GRADUATION PROJECT

Degree in Dentistry

TOOTH MOVEMENTS PREDICTABILITY WITH CLEAR ALIGNERS IN ORTHODONTICS

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RESUMEN

Introducción: El último siglo ha sido testigo de un aumento en la búsqueda de la belleza, y la búsqueda de una sonrisa mejor, si no perfecta, es un componente indiscutible de ello. La Terapia de Alineadores Transparentes fue introducida como un conjunto completo de alineadores hechos de materiales termoformados de policarbonato. Sin embargo, los alineadores transparentes han recibido críticas de profesionales que critican sus limitaciones y sus efectos indeseables. Además, el resultado de la Terapia de Alineadores Transparentes depende en gran medida de la cooperación del paciente, pero también de las habilidades del profesional. **Objectivos;** Este trabajo tiene como objetivo principal evaluar la previsibilidad del movimiento dental con alineadores transparentes entre dentistas y ortodoncistas españoles y franceses. Además, intentaremos entender por qué algunos movimientos pueden percibirse como más predecibles que otros. **Metodología;** Para evaluarlo se distribuyó un cuestionario compuesto por 25 preguntas a dentistas españoles y francés entre el 08.03.2023 y el 23.03.2023. Recibimos un total de 54 respuestas, de las cuales se excluyeron 14 participantes. **Resultados;** Cada resultado fue explicado detalladamente y organizado en tablas. **Conclusion;** Los profesionales españoles y franceses tienen una visión generalmente positiva de la previsibilidad de los alineadores transparentes. Encontraron que la rotación de los incisivos superiores es el movimiento más predicible y la intrusion del sector anterior inferior es el menos predecible. Los movimientos de rotación en caninos y premolares resultaron más difíciles debido a sus formas redondeas. Los movimientos horizontales y en el sector anterior se encontraron más predicible. Los movimientos verticales resultaron más difíciles de lograr debido a que son más complejos y a menudo producen movimientos no deseados. Se han introducido algunas herramientas para tratar de mejorar la previsibilidad de ciertos movimientos, como los Power ridges, los elásticos, los mini-screws, los bonding buttons y la reducción interproximal.

Palabras clave; Odontologia, Alineadores transparentes, previsibilidad, movimientos dentales, elementos auxiliares.

ABSTRACT

Introduction; The last century observed an increase in beauty conquest, and the quest of a better, if not a perfect smile is an undisputed component of it. This could explain the democratisation of orthodontics treatments among adult patients. A discrete and removable appliance is much more appreciated. Clear Aligner Therapy was introduced as a full set of aligners made of thermoformed polycarbonates materials. However, CAT received some criticisms from professionals that disparage its limitation and its parasites effects. Moreover, the outcome of CAT depends mostly on patient's cooperation but also on the practician's skills. **Objectives;** This work aims primarily to evaluate the perceptibility of tooth movement predictability with clear aligners among Spanish and french dentists and orthodontists. Moreover, we will try to understand why some movements can be perceived as more predictable than others. **Methods;** In order to assess it, a questionnaire composed of 25 questions was distributed to Spanish and french dentists between the 08.03.2023 and the 23.03.2023.. We received a total of 54 answers from which 14 participants were excluded. **Results;** Each result was thoroughly explained as well as organised in tables. **Conclusion**; Spanish and French practicians have an overall positive view on CAT's predictability. They found the rotation of the upper incisors to be the most predictable movement and the intrusion of the lower anterior sector as the least predictable. Rotation movements in canines and premolars were found more difficult because of their rounded shapes. Horizontal movements were found more predictable. Movement in the anterior sector were also ranked as more predictable. Vertical movements were found more difficult to achieve because there are more complex and often produce unwanted movements. Some tools were introduced to try to improve some movement's predictability such as; Power ridges, Inter and intra maxillary elastics, mini-screws, bonding buttons and IPR.

Keywords; Dentistry, Clear Aligners, predictability, tooth movements, auxiliaries elements

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1 INTRODUCTION

The last century observed an increase in beauty conquest, and the quest of a better, if not a perfect smile is an undisputed component of it. This could explain the democratization of orthodontics treatments among adult patients. However, exigences in these patient is ever growing. A discrete and removable appliance is much more appreciated; hence the phenomenal ascent of clear appliance uses in orthodontics.

The popularity of this technic is not only due to its aesthetic, but it offers comfort, less pain and better conditions for an optimal oral hygiene when compared to conventional fixed appliances. Clear aligner treatment (CAT) is defined as a full set of aligners made of medical grade polycarbonates thermoformed materials. Each aligner is responsible for an established number of dental movements. Thereby, the number of aligners and, consequently, the duration of the treatment depends on the importance of dental misalignments.

However, CAT received some criticisms from professionals that disparage its limitation, its parasites effects and its cost. Moreover, the outcome of CAT depends mostly on patient's cooperation but also on the practician's skills.

1.1 Generalities

1.1.1 Definition

Aligners are transparent trays made from a sheet of thermoformable plastic which, chemically speaking, is a polymer (polypropylene, polyethylene, polyurethane, ...). This device, intended for orthodontics purposes, makes possible to move the teeth from a dento-alveolar point of view.

1.1.2 History

In 1925, Remensnyder invented a new device made of soft rubber intended to treat periodontitis by the means of an appliance simulating the gingiva. Surprisingly, he recorded minor tooth movements after the use of his appliance in the following years.(1)

Herald Dean Kesling created in 1946 a tooth positioner made of vulcanite plastic. This was meant to be used after an orthodontic treatment but Kesling realised the potential this device could achieve in terms of tooth movements. However, he also knew it could not properly be used for this intent yet. Nevertheless, he stated that: « Major tooth movements could be accomplished with a series of positioners by changing the teeth on the setup slightly as treatment progresses. At present this type of treatment does not seem to be practical. It remains a possibility, however, and the technique for its practical application might be developed in the future."(2)

In 1964, Nahum experimented with different thermoformable plastic materials (acetate, polyethylene…) and created the very first aspirated thermoformed appliance. This aligner was mainly used to correct either spaces in the anterior region or minor rotations. The use of these appliances was extended to other dental specialities; in surgery to prevent post-operatories haemorrhages, in periodontology and in prosthesis to make provisional crowns.

We had to wait until 1985 for Mac Namara to create the very first thermoformable appliance which uses positive air pressure solely for orthodontic purpose (BIOSTAR). Mac Namara was heavily influenced by Ponitz's « invisible retainer » used for contention and expended its use to the correction of minor tooth misalignments. Contrary to its predecessor, Mac Namara recommended the correction of only one tooth per quadrant.

In 1995, Sheridan developed the ESSIX® system based on the same principles as Kesling's one. However, he innovates by adding to his aligner:

- Ergots (devots) placed on the adjacent teeth to allow more pressure to be put. It was placed by deforming the gutter using a stamping tool (Hillard pliers) or by putting composite buttons on the tooth.
- Windows using a bur to create a space in which the tooth can move. (3)

In 1997, two MBA students, two orthodontists and a computer engineer created the company Align Technology Inc. The Invisalign® system was born using mainly two manufacturing systems:

- The CAD-CAM (computer-aided design and computer-aided manufacturing) which allows the digitization by tomography of the impressions (taken only once before the start of the treatment) to obtain a 3D set-up and thus virtually preview the whole treatment step by step.
- Stereolithography (3D printer) of liquid resin for industrial purposes which allows the manufacture of a series of aligners from their 3D images by computer-aided design.(4)

In 2006, Wajeek Khan developed the Orthocaps® system which is currently considered the direct competitor of the Invisalign® system. This system incorporates the concept of virtual set-up and computer-aided design and manufacture. Nevertheless, it differs by:

- The use of a set of 2 aligners per treatment step; a first rigid aligner (hardCAPS) worn during the day and a second more flexible one (softCAPS) worn during the night. This approach is called the Twin Aligner® system.

- Wearing time for each series of gutters is three weeks instead of two for Invisalign®.
- Aligners are not all provided from the start, impressions must be taken and/or reassessed every 6 months.(5)

1.2 Biomechanics principles.

1.2.1 Definition of biomechanics

Mechanic is a division of physics that approaches the mechanical features of a system, either in a static or in a rigid point of view. When this branch of physics is applied to the structures and functions of a living system, in this case the tooth and their surroundings, we call it biomechanics. (6)

The study of biomechanical process and notions is a crucial component of CAT success. In this way, the recollection of these principles was a necessary section of this work.

1.2.2 Force

A force is defined as a mechanical action that can deform or cause a change in motion in a body, as shown in the figure 1. It is almost always measured in grams (g) in orthodontics. (It is usually measured in Newtons (N) otherwise)..(6)

1 N = 101.9g

It is defined by:

- Its **Magnitude:** The amount of force applied
- Its **Direction:** Its orientation
- Its **Point of application:** The system body receiving the force
- The **Line of action of force**: Straight line situated in the same plane and in the direction of force passing through the application's point. (6)

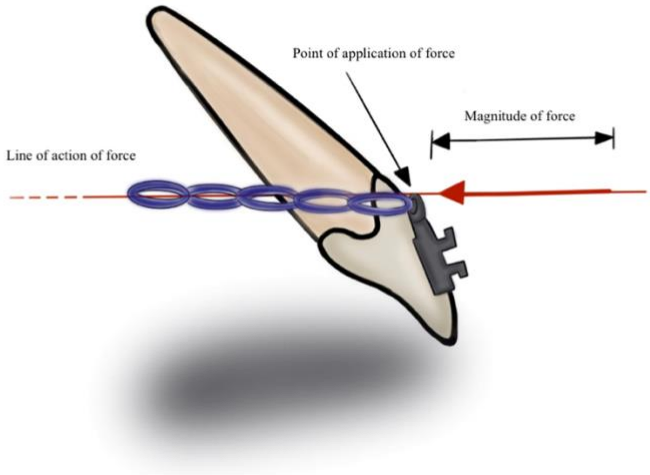


Figure 1: The properties of an external force applied to a tooth.

