medline, Pubmed, Cochrane Library, Science Direct, Google Scholar databases as well as through a manual search at the UIR library (International University of Rabat). We have limited our search to articles published in French and English. We also used the keywords found in MeSH for the articles in English, according to the search equation (Aligners * OR Aligners orthodontic *) AND ("Tooth movement"). As for the articles in French we have implemented the equation ("Aligneur *") AND ("Mouvementorthodontique"). A first digest of articles was made by two readers and was based on reading the title and the abstract. A primary selection of the articles was made by three readers and was based on reading the title and the abstract. The inclusion and exclusion criteria for the admission to the systematic review were reported in (Table I).

Inclusion criteria

Exclusion criteria

Studies published until 2019

In vivo qualitative research studies

Or quantitative studies Studies with questionnaires

Prospective or retrospective

Studies regarding orthodontic treatment in adults;

Literature reviews

Studies assessing the effectiveness of orthodontic aligners

Studies on animals

In vitro research studies

Case reports

Studies evaluating orthopedic aligners

In the 3D control of dental axes
 Studies comparing the effectiveness of aligners
 With that of multi-braces fixed devices.

Table I:- Study selection criteria.

The “PICO” approach was implemented to extract data from the selected articles. PICO stands for "population (patients), intervention (Information on performed treatment), comparison, results and study design (Table II). The result of this study evaluated the effectiveness of orthodontic aligners in controlling planned tooth movements. The methodological quality evaluation gives an indication of the strength of the evidence provided by the study because defects in the design or conduct of a study can lead to bias. The Cochrane method was used to assess the methodological quality of the articles and intrinsic design.

Data Overview :

Based on the keywords, 1503 articles were eligible for our search. While reading the titles and abstracts and considering the inclusion and exclusion criteria, 1,486 references were excluded because they were articles showing point of view, case reports, literature reviews and studies with questionnaires. After a full text assessment, 16 articles were retained for this systematic review.

Table II (Pico)

Author/Year/CURRENT (Source)	Study	Population (Patients)	Intervention	Comparison	Results
Siomon .M et al 2014 (4)	Perspective	30 patients (Adults)	Derotation of the PM superior than 10 °; distalization M superior than 1.5mm and torque I; Attachment implementation	Motion prediction made during digital simulation by software (Clincheck).	Translation (MD): predictable with aligner at 87% of expected movement; Derotation is less predictable quantified at 32% of the expected movement; Torque not predictable with orthodontic aligner (50% of expected movement)
Zhang.J et al 2015 (5)	Prospective	32 patients (Adults)	- Translation (VL); attachment implementation,	Predicted movements of crowns and roots of anterior teeth (canine to canine) and final result.	Unpredictable translation (VL) with aligner; the mean deviations in the positions of the upper (0.376) and lower (0.398) crowns
Kravitz et al 2009 (6)	Prospective	37 patients (Adults)	-Expansion, rotation, constriction, intrusion,extrusion, version (M-D, V-L); attachment implementation.	- Expected and achieved movement quantity after the treatment :	-The most precise tooth movement: lingual constriction (47.1%); The least precise is the extrusion movement (29.6%); the lower canine was the most difficult tooth to control in rotation, especially above 15 °; There was no

					statistical difference in accuracy between maxillary and mandibular teeth of the same type for any studied tooth movement .
Ravera et al 2016 (7)	Retrospective	20 adult patients (9 men and 11 women); (dental malocclusions in CI I or CI II Sq.)	Molar translation, M and I anchoring; use of attachment and elastic CI III.	-cephalometric values of the GoGn-Sn angle between T0 and T1	Molar distalization movement is predictable by orthodontic aligners with auxiliary use with optimal control of the vertical direction of the posterior sector and loss of anchorage in the anterior sector; The first molar moved 2.25 mm and the second molar moved 2.52 mm; no statistically significant difference (GoGn-Sn angle) between T0 (32.80 °) and T1 (32.35 °).
Caruso et al. 2019 (8)	Retrospective	10 adult patients (8 women and 2 men- average age 22.7 ± 5.3 years); Duration of treatment and 1.9 ± 0.5 years	-Translation and Torque I; use of Class II attachment and elastic.	- Motion prediction made during digital simulation by a software (Clincheck).	Translation (MD) and torque I are predictable with aligner with use of attachment; good control of the vertical dento-skeletal dimension by orthodontic aligners during the movement of (MD translation) distalization of the upper molars.
Lombardo.L et al. 2017 (9)	Retrospective	16 adult patients	Torque; Tip MD; Rotation; attachment use.	Expected and achieved amount of movement after treatment.	
Grunheid et al 2017 (10)	Retrospective	30 adult patients	M-D,V-L Translation ; Version , Torque , Intrusion and Extrusion ; Rotation ; Attachment implementation	Classic and digital modals	More important intrusion of the anterior teeth ; incomplete rotation of the anterior teeth ; motion at the level of

					posterior teeth that were not completely damaged / Predictable programmed movements with aligners and attachment
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Hennessy.J et al 2016 (11)	Randomized Prospective	44 adult patients in two groups (22 patients treated with aligners and 22 others with fixed multi-braces	Mandibular vestibulo version I	Movement through aligners and fixed devices	No statistically significant difference of the Vestibulo-version between the two groups treated with Bracket(5.3 ±4.3) and Invisalign (3.4 ±3.2).
Krieger.E 2012 (12)	Retrospective	50 patients , a duration of 13 months	Intrusion and extrusion movement , attachment implementation	Prediction of the movement produced during the digital simulation	Predictable intrusion and extrusion with orthodontic aligners with attachment (Invisalign)
Charalampakis. O 2018 (13) (Translation, intrusion, extrusion, rotation)	Retrospective	20 patients	Translation , Intrusion , extrusion and usage of attachment	Prediction of the movement made during the digital simulation	All programmed movements are predictable; The extrusion and horizontal movements of all the incisors were almost precise with insignificant differences (0.20-0.25 mm) between the quantities planned and achieved, however the intrusion was less precise; all rotations obtained were significantly less than expected, with the maxillary canines showing the greatest difference of 3.05 degrees (p <0.001)
Garnett et al 2018 (14)	Retrospective	53 hyperdivergent adult patients	- Extrusion of the mandibular incisors	The effectiveness of	- Predictable

		(36 treated by aligners and 17 by fixed equipment)	-Correction of the anterior recovery and control of the DVO.	orthodontic aligners with fixed multi-brace appliances.	lower incisor extrusion with optimized attachment; overjet (ttt by aligner: T1 = 3.82, T2 = 2.6; fixed fitting: T1 = 2.98, T2 = 2.69). Overbite: by aligner (T1 = -1.57mm, T2 = 0.71mm); fixed equipment : T1 = -1.3, T2 = 0.46); No statistically significant difference between the 2 groups when correcting the incisal recovery.
Dai et al (15) 2019	Retrospective	30 adult patients	-Molar anchorage; Molar translation (M-D), (V-L) -Incorporation of attachment	-Quantity of movement predicted and achieved by aligners.	-Planned movements are predictable by aligners. ; predicted incisor torque (-9.27 °) that reached (-14.43 °); Translation M of the 1 st M sup (predicted: 0.87 and achieved: 3.13mm), Translation D (predicted: 0.88 and achieved: 3.19); V-L translation (predicted: -6.60mm and achieved: -4.47mm)
Houle et al (17) 2016	Retrospective	64 patients , Average duration of the treatment was for 56 weeks	Translation V-L and version , use of attachment	Arch widths predicted by digital simulation and post-processing	Predictable arch expansion with orthodontic aligners; there was a statistically significant difference between the digital simulation carried out and the final result obtained; the

					average precision of expansion predicted with the Invisalign system for the upper arch was 72.8%, while at the lower arch the overall expansion accuracy was 87.7%;
Duncan et al 2015 (18)	Retrospective	61 patients	Translation V-L, version of the lower incisor; without using attachment	Arch widths predicted by digital simulation and post-processing. -Arch width (intercanine, inter-premolar and intermolar) as well as the change of position of the mandibular incisor using digital software.	V-L translational (expansion) and version (vestibulo-version) movements are predictable with orthodontic aligners without the use of an attachment; the difference in arch width (an increase) between T0 and T1 by orthodontic aligners was statistically significant in the 3 groups.