1.2.3 Force couple.

A force couple is composed by two parallel forces that have the same intensity but have opposite direction and two different application points. This will produce a rotation movement on the solid, as shown in figure 2. The intensity of a force couple can be measured by its **moment**, which is the product of the intensity by the distance between the two forces. (7)

$$M = F \times D$$

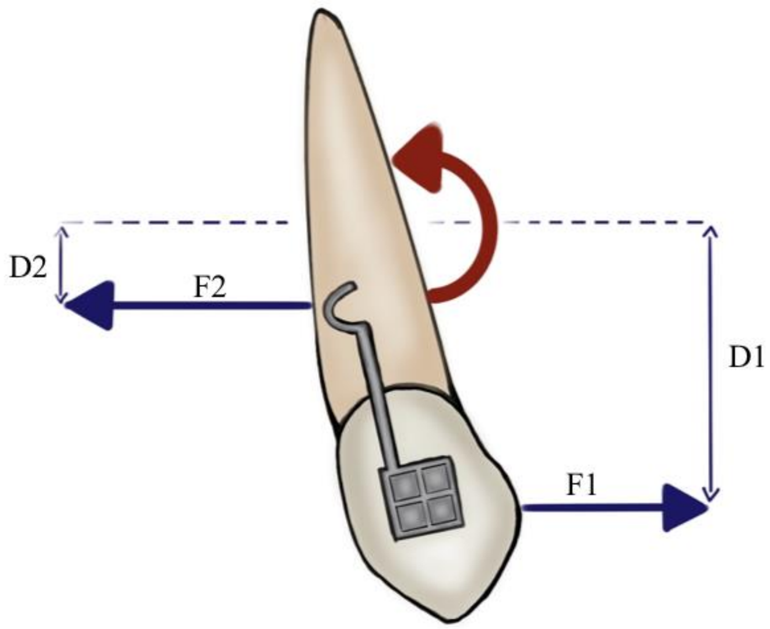


Figure 2: Schematisation of a movement created by a two opposite but equal forces.

1.2.4 Center of resistance.

It is important to note that the tooth doesn't resist a movement, but rather transmit forces. Resistance is done by the bone and by the desmodontal environment. In this way, a better term that can be used would be « Resistance center associated with a tooth ». It is defined by the point which a force should go through to produce a pure translation movement of the tooth. This means that absolutely all points in the tooth would move through parallel lines, as shown in figure 3.

The center of resistance is a fixed point in a given situation and in a given time.(8) However, it depends mainly on the tooth's radicular surface and on the bone present, both its nature and its quantity. In a normal tooth (read by that with an intact periodontium), it is situated:

- Between the medial and the apical third of the root of a monoradicular teeth.
- In the furcation area of a multiradicular tooth. (8)

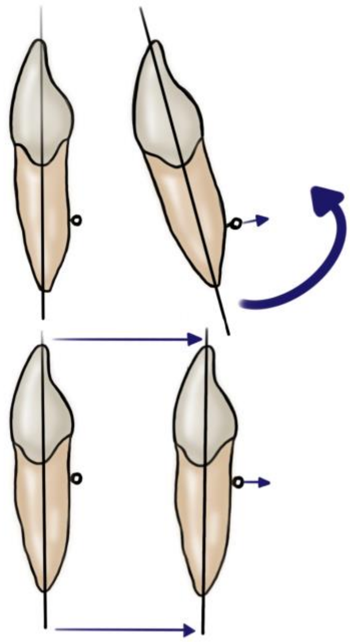


Figure 3. Localisation of the resistance center (Cr) and its subsequent pure transitional movement.

1.2.5 Center of rotation

It is a chosen point through which the tooth is going to do a circular movement and is a key to define the tooth movement. It is important to note that a two-dimensional shape rotates around a fixed point whereas a three-dimensional one rotates around an axis. As opposed to the resistance center, it is defined by the force system and can or cannot be located within the tooth although the center of resistance is excluded from the possibilities. Center of rotation (Crot) is mostly determined by treatment's needs.

The position of Crot is closely linked to the ratio moment/force. It also defines the type of movement we can achieve. (9)

- When moment/force = 0, Crot is situated to the infinity when compared to the Cr. This will produce a movement of pure translation.
- When moment/force tends to infinity, this means Crot is situated close to the Cr. This will produce a movement of pure rotation.

- When moment/force is situated betweeen those two, we will have a combined movement of rotation and translation. (9)

We can estimate Crot by taking two points in a tooth and connect their initial and final positions with a line. Crot will be located where the perpendicular bisectors of these two lines intersect. (6)

1.2.6 Anchorage

1.2.6.1 Definitions

In the biomechanics of orthodontics, the notion of anchorage is used to describe the resistance of a body to a movement. When a body moves, it is safe to say that motor forces exceed resistances forces. (10)

In orthodontics, we describe two types of resistance:

- Stabile resistance: describe the anchorage point of a force needed to move one or several tooth. It is either several other teeth or a pericraneal support.
- Mobile resistance: describe the tooth or teeth to be moved. It is the application point of the motor force.(10)

1.2.6.2 The Trinomial of De Nevreze

De Nevreze defines the Stabile Resistance (SR) as the anchorage teeth and the Mobile Resistance (MR) as the teeth to be moved. The Moving Forces (MF) are creating a displacement as a form of a translation, tipping or rotation. SR and MR depend on the age, the gender, the dentition, the type of movement among other components. (10)

The optimal situation described by De Nevreze is the one where the moving forces cannot move a major anchorage but is enough to move the chosen tooth. (MR<MF<SR). The primary condition of this equation would be that SR>>RM. (10)

1.3 Types of dental movements

1.3.1 Tipping

Tipping is known to be one of the easiest orthodontic movements to obtain. It is achieved when a unique force is applied in any point of the crown. The tooth will tip around its Crot (fulcrum) located near its Cr, in the root. The direction can be mesial, distal, vestibular or lingual/palatal. The crown will move in one direction while the root will remain relatively stationary. (6) (figure 4)

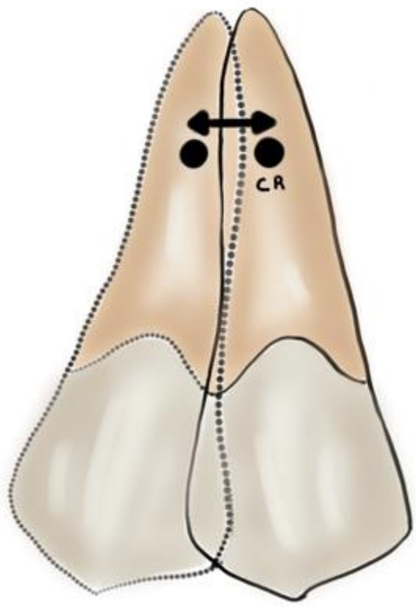


Figure 4: Tipping movement

1.3.2 Translation (Bodily tooth movement)

The said movement showed in figure 5 is produced parallel to the long axis of the tooth. To achieve this movement, the force system needs to go through de center of resistance. (6,11)

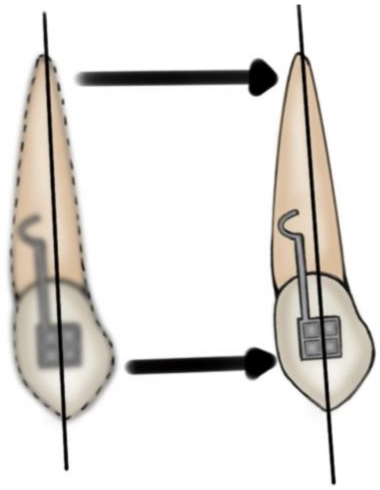


Figure 5: Pure translational movement

1.3.3 Extrusion and intrusion

- Extrusion: Physiological movement that occurs spontaneously in the teeth without antagonists. It is done all along the axis of the tooth, tending to come out of its alveolus. In orthodontics it refers to a controlled movement from which a tooth is pulled away from the alveolus.(8,12)
- Intrusion: Movement that tends to push the tooth into the alveolus, it requires an axial force in the apical direction. It can cause bone and root resorption, especially in the upper lateral incisors. Both extrusion and extrusion movements are shown in figure 6.

Figure 6: Extrusion and Intrusion movement

1.3.4 Rotation

It is a movement of the tooth around its axis (axial rotation) or around an axis parallel to its long axis (marginal rotation). This movement requires a couple of forces applied to the crown and in a plane perpendicular to the long axis of the tooth. For this movement, it will be necessary to consider:

- The anatomy: Position, size and form of the tooth.
- That this type of movement is subject to recurrences. (13)

1.3.5 Torque

As shown in the figure 7, it is a rotation in the vestibulo-lingual direction around a mesio-distal axis passing through a point on the tooth; this movement requires the application, in a point of the crown, of a couple of forces located in a plane passing through the axis of the tooth and perpendicular to the vestibular surface. During this torque movement, greater stress occurs at the apex than at the alveolar crest: the consequences can result in root resorption. (13)

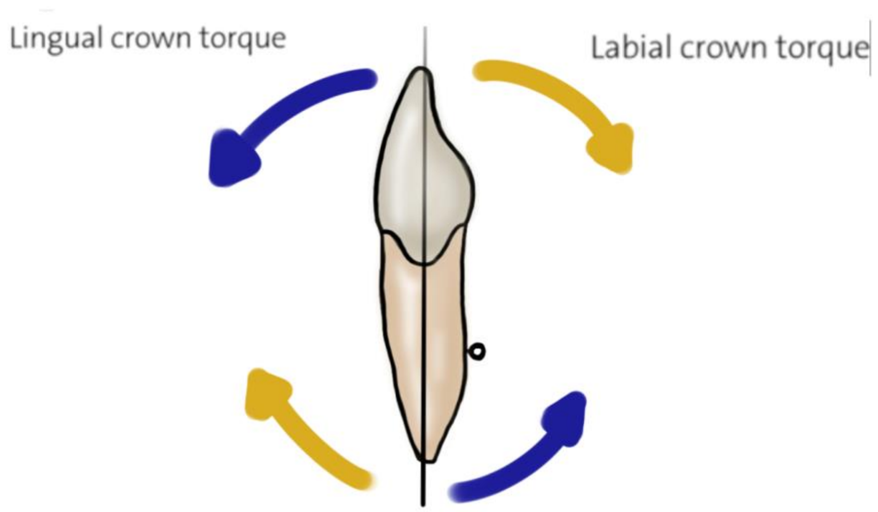


Figure 7: Lingual crown and labial crown torque movements

1.4 The clear aligners system.

1.4.1 Biomechanics of clear aligners therapy

Biomechanics applied in orthodontics refers to the study of the periodontal system when forces are applied to it. Those forces produce a tooth and a periodontal response according to;

- Their direction
- The degree of incidence
- Their distribution
- Their duration.

The sum of these factors produces dental movements; either wanted or unwanted.
To obtain optimal movements with targeted and programmed action, it is utterly important to have a maximum of the tooth crown covered. This allows an optimum transmission of information.