Findings:

-Study selection :

From searches elaborated on the electronic databases, 1543 articles were found, of which 82 met the inclusion criteria and were considered potentially eligible. After a complete reading, 65 studies were excluded and 15 articles were finally retained in this systematic review of the literature, as it is shown in the flowchart (Figure1).

-Analysis of methodological quality (Cochrane method) :

In fact, the quality of all included studies was assessed during the data extraction process and consisted of evaluating the methodological elements that are likely to impact the findings of each study (Table II). The Cochrane Risk of Bias Handbook (19) was used to assess a given study bias and to identify articles with inherent methodological and design flaws. Based on the information provided in each study, the potential risk of bias was divided into three categories: low risk of bias (+), unclear risk of bias (?), Or high risk of bias (-).

	Generation of a randomization sequence (generation sequence)	The allocation secret (allocation concealment)	A performance bias: were patients and caregivers blinded? (Blinding of Participants and Personnel)	A detection bias: Blinding of Blinding of Outcome Assessment	Attrition bias: Incomplete Outcome Data	Reporting bias: Selective Reporting	Other biases
Simon.M et	-	-	-	+	+	+	+

al. 2014 (4)							
Zhang.J et al 2015 (5)	-	-	-	+	+	+	+
Kravitz et al 2009 (6)	-	-	-	+	+	+	+
Ravera et al 2016 (7)	-	-	-	+	+	+	+
Caruso et al. 2019 (8)	-	-	-	+	+	+	+
Lombardo.L et al. 2017 (9)	-	-	-	+	+	+	+
Grunheid et al 2017 (10)	-	-	-	+	-	+	+

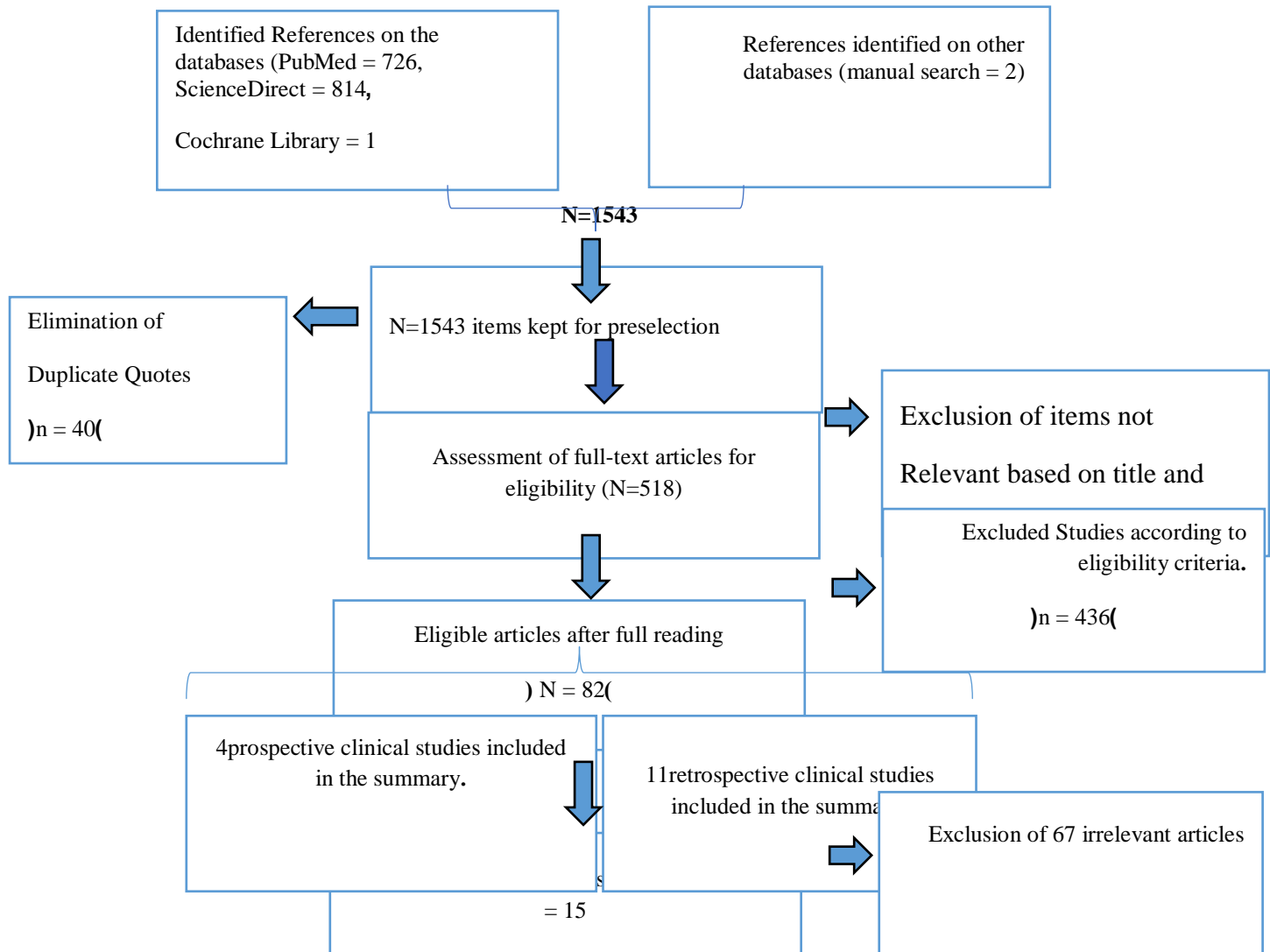
Hennessy.J et al 2016 (11)	-	-	-	+	+	+	+
Krieger.E 2012 (12)	-	-	-	+	+	+	?
Charalampakis. O 2018 (13)	-	-	-	+	+	+	+
Garnett et al 2018 (14)	-	-	-	+	+	+	+
Dai et al 2019 (15)	-	-	-	+	+	+	?

Sfondrini et al 2018 (16)	-	-	-	?	+	+	+
Houle et al 2016 (17)	-	-	-	?	+	+	+
Duncan et al 2015 (18)	-	-	-	+	+	+	+

Study Characteristic:

Table II represents a summary of the authors, years of publication, treatment protocol including type of aligners, whether attachments are used or not, exact number of treated patients, method of assessment, results and author's conclusions.

The fifteen articles included, classified into 4 prospective studies (4,5,6,11) and 11 retrospective studies (7,8,9,10,12,13,14,15,16,17,18). All articles were written in English. Most of the included studies assessed mild to moderate malocclusions without planning for extraction. 11 studies used the Invisalign system with attachment incorporation (4,6,7,8,10,11,12,13,14,15,16,17) however one study used the Invisalign system without attachment addition (18); other studies have used other systems: Nuvola, F22, EA. Inc (5,9) and 2 studies did not specify the type of the aligner used. The data collected from each of the included articles are described in Table (II). Sample sizes ranged from 16 to 64 with a total of 580 subjects. Studies included in the review assessed the predictability of dental movement in the three directions of space (horizontal, vertical, and rotational) as well as the need or not to use the attachment, comparing by layering models that were predicted (Clincheck) and achieved in the initial model (6,10,13,15,17). Four studies have compared the outcome of aligner treatment to the outcome of multi-brace fixed appliance treatment (11, 14, 16, 18) and five studies had compared the amount of movement obtained to that planned by digital simulation (4,5, 8,9,12,). All the studies specified the incorporation of auxiliary (attachment) having different shapes and arrangement at the level of the aligner thus allowing the achievement of the planned tooth movement, however two studies did not use the attachments to improve the result of the aligner treatment (3,18). Another study did not mention the use of attachment during the aligner treatment protocol (11).