Clear aligners are designed according to two main principles: (14,15)

- **Creating space:** tooth extraction, interproximal reduction, arch expansion…
- **Force application:** it is important to note that while traditional orthodontic appliances work by pulling the tooth, CAT works by pushing it. Movements are small and gradational. They can either be done by clear aligners only or by adding attachments, elastics, or other accessories. Pressure applied to produce movement is linked to physiological and anatomical properties. (Tooth shape, size, periodontal conditions…)(15)

An aligner inserted in the mouth has just enough difference with the initial intraoral tooth position for them to move toward the aimed position without creating traumatic lesion. A new aligner will develop a force that aims to be continued but with a decreasing intensity over time. These little movements are repeated as long as needed to achieve the desired outcome by changing each aligner just a little bit from the previous one. (12)

In CAT, teeth engagement in a movement is proportional to the percentage of teeth wrapped into the material. In this way, the longer a clinical crown is the better the expression of tooth movement. (12)

Each aligner should be worn for at least 22h a day to have optimum results. Wearing them less than 18h a day reduce drastically the success rate of CAT. However, recent studies showed that keeping the aligner while eating or drinking staining beverages was leading to changes of the aligner's optical and mechanical properties.In this way, it is recommended to remove the aligner while eating or drinking. (16)

1.4.2 Criteria influencing CAT success.

1.4.2.1 Material's thickness and stiffness

According to literature, clear aligners can be found having a thickness ranging from 0.5mm to 1.5mm. Undoubtedly, thickness has been proven to have a noticeable impact on mechanical properties and ultimately performance of CAT. Studies have agreed that harder material (0.75-0.8mm) used for CAT produced noticeably higher resistance forces than thinner material (0.4mm-0.5mm). (17)This is particularly useful for dental movements that require greater forces. It has also been noted that the greater the amount of activation, the lower the orthodontics forces applied. However, this does not apply to thinner materials. (17) Nonetheless, as opposed to thinner materials, thicker materials are less comfortable for patients to wear. They are also more visible which also gives rise to aesthetic problems.

The definition of young's modulus is the ration of stress to strain, as shown in figure 8. It is typically used to measure a material's stiffness and has been used in various studies to compare different CAT materials. (18) In CAT, the chosen material should have enough stiffness to produce wanted force. However, an overly stiff material will lead to difficulties of insertion and removal for the patient. (17)

1.4.2.2 Material's selection

When it comes to material's choice in CAT, its composition influences the success rate of the therapy as much as the manufacturing process. (19) However, they are not the only components to consider. Growing demands are leading to practician and patients requiring easy to use, cheap and aesthetic materials without compromising on their biomechanical properties. (19)

A. What is a polymer?

The term polymer has a greek origin and is composed of two words: « Poly », which means *many*, and « meros », meaning *units*. Typically, a polymer refers to thousands of repeated units connected to each other's through chemical bonds. We distinguish 3 types of polymers based on their thermal behaviour: *thermoplastic, elastomer* and *thermoset.*

According to literature, two thermoplastic polymers are mostly used in CAT; polyethylene terephthalate glycol (PET-G) and thermoplastic polyurethane (TPU). (20)

TPU is regarded by many as a new gloden standard for CAT. However, colour stability and transparency are essential for this therapy. This is compromised by pigment absorption from beverage and food. This is an issue raised by recent studies about TPU. Thereby, patients are advised to take the appliance out when eating or drinking. Nevertheless, patients failing to comply observed a clinically concerning color change less noticeable with other polymers. (20)

B. Resistance to thermo-chemical corrosion

Polymers are widely used in the medical fields, but when it comes to orthodontic appliances, they should have particular properties. Indeed, in orthodontics appliances they are subject to the intraoral environment composed of electrolytes material enzymes or bacterias. A proper material used for CAT should be able to withstand chemical erosion, otherwise this might lead to changes of the polymer's mechanical properties. Ultimately, this could compromise CAT's outcome. (20)

The intraoral medium has a relatively constant temperature of around 37C. However, clear aligners appliances are subject to temperature changes in the mouth, varying from sub-zero to relatively high temperatures according to what the patient is eating. (Ice cream, tea…)(20)

Studies showed that TPU were more stable in the intra-oral environment than other materials when subjected to thermal changes, thanks to their great shape memory. (21)

However, the slight change in thickness found in PeT-G was not enough to affect the CAT outcome. (22)

Recent studies were conducted to evaluate the risk of bisphenol-A (BPA) release in the intra-oral cavity. BPA is an endocrine disruptor but it is also a polymer of Polycarbonates. Literatures showed that although polycarbonates were releasing BPA in artificial salivas, the amount released was never exceeding the maximum amount recommended. (23)

C. Mechanical properties

CAT appliances are subjected to short and long-term forces in the oral cavity. Short term loading forces are applied immediately after the fit in the oral cavity whereas long-term is caused by tooth movements and biomechanical forces produced by the musculoskeletal system.

However, thermoplastic polymers subjected to short duration forces are following Hook’s law. Within the elastic limit, the stress applied to the material and its strain are proportional. Before the elastic limit, the material returns to its initial shape and size once the force applied is removed. Once an applied stress surpasses the yield strength, the material doesn’t behave like an elastic but like a plastic. The ultimate strength is the amount of strain necessary for the material to break. The scientific consensus is that materials with higher yield strength and thoughness are desirable for CAT manufacturing. (Figure 8) (17)

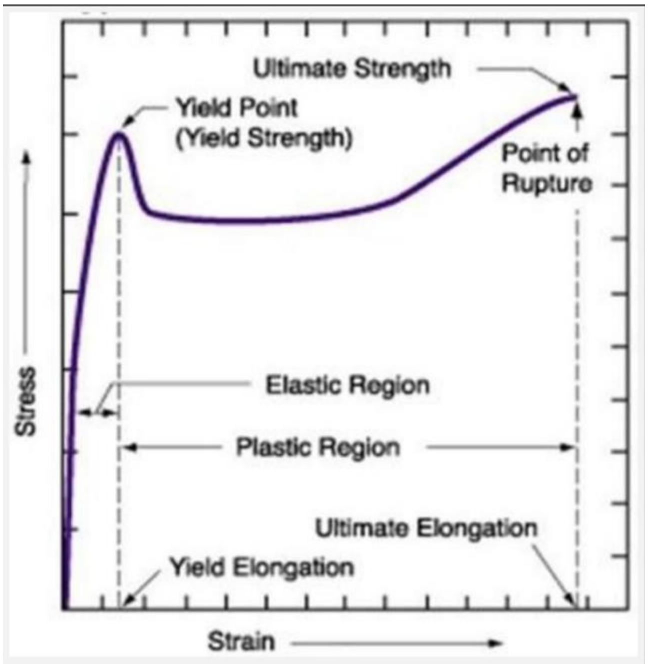


Figure 8: Stress Strain graph of a thermoplastic Material (17)

1.4.2.3 Manufacturing process

The workflow for each manufacturing process starts with virtual planning software using a plaster or a scanned initial impression. The practician can either take a PVS impression or use an intra-oral scanner. Most aligners companies work hand-to-hand with their dentists to deliver an optimal treatment plan. Once the treatment plan is established, the 3D model is used to create a series of several aligners for them to be worn sequentially by the patient. They are fabricated mainly by using two methods:

A. Thermoforming methods

To make each aligner that will compose the CAT, a physical model is needed. It is made either by 3D printing, by stereolithography or by material jetting.

There are currently 2 types of thermoforming methods:

- The majority works following the principle of air depressurisation. An air suction phenomenon is created below the 3D model, causing the aspiration of the thermoformable plastic over it. This method is used notably by Essix machine, Tray Vac or Econo Vac.

- Other create pressurised air on top of the thermoplastic material, causing it to fllatten itself over the model. (24)

B. Direct 3D Printing

Also known as additive manufacturing, 3D printing is widely used in medical modelling. Uses are multiple and diverse in dentistry, ranging from oral surgery to implantology.

In modern orthodontics, 3D printing works by manufacturing trays layers by layers, rather than by using substractive methods or vacuum-formed trays. Currently, acrylonitrile-butadiene-styrene plastic, epoxy resin, poly lactic acid and polycarbonate among others are widely used in this manufacturing method.

Studies showed that the use of 3D printing was minimising inaccuracies following impressions. Ultimately, its use can avoid cumulative errors made with traditional workflows. (25)

Several methods can be used to obtain 3D printed aligners, but research concluded that photo polymerisation from clear resin is the best option regarding clear aligners properties and mechanical requirements.(26)

1.4.3 Auxiliaries elements and additional procedures

Although clear aligners are relatively new appliances, numerous amelioration and additions were created to compete with traditional appliances. To obtain more controlled, precise, more complex or harder movements, auxiliaries elements can be added to help clear aligners. Treatment planning software established by CAT companies are helping tremendously with the choice and the location of auxiliaries elements.

1.4.3.1 Composite attachments/ Buttons

Composite attachments were among the first ones to be introduced. They were introduced as an attempt to control unwanted tipping after incisor extraction. Composite attachments were submitted as rectangular structures that can be bonded to the tooth, in this case, to lower incisors. The thermoplastic aligner colliding with the composite attachment creates a force couple that clashes with the initial movement, avoiding unwanted tipping movements (Figure 9). Composite attachments can also provide aligner retention, especially in the case of inter maxillary elastics use where the dislodgement of the appliance can affect CAT success. Composite attachments have various uses ranging from vertical control to extrusion based on the location, the size and the use of the attachment.They can either be used anteriorly or posteriorly. (20)

However, one of the advantages of CAT was the absence of enamel involvement. Even though it would potentially involve drastically less tooth than in traditional bracket bonding, this still could lead to potential white spot or enamel’s optical properties changes. (27)

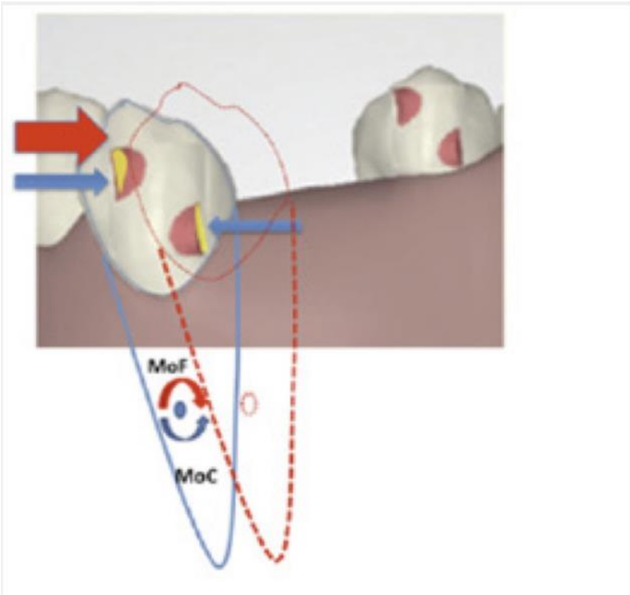


Figure 9:Schematic representation of transnational movement with composite attachments bonded to the tooth. (28)

1.4.3.2 Micro screw

Microscrew are temporary titanium fixations placed in the bone. It acts as an additional anchor system to avoid unwanted tooth movements when surrounding teeth are used. Microscrew are described as minimally invasive osteoperforation and are used in various cases. Studies showed that perforations increased the rate of tooth movements in CAT while giving little to no discomfort to the patient. (29)

However, microscrew requires a minimal surgery which collides with one of the benefits of CAT; a non-invasive treatment. This can lead to several complications, such as premature loosening of the micro-screw or inflammatory reaction to the titanium fixation.

1.4.3.3 *Power ridge*

Power ridges, as presented in figure 10, are small elevation added directly into the aligner during its manufacturing process. This allows a force to be applied directly onto the tooth, notably creating a moment of force necessary to produce a radiculo-lingual torque movement. (30)

Figure 10. Power ridge (30)

1.4.3.4 *IPR*

Interproximal reduction, or IPR, can be added to the treatment plan when teeth are considered too close to each other to create proper movements. In this way, they are increasing the amount of space available and are a more attractive alternative to extraction. They are also performed in the presence of black hole in between teeth to allow smoother movements, especially with triangular shaped teeth or patients with periodontal issues. Although IPR can be seen as relatively invasive, studies have shown that it is a safe procedure with little to no negative consequences. Abrasive strips are mostly used when the reduction is minimal, whereas for bigger procedure practician could use contra-angle mounted discs. (31)

1.4.4 Advantages

When it comes to CAT, case selection is utterly important whether it is regarding CAT's limitations or the practician's one. This therapy is extremely technique sensitive. In fact, Invisalign has developed a treatment planning guide according to the practician's experience. The more case he has worked on, the more difficult cases he will be able to take. (32)

CAT offers a range of advantages. The first one being its aesthetic. Indeed, this treatment is relatively imperceptible. This is undoubtably one of the main advantages among the adult population looking for an orthodontic treatment. Adult patients are sensible to this argument and find clear aligner more compatible with their social and professional lives.

Moreover, CAT are comfortable and removable. Although aligners should be worn for a minimum of 20h/day to be efficient, it is removable. This offers a better control over the appliance's hygiene and, thus, the overall oral hygiene. Patients also refer to less irritation and pain while being treated with CAT. (33)

1.4.5 Disadvantages

As opposed to traditional appliances, CAT success relies primarily on patient's compliance. A trust bond should be established between the practitioner and his patient. An appliance worn less than 22 hours a day represent a drastically less successful treatment. New indicators were introduced by Align Technology (San Jose, CA) to monitor the use of aligners by placing color-fading dots. The predictability of CAT success is also greatly influced by tooth anatomy. As we have seen, the greater the clinical tooth the bigger the chances of success.(34)

Moreover, movements through clear aligners are achieved more difficultly than with traditional appliances. Indeed, to move a tooth we need a set and distinct amount of points to apply force on. (35)

1.5 Justification

Clear aligners have an ascending popularity and are considered by many as the future of orthodontics. However, many practicians and patient seem to think that fixed aligners have better tooth movement predictability.

In this way, I think it would be interesting to carry out a research based on practician's perception of tooth movement predictability with clear aligners. Moreover, comparing these results with those obtained in literatures would be especially informative and useful to try and explain the outcome of this research.

1.6 Research question and hypothesis

- Which tooth movements seem to be more predictable with clear aligners for dentist and orthodontists in Spain and in France and why?

The null hypothesis is that although most movement are perceived as predictable, vertical movement exerted on anterior sectors would be perceived as more predictable due to, among other things, tooth's anatomy, and the nature of the required movement.

2 OBJECTIVES

2.1 Primary objective

- This cross-country study aims to evaluate the perception of dentist and orthodontist regarding tooth movement predictability with clear aligners.

2.2 Secondary Objective

- To compare our results to literature and to explain why some movement can be perceived as less predictable.
- To expose some tools and technics that could improve tooth movement predictability with clear aligners.

3 MATERIALS AND METHODS

3.1 Study design:

This multi- country cross sectional study is based on a questionnaire given to dental surgeons and orthodontist that are or have been treating patient using clear aligners appliances. This questionnaire was given to Spanish and French practicians and was available from the 8/03/2023 to the 26/03/2023. The purpose of the investigation has been explained prior to the questionnaire. It received ethical approval from the Ethics Committee of Investigation of the Universidad Europea (Project CIPI/23.102). Dental surgeons based their participation on their free will and comprehensive explanations about the study and its purpose have been communicated, preceeding the questionnaire.

3.2 Questionnaire:

The questionnaire has been edited in 3 languages to reach the different audiences. It has been developed in English and translated in Spanish and in french. The aim of the questionnaire and of the study was explained prior the questions and all the participants gave their informed consent to participate to the study.

The questionnaire was composed of 25 questions. The first 5 ones were drafted as personal questions to the audience, defining their speciality and affinity toward clear aligners.

The third question, « Have you ever used clear aligners in your patients? » was asked to exclude practicians who hadn't used invisible aligners in their practice from the study.

The next 20 questions were about their personal views on tooth movement predictability using CAT. Each question presented a specific tooth movement and participants had to choose a subjective value from 0 to 10 regarding tooth movement predictability with CAT. 0 being not predictable at all, 10 being very predictable.

Statistics and Data analysis:

The collected datas have been stored in an Excel sheet. The personal data answers are qualitative variables. Answers about practicians' views about tooth movement predictability using CAT were also analyzed as qualitative variables. All qualitative variables are presented as absolute values and percentages. As we are treating qualitative variables, we decided not to include standard deviation, mean or median values. Data analysis were done and organized by using R studio.

4 RESULTS

4.1 Presentation of the participants and exclusion criteria.

All the participant to the questionnaire gave their informed consent to participate to this study. This was confirmed by the first question.

The questionnaire was handed to both Spanish and french dentist. Out of 40 answers to the french questionnaire, 8 responded to the question 3 by the negative. Those 8 practicians never used CAT with their patients and their answers were excluded from the study.

Out of 14 participants to the Spanish questionnaire, 6 were excluded from the study for the same reason. The total number of answers post-exclusion was of 40, all of them gave their informed consent, as explained in the figure 11.

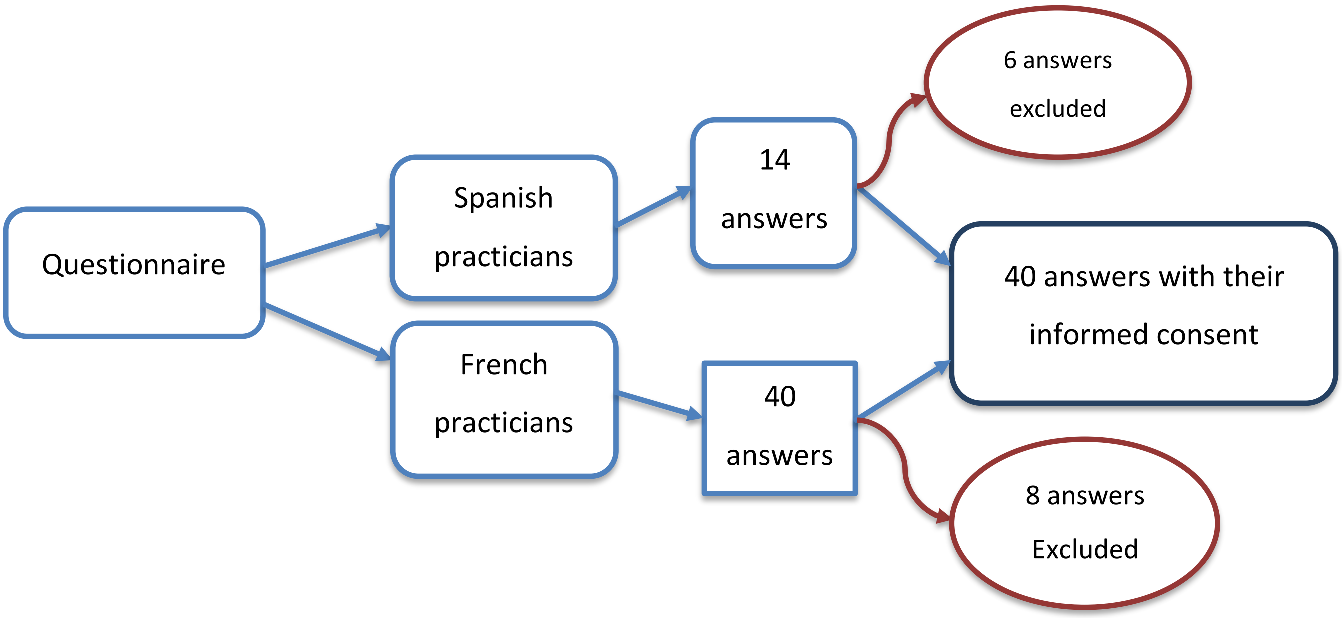


Figure 11: Inclusion and exclusion of participants.

Out of the 40 participants of the study, 7 were omnipraticiens and 33 were specialised in Orthodontics.

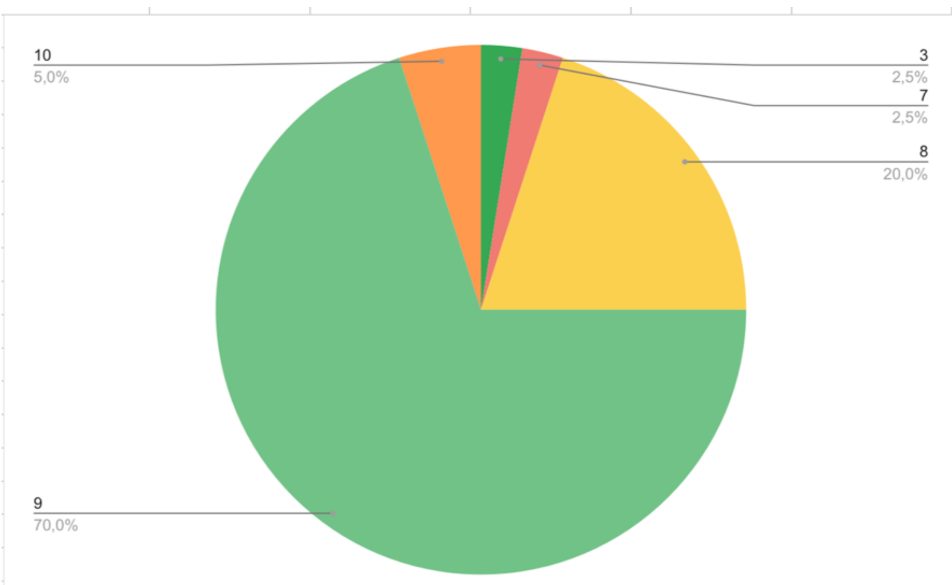
The table 1 regroups the responses to the question 5 regarding the number of patients treated with CAT by each practician. 75% of the participants treated between 50 and 100 patients before pertaining to the study.