Flow diagram for the identification and selection of studies for review according to PRISMA

The 15 studies had addressed four distinct main topics: horizontal direction, derotation of the anterior and lateral teeth and vertical direction (intrusion, extrusion). The 15 studies were classified into 4 prospective studies and 11 retrospective studies.

Discussion:-

Horizontal direction (Alignment, molar distalization, version)

Two studies (5,18) have shown that translational movement (MD, VL) is unpredictable with orthodontic aligner. The implementation of an auxiliary tool (attachment, power ridge) would optimize the results and ensure control over the dental axes during the simulated movement without the appearance of an unwanted movement such as the uncontrolled version movement. However, 7 studies (4,7,8,10,13,15,17) have confirmed the predictability of translational movement (MD, VL) with an orthodontic aligner while using attachments.

The translational movement is predictable in the direction (VL) and also in the direction (MD) with orthodontic aligners by resorting to current optimized attachments (the power-ridge) which could control the roots in the direction (MD) or in the direction (VL).

- Seven studies (6,9,10,11,15,17) highlighted that version movement is a predictable movement with orthodontic aligners with the use of attachment. (9): The version movement (MD) showed the greatest predictability at (82.5%) compared to the ideal; this was followed by the version movement (VL) to a degree of (72.9%). They found (9) that without the use of the auxiliary orthodontic aligners would be unable to achieve the programmed movement with

100% predictability. In particular the version movements, precisely located at the level of the molars and premolars. They reported (17) that dental arch expansion with orthodontic aligners is achieved by performing translational motion with the use of attachment accompanied by unwanted versioning motion. However, only one study (18) has shown that version movement is predictable with aligners without resorting to attachments.

To conclude, version movement is predictable by orthodontic aligners with the need for attachment use to improve results and to prevent the occurrence of unwanted orthodontic movements during the treatment.

Incisive Torque:

- **Simon.M et al (4)** had confirmed that torque movement is unpredictable with an orthodontic aligner, however 4 studies (8,9,10,16) found that torque movement is predictable with the implementation of attachment. (9): the use of auxiliary (attachment) of new devices (power-ridge) strengthening at the cervical level the contact between the tooth and the internal surface of the aligner would make it possible to obtain more root control and therefore optimize the predictability of torque movement. They have demonstrated (16) that there is no statistically significant difference between the 3 groups treated with aligners, conventional brackets and self-ligating in relation to the amount of the torque movement finally obtained from treatment.

- **Grünheid T (10):** Had showed a limited torque control for the central incisors, second premolars, and upper first and second molars. Torque control was also limited for the lower canines and the lower first and second molars.

- In 2009 **Bouchez . R (2)** observed that the predictability of torque movement by orthodontic aligners with the use of attachment can achieve up to a maximum of 15 ° while ensuring a good control of the root axes of the teeth and increasing the wearing time.

In conclusion, torque movement is predictable but still remains a tough task to be controlled with orthodontic aligners. The incorporation of new devices (power-ridge) would allow the application of an effective and double force to improve the control of the root axes.

Rotation:

Five studies (4,6,10,13,15) had confirmed that rotational movement is predictable by orthodontic aligners with the use of attachment. (4): the PM derotation showed the lowest precision (32%). (6): The lower canine was the most difficult tooth to control in rotation with an aligner, especially above 15 °. (10): the derotation of lower canine is limited to 10 °; the rotation of the lower canines was an extremely unpredictable movement by orthodontic aligners where there is a need for attachment incorporation.

- In turn, in 2009, **Crosby . D (20)** confirmed the predictability of the rotational movement arriving at the incisor level up to 45 ° and at the canine level up to 30 ° which contradicts the findings of **Lombardo et al (9)** who have limited derotation of canines below 10 °.

In conclusion, the rotational movement is predictable with limited degree by orthodontic aligners, which makes essential the use of attachment to increase the effectiveness of the obtained result.