Table 1: Number of patients treated with CAT	
Number of patients treated with CAT	Number of answers
1-50	4
50-100	30
100-150	2
150-200	3
➢ **200**	1

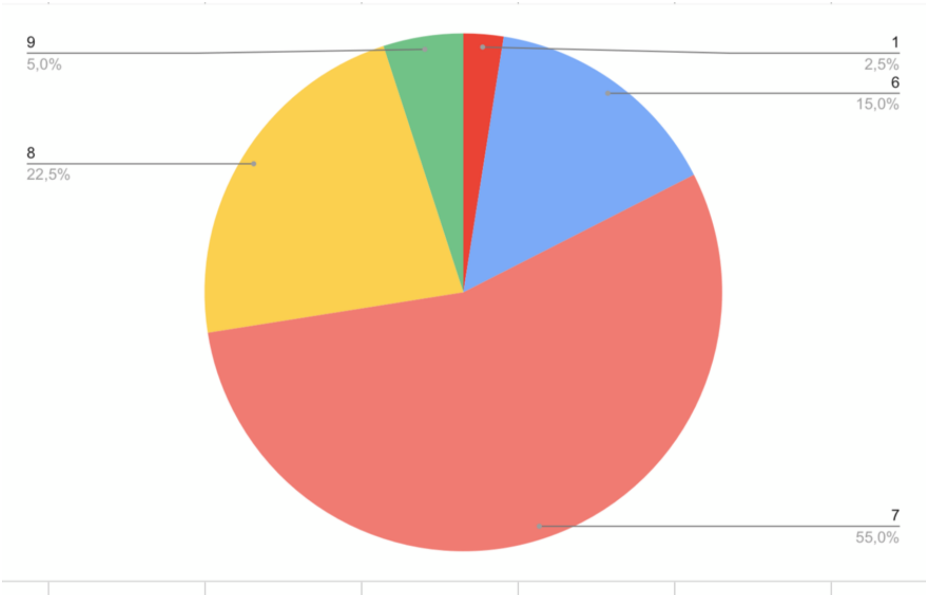
4.2 Tooth movement predictability results

For the second part of the questionnaire, 20 questions regarding different tooth movement were presented. The professionals were asked to give a subjective qualitative value to each of them, ranging from 0 to 10. In addition to being explained in the following section, results were organised and given in the **2nd table**. Each question was designated by **Qn**, n being the numbered question. Each question was followed by its own corresponding pie chart.

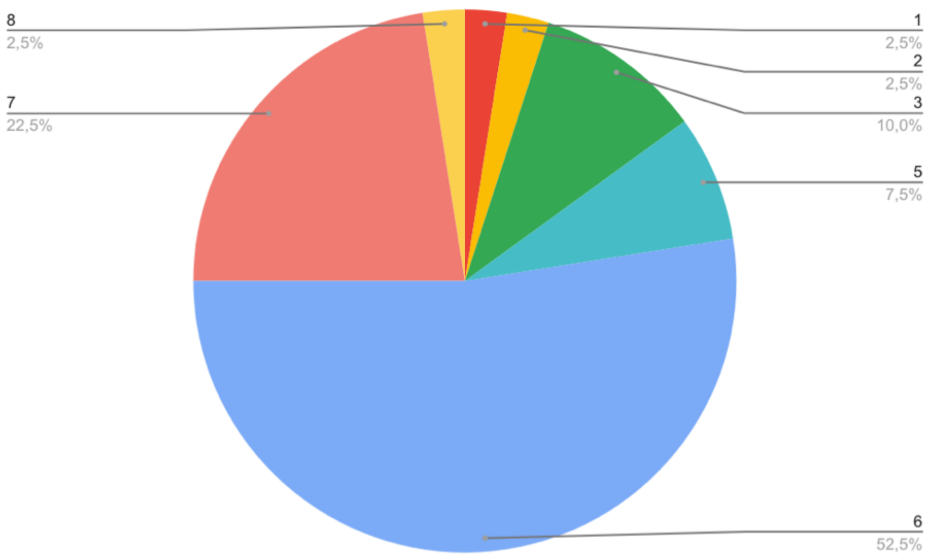
- The first question (Q1) was focused on the movement of rotation on a maxillary incisor. 28 out of the 40 participants gave a predictive value of 9 out of 10. (n= 68.29%) None of the profesional gave a ranking of less than 6 out of 10.



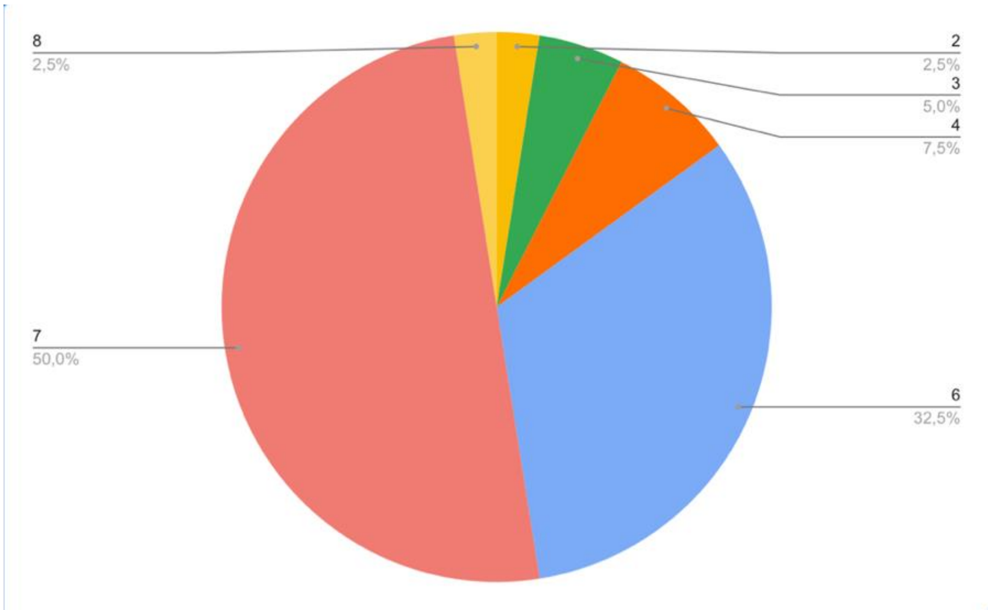
- The second question (Q2) was focused on the rotational movement of a mandibular incisor. 22 out of the 40 participants gave a predictive value of 7 out of 10. (n= 55%). Only one of them gave a grade of 1 out of 10, 6 being the second lowest grade.



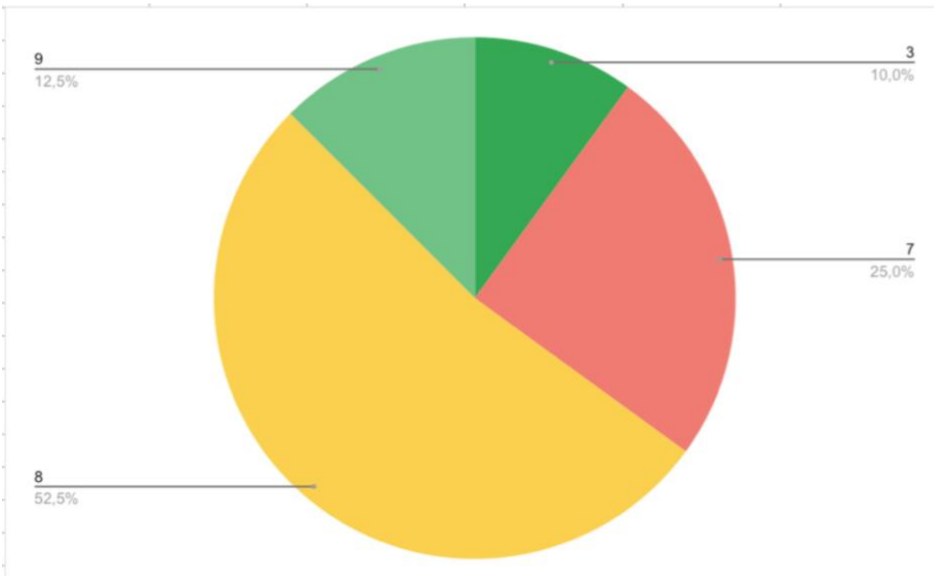
- The third question (Q3) was focused on the movement of rotation of a maxillary canine. 21 out of the 40 participants gave a predictive value of 6 out of 10. (n=52.5). However, 9 of them gave a predictive value lower or equal to 5. (n= 22.5).



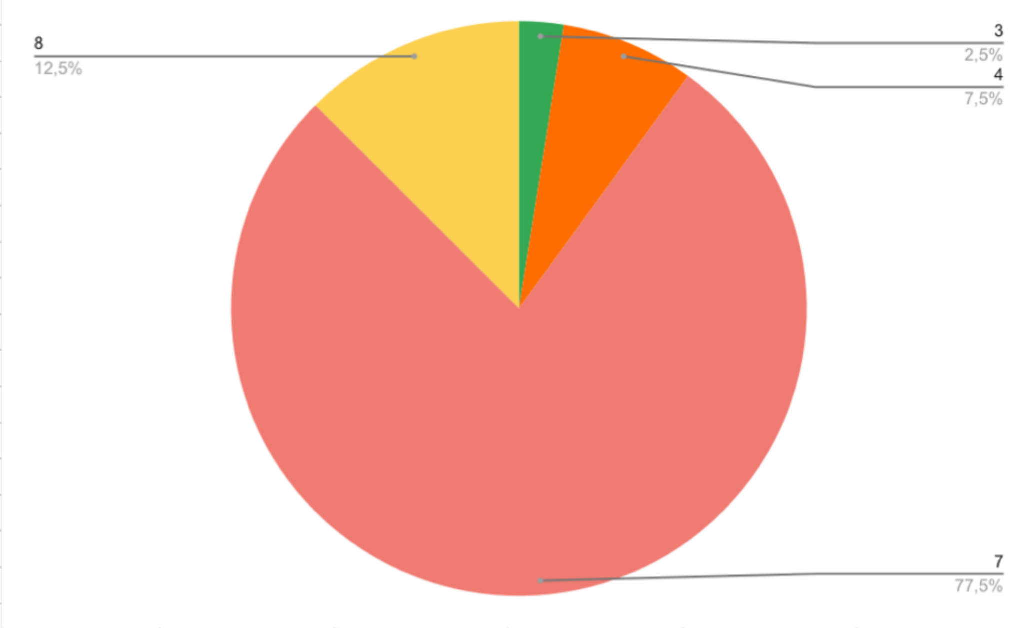
- The fourth question (Q4) was about the movement of rotation of a mandibular canine. 20 out of 40 participants gave a predictive value of 7 out of 10. (n=50%).



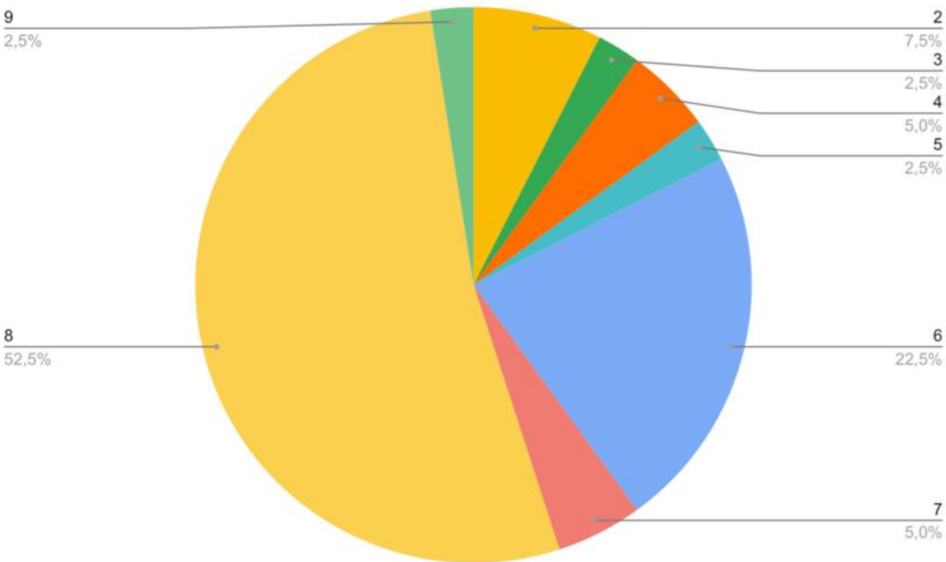
- Q5 was about the upper incisor torque. 21 out of 40 professionals gave a predictive value of 8 out of 10. (n=52.5). Only 4 of them gave a grade strictly lower than 5.



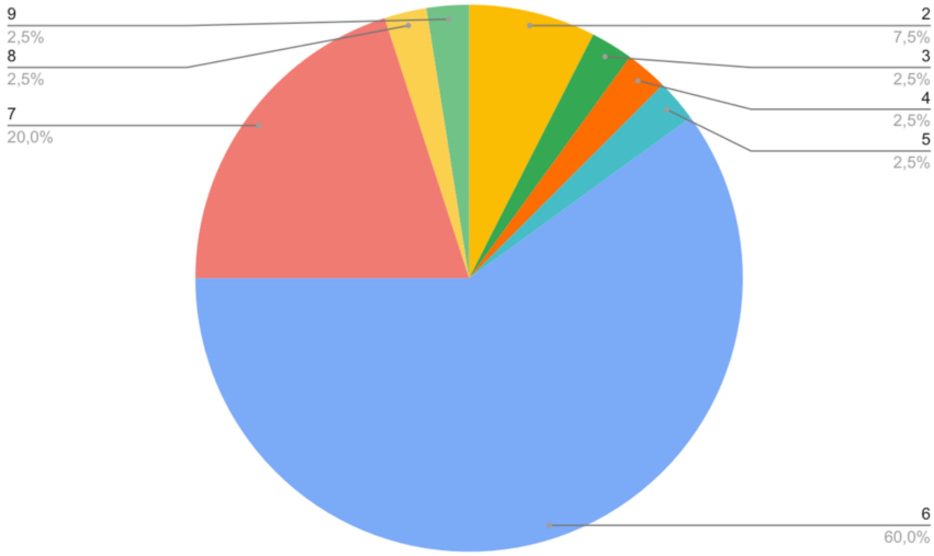
- Q6 was about lower incisor torque. 31 out of 40 participants gave a predictive value of 7 out of 10. (n=77.5%) 4 of them gave a grade strictly lower than 5.



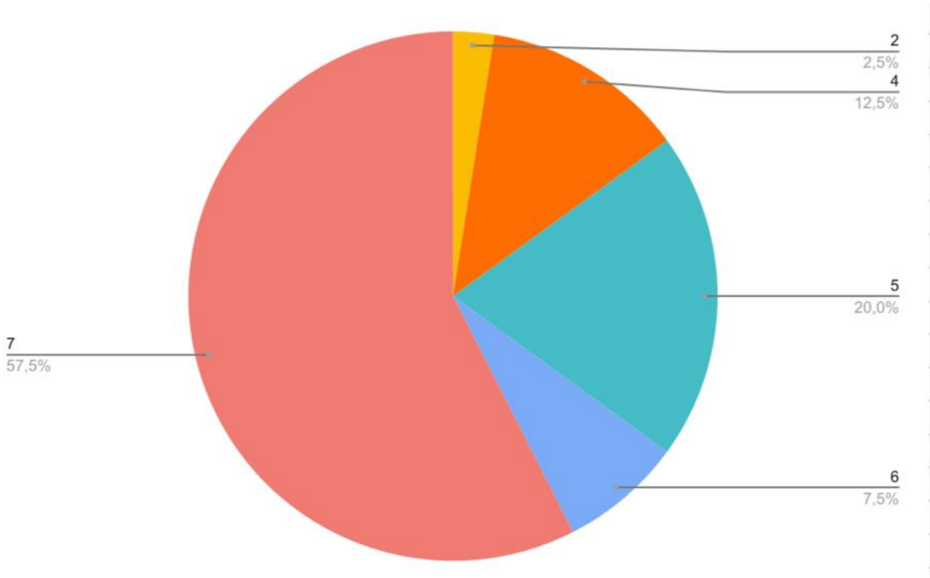
- Q7 was aimed to evaluate the predictability of the maxillary expansion's movement. 52.5% of the participants gave a grade of 8 out of 10 for this question. However, the second most given grade was 6. (n=22.5%)



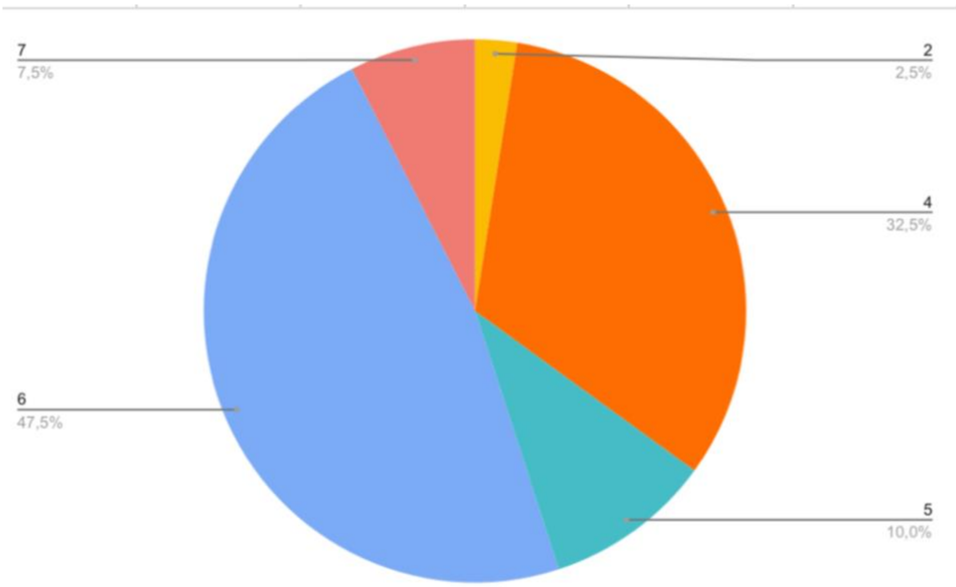
- Q8 was aimed to evaluate the predictability grade of a mandibular expansion movement. Most of the participant gave a grade of 6 out of 10. (n= 60%). The second most given grade was 7 out of 10. (n=20%), however 15% gave a grade equal or lesser than 5 out of 10.



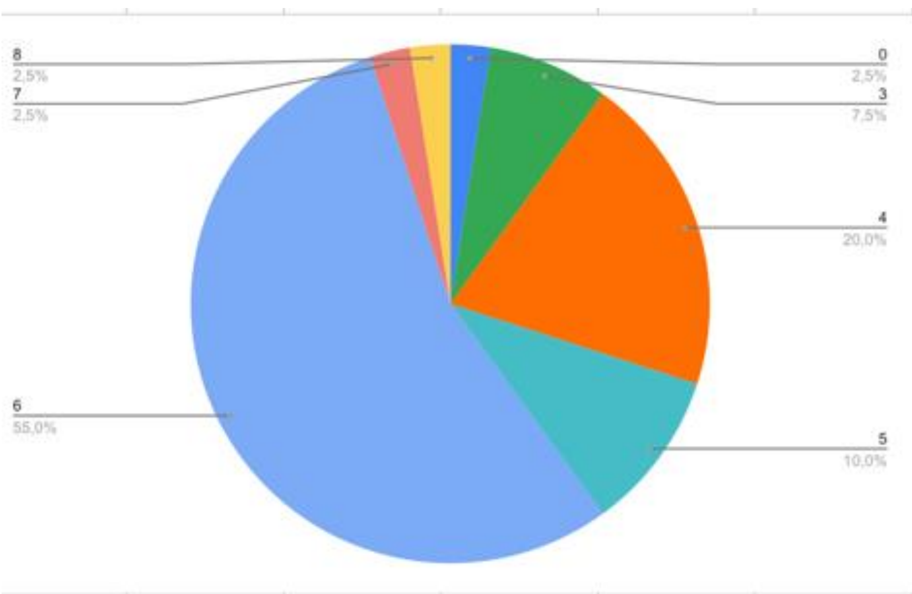
- Q9's purpose was to evaluate the perceived grade given to an upper posterior intrusion's movement. 57.5% of the 40 participants gave a grade of 7 out of 10. However, the second most given grade was 5. (20%)



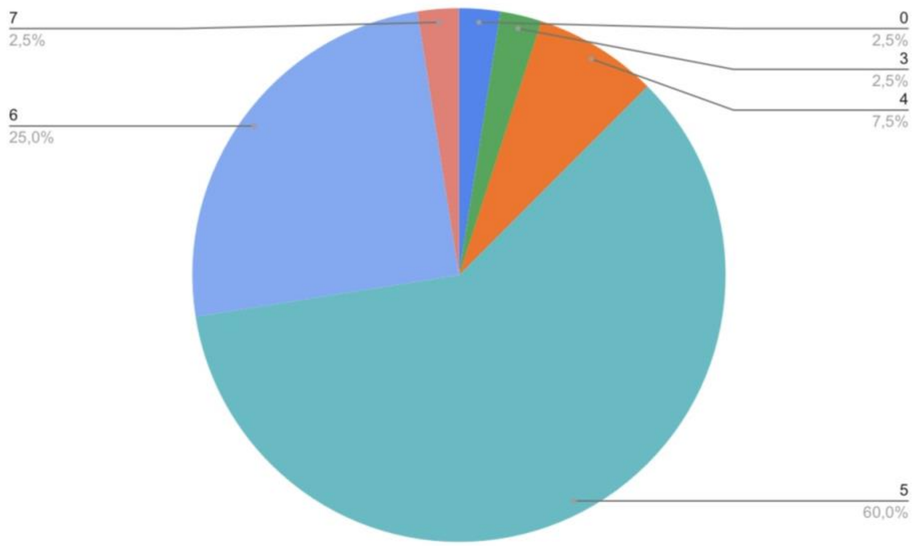
- Q10 was intended to question about lower posterior extrusion perceptibility. 47.5% of the participants gave a grade of 6 out of 10. It is important to note that 32.5% of the sample gave a grade of 4 out of 10.