Vertical direction (Intrusion, extrusion)

-Six studies (6,7,12,13,14,15) have shown that vertical movements (intrusion, extrusion) are quite predictable by orthodontic aligners with the use of attachment. They have confirmed that the over-bite was not sufficiently adjusted by orthodontic aligners with average accuracy for the anterior intrusion and extrusion movements.

- In 2003, **Joffe. L (21)** et al had also noted that the predictability of the extrusion movement with the orthodontic aligner, he also limited his findings to 1mm at the incisive level with the implementation of attachments and to 0,5 mm at the level of the molars. However, to him, this displacement at the posterior level seems very subtle if not impossible to achieve.

-In 2009, **Orhan.C** et al (22) had also confirmed the predictability of the intrusion movement, they have also limited their findings to 2mm per arch at the incisive level and to maximum 2 mm at the level of the molar with the implementation of the attachment on the adjacent teeth. In conclusion, the vertical movements could be predictable with orthodontic aligners which permits to resolve much complex cases thanks to the implementation of new incorporated devices carefully managed (Bite ramp) which improves the desired degree of the vertical movement.

Limits of the Study:

Just few studies were interested in the assessment of the predictability of the dental movements through thermoplastic molds or orthodontic aligners. In addition, the predictability of the teeth movement varies according to the tooth, the type of the planned movement and the implementation of an auxiliary attachment (23).

Among the included studies within the systematic review, there is a huge diversity of what regards the number of patients (low sample) treated exclusively with aligners , the parameters used during the selection process , the movements assessed during the treatment as well as the type of the aligner and the attachment placement . Some of the potential limitations were not inevitable regarding the methodology of different studies. For instance , the bias of selection was not fully avoidable , and that is a common problem for the whole systematic reviews .Electronic databases as well as the current studies were the subject of a profound research in order to find the most relevant information. A manual research was also elaborated which may have limited the endemic bias in a certain perspective . Although the movements control via orthodontic aligners was not totally possible to be predicted and well defined , there is a big need to quality analyses in the future for the sake of obtaining clear, reliable and exact results.

Clinical Recommendations:-

Taking into consideration some gaps that exist within the literature review as well as the recent knowledge, it would be useful that clinicians are able to detect, at first, cases that can be treated using orthodontic aligners. In this present study; these were difficult to be achieved through using orthodontic aligners, and with no doubt, they require the implementation of auxiliary devices which can limit the control of predictability over the dental movements simulated during the treatment . The impact of attachments was also assessed. Other future research regarding aligners biomechanics would bring a big value to this orthodontic discipline.

Clinical Implications:

The 3D dental movement control by aligners could be improved through using a correct and exact digital simulation taking into consideration the placement and the shape of the attachments in order to optimize the results and minimize unwanted orthodontic movements. This aesthetic and comfortable technique may be very necessary for the development of orthodontist field and makes a better future.

Conclusion:-

Due to the diversification of the included studies in what concerns the review and methodology, it was difficult to get concrete conclusions regarding the efficiency of flexible aligners in the 3 D control of the teeth. Orthodontics by aligners is current and in a process of development should not be perceived as a codified and fixed technique. The obtained results have proven that orthodontic aligners are capable of assuring the predictability of certain movements without difficulty (version movements) by the implementation of attachment. Notwithstanding, aligners are not able to possess translation movement and by this the derotation remains less predictable.

Based on these results, the dental movement control by orthodontic aligners is not completely conceivable, and that is a fact related to our present judgment in terms of the lack of fundamental knowledge of what concerns aligners biomechanics. This actually produces new optimized attachments that may make of certain movements more achievable and efficient (For instance: translation movement, rotation and torque) in order to better mastering the control of dental axes during finishing phases without the need to use multi-brace conventional techniques.

The welfare of the patient is a primordial concern in the treatment that either therapeutic control quality or future developments are very promising from both biomechanics and biological knowledge as from info graphic point of view (3D image) (2) .

References:-**(1)-Proffit WR.**

Contemporary orthodontics. St. Louis, Mo.: Elsevier Mosby; 2012.

(2)- Bouchez R.

Les traitements orthodontiques Invisalign.
Paris: Quintessence International,2009:142

(3)-Ojima K, Kau CH.