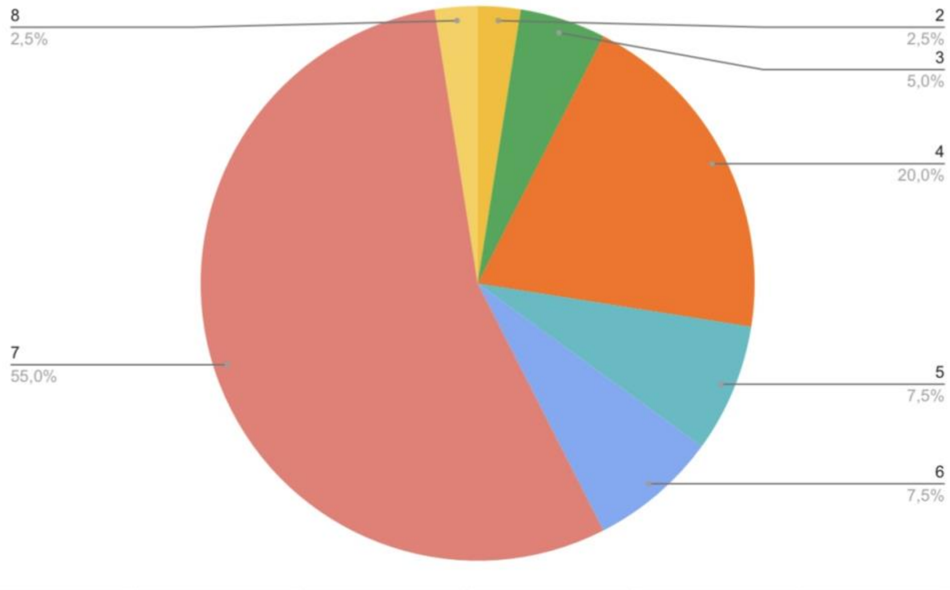
- Q11 was questioning about upper posterior extrusion predictability. 55.0% of the sample gave a grade of 6 out of 10. However, 30% of them gave a grade lower than 4 out of 10.



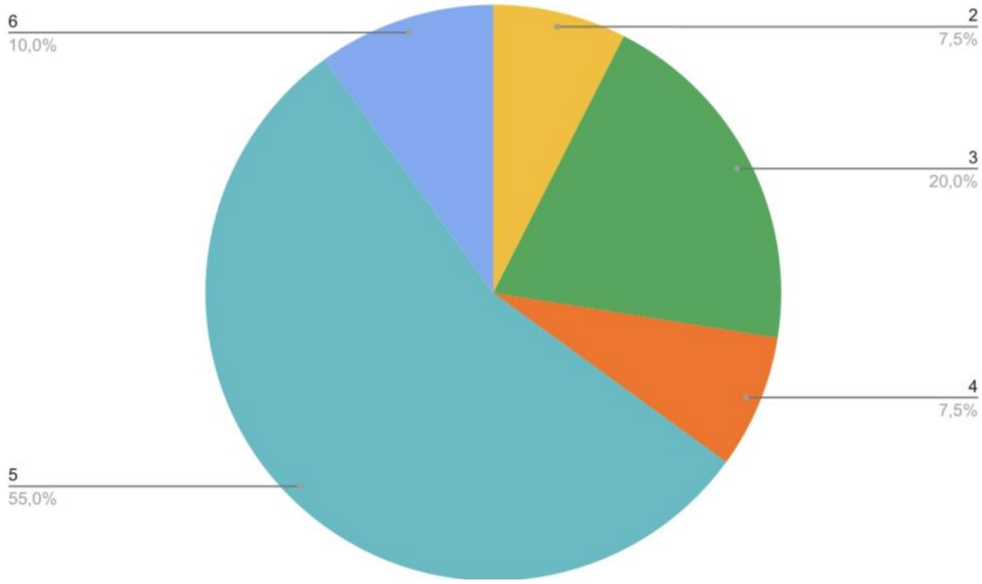
- Q12 was questioning about lower posterior extrusion predictability. 60% of the sample gave a grade of 5 out of 10 whereas the second most given answer was 6 out of 10. (n=25.0%)



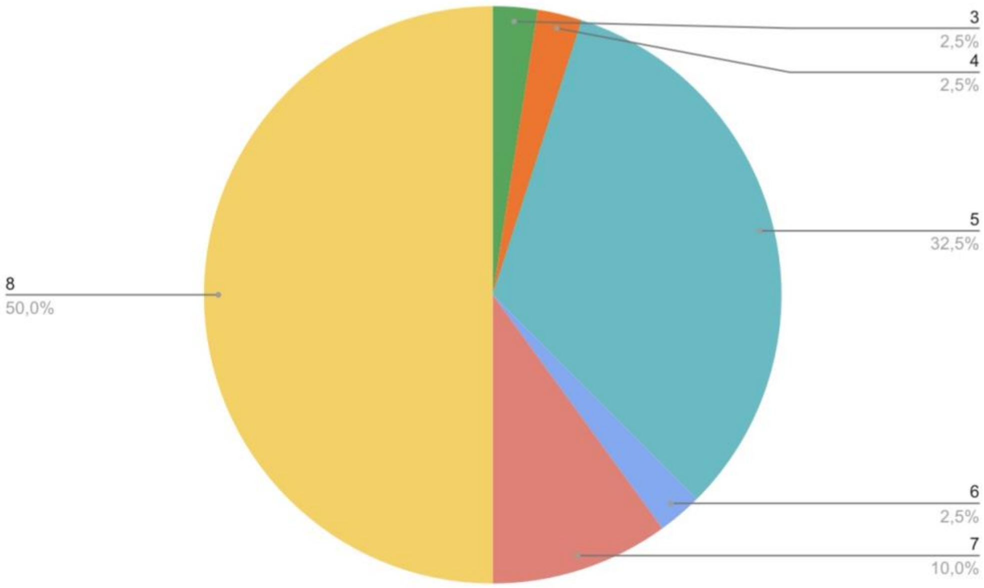
- Q13 was questioning about upper anterior intrusion predictability. 55.0% of the sample gave a predictive value of 7 out of 10. However, 35% of them gave a predictive value lower than 5 out of 10.



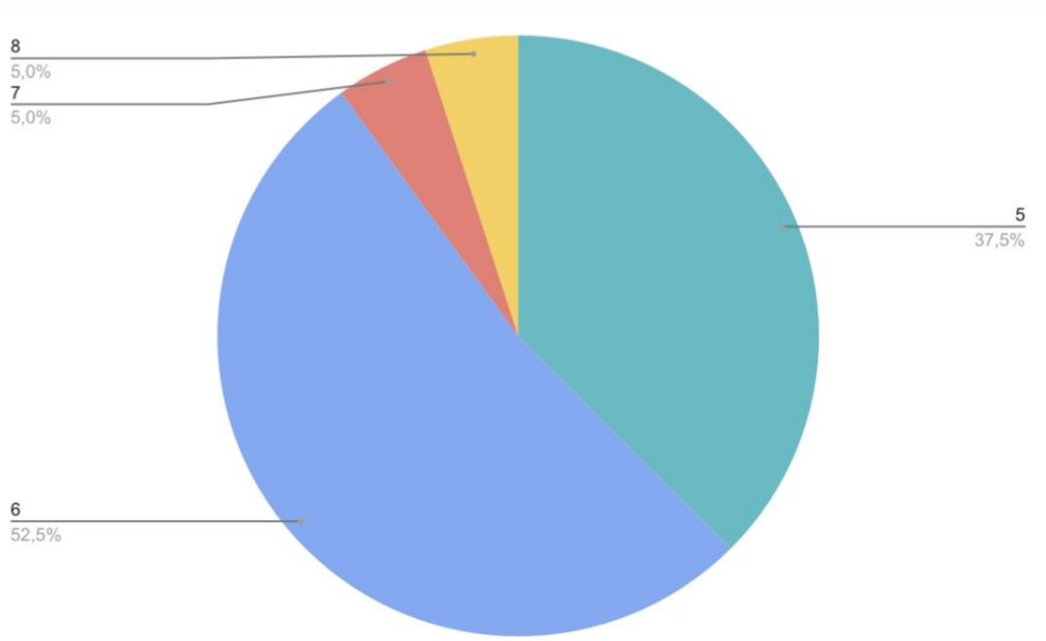
- Q14 was aimed to evaluate the lower anterior intrusion predictability. 55.0% of the sample gave a predictive value of 5 out of 10. However, 20% graded it a 3 out of 10.



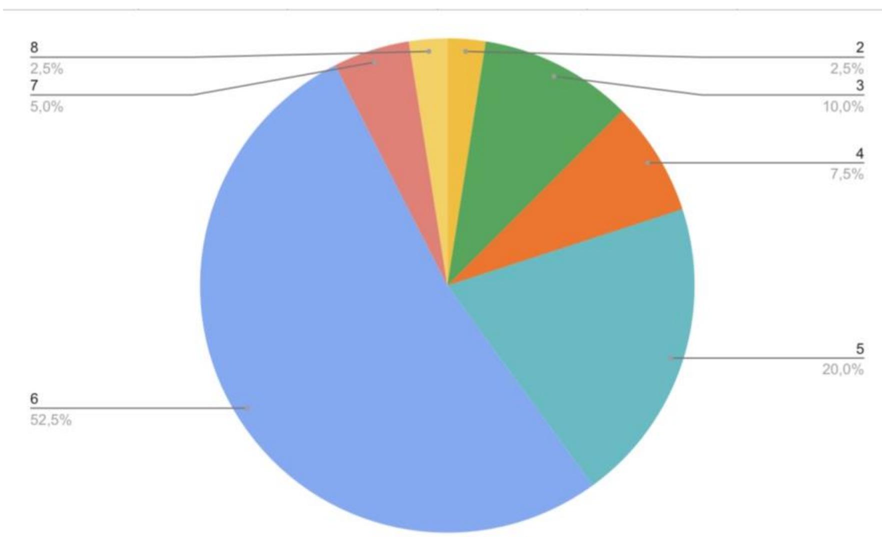
- Q15 was evaluating the upper anterior extrusion's predictability. 50% of the sample gave a grade of 5 out of 10. 37.5% of them gave a grade equal or lower than 5 out of 10.