A perspective in accelerated orthodontics with aligner treatment.

Semin Orthod. 2017 ;23(1):76-82.

(4) -Simon.M ,Keilig.L, Schwarze.J et al.

Treatment outcome and efficacy of an aligner technique regarding incisor torque, premolar derotation and molar distalization. BMC Oral Health 2014, 68(14) : 1-7

(5)-Zhang.X.J and al.

Integrated three-dimensional digital assessment of accuracy of anterior tooth movement using Clear aligners. Korean J orthod. 2015.

(6)-Kravitz.N, Kusnoto.B, Begole.E et al .

How well does Invisalign work ? A prospective clinical study evaluating the efficacy of tooth movement with Invisalign. Am J Orthod Dentofacial Orthop. 2009; 135(1):27–35.

(7)-Ravera.S et al

Maxillary molar distalization with aligners in adult patients : a multi center retrospective study. Progress in Orthodontics. 2016 ; 17 :12 .

(8) - Caruso.S et al.

Impact of molar teeth distalization with clear aligners on occlusal vertical dimension : a retrospective study BMC Oral Health 2019, 182(19): 2-5.

(9)-Lombardo.L, Arreghini.A , Ramina.F et al .

Predictability of orthodontic movement with orthodontic aligners: a retrospective study. Progress in Orthodontics. 2017, 18(35): 2-12.

(10) - Grünheid T, Loh C, et al.

How accurate is Invisalign in non-extraction cases? Are predicted tooth positions achieved? Angle Orthod. 2017;87(6):809-815

(11)- Hennessy . J, Garvey. T, Al-Awady. E et al

A randomized clinical trial comparing mandibular incisor proclination produced by fixed labial appliances and clear aligners

. Angle Orthod. 2016;86(5):706-712

(12) -Krieger, Seiferth.J, Marinello.I et al.

Invisalign® treatment in the anterior region Were the predicted tooth movements achieved? J Orofac Orthop 2012 73(5):365-376.

(13)-Charalampakis O, Iliadi A, et al

Accuracy of clear aligners: A retrospective study of patients who needed refinement.

Am J Orthod Dentofacial Orthop. 2018;154(1):47-54

(14)-Garnett .B , Mahood.K , Nguyen.M et al .

Cephalometric comparison of adult anterior open bite treatment using clear aligners and fixed appliances. Angle Orthod. 2018, 0(0) :1-7

(15)-Dai FF, Xu TM, Shu G.

Comparison of achieved and predicted tooth movement of maxillary first molars and central incisors: First premolar extraction treatment with Invisalign.

Angle Orthod. 2019;89(5):679-687.

(16) - Sfondrini MF, Gandini P, Castroflorio T, et al.

Buccolingual Inclination Control of Upper Central Incisors of Aligners: A Comparison with Conventional and Self-Ligating Brackets.

Biomed Research International. 2018, 2-8

(17) - Houle.J. P et al.

The predictability of transverse changes with Invisalign.

Angle Orthodontist .2016 ; 0(0) : 1-6

(18) - Duncan.O et al .

Changes in mandibular incisor position and arch for resulting from Invisalign correction of the crowded dentition treated without extraction.

(19) – Higgins JPT, Altman DG.

Assessing risk of bias. Cochrane Handbook for systematic reviews of interventions. Wiley, chichester, 2008 ; 0(1) : 8-12

(20) – Crosby.D ,Lee.J et al .

A patient – classification system for Invisalign cases.

J. Clin.Orthod.2009 ; 43(8) : 502-506.

(21) – Joffe.L

Invisalign : Earlyexperiences.J. Orthod.2003 ;30(4) : 348-352.

(22)-Orhan.C, Bowman.Sj,Amy.B .

Effectiveness of a Compliance Indicator for Clear Aligners.

J. Clin.Orthod.2009; 43(4):263-268.

(23)-Jonathan.L.

Traitement par gouttière d’alignement transparente.

In: Elsevier Masson.Dentisterie esthétique: le sourire.2017