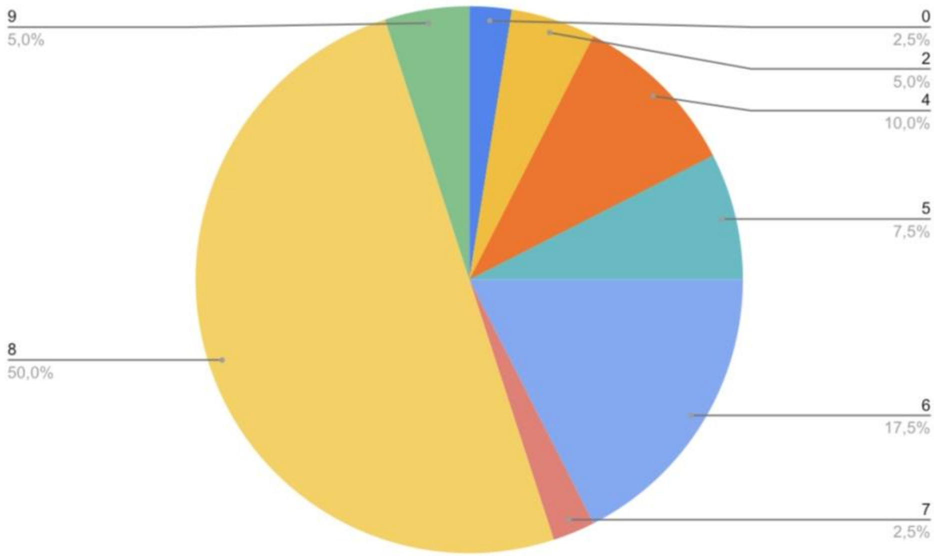
- Q16 was questioning about lower anterior extrusion movement's predictability. 52.5% gave a grade of 6 out of 10 and 37.5% gave a grade of 5 out of 10.



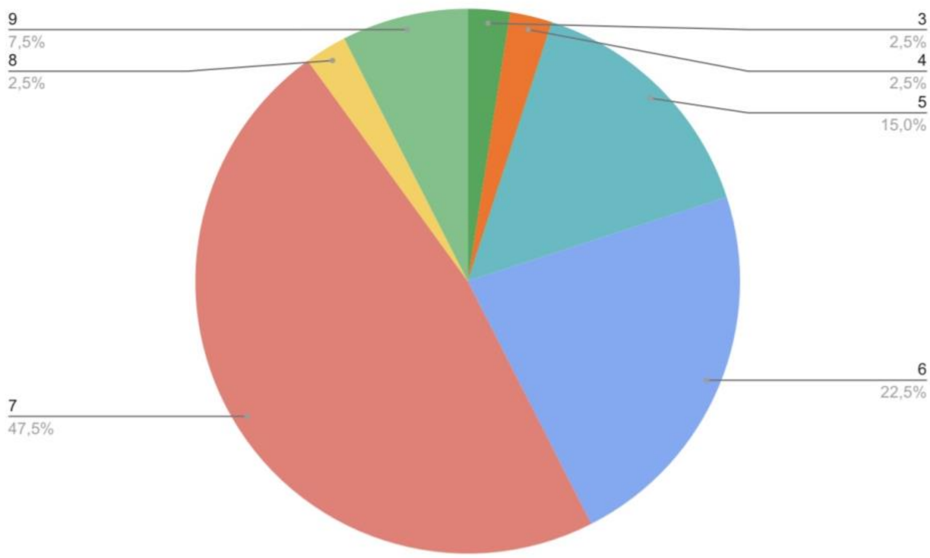
- Q17 was evaluating the sample's perception of upper posterior tip correction. 52.5% gave a grade of 6 out of 10.



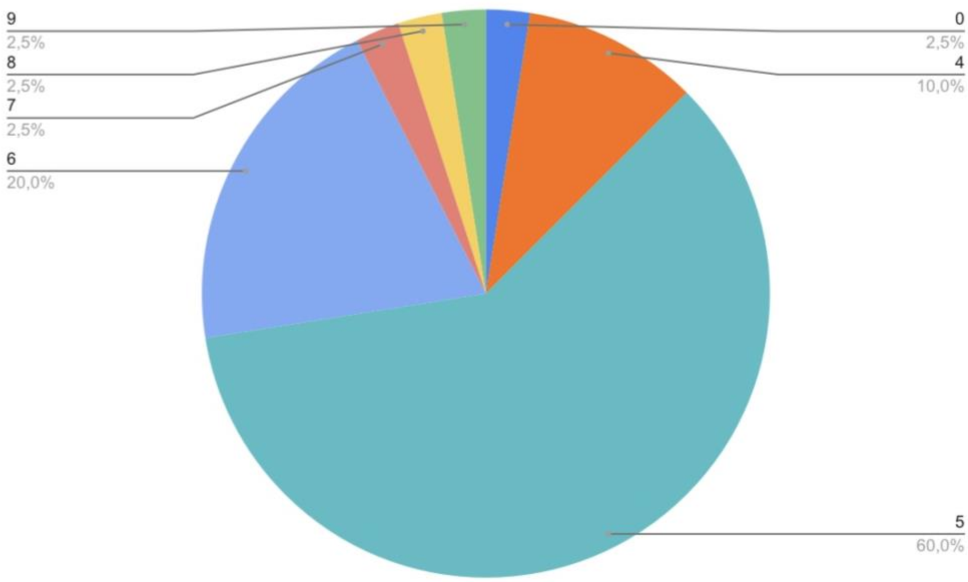
- Q18 was evaluating the predictability of upper anterior tip correction. 50% of the sample gave a grade of 8 out of 10. 82.5% of them gave grade equal or superior to 5 out of 10.



- Q19 was evaluating the lower posterior tip correction movement's predictability. 47.5% of the sample gave a grade of 7 out of 10. The second most given answer was 6 out of 10.



- Q20 was evaluating the Lower anterior tip correction movement’s predictability. 60% of the sample gave a grade of 5 out of 10. However, 87.5% of them gave a grade higher than 5 out of 10.



All the previous results were organised in **table 2**, regrouping all the values obtained. In this table, the grade receiving the most votes was highlighted in red allowing us to organise the movements in a ranking table resumed in **table 3**.

Table 2: Summary table of all the values obtained in the questionnaire.

	0	1	2	3	4	5	6	7	8	9	10	TOTAL
Q1				1				1	8	**28**	2	40
Q2		1					6	**22**	9	2		40
Q3		1	1	4		3	**21**	9	1			40
Q4			1	2	3		13	**20**	1			40
Q5				4				10	**21**	5		40
Q6				1	3			**31**	5			40
Q7			3	1	2	1	9	2	**21**	1		40
Q8			3	1	1	1	**24**	8	1	1		40
Q9			1		5	8	3	**23**				40
Q10			1		13	4	**19**	3				40
Q11	1			3	8	4	**22**	1	1			40
Q12	1			1	3	**24**	10	1				40
Q13			1	2	8	3	3	**22**	1			40
Q14			3	8	3	**22**	4					40
Q15				1	1	13	1	4	**20**			40
Q16						15	**21**	2	2			40
Q17			1		4	3	8	**21**	2	1		40
Q18	1		2		4	3	7	1	**20**	2		40
Q19				1	1	6	9	**19**	1	3		40
Q20	1				4	**24**	8	1	1	1		40

Table 3: Summary table ranking all the movements evaluated by their grade and percentage obtained.

RANK	MOVEMENT	PREDICTABILITY
1	U.I Rotation	**9 (68.29%)**
2	U.I Torque	**8 (52.5%)**
3	Maxillary Expansion	**8 (52.5%)**
4	Upper anterior tip correction	**8 (50%)**
5	Upper Anterior extrusion	**8 (50%)**
6	Lower incisor torque	**7 (77.5%)**
7	Upper posterior intrusion	**7 (57.5%)**
8	Lower incisor rotation	**7 (55%)**
9	Upper anterior intrusion	**7 (55%)**
10	Upper posterior tip	**7 (52.5%)**
11	Lower canine rotation	**7 (50%)**
12	Lower posterior tip	**7 (47,5%)**
13	Mandibular expansion	**6 (60%)**
14	Upper posterior extrusion	**6 (55%)**
15	Upper canine rotation	**6 (52.5%)**
16	Lower anterior extrusion	**6 (52.5%)**
17	Lower posterior intrusion	**6 (47.5%)**
18	Lower posterior extrusion	**5 (60%)**
19	Lower anterior tip correction	**5 (60%)**
20	Lower anterior intrusion	**5 (52.5%)**

5 DISCUSSION

The principal objective of this study was to evaluate the perception of tooth movement predictability with clear aligners of Spanish and french practician. One of the secondary aim was to compare these results with those found in the literature. Most studies were gauging the tooth movement predictability of clear aligners by comparing the discrepancies between virtually planned movement to the achieved one.

5.1 Predictability of rotational and torque movements.

Our study aimed to evaluate the practician's perceptibility in a purely subjective way. According to their insight, they perceived the **rotation of an upper incisor** as the most predictable movement to achieve by using clear aligners. Indeed, 68.29% of the practician gave a grade of 9 out of 10. Not too close behind, most of the participants ranked the **torque of the upper incisors** as the second most predictable movement to perform, suggesting that torque and rotation of incisors might produce more predictable results. This was shown to be agreed by recent studies on that matter. Indeed, the retrospective study conducted by ***Charalampakis et Al*** on n=398 teeth showed that horizontal movements of all incisors were among those who presented the less discrepancy between predicted and final results. The differences between those two values were merely significant, between 0.20 to 0.25mm. (36)

However, ***Tepedino et Al*** (37) concluded their retrospective study on 39 anterior teeth by saying that torque movement were better achieved in the lower arch, clashing with our sample's perception. Indeed, while **torque** movements of upper incisors were highly ranked by the practician, those exerted on **lower incisors** were graded a 7 out of 10 by 55% of the sample. Better results in the lower anterior sector could be explained by tooth morphology, as well as the root's length and size. This has been supported by the study conducted by ***Lombardo et Al*** (38) which was evaluating the predictability of aligners for tipping and rotation movements. In this study, discrepancies between planned and achieved results were significantly higher in the upper arch than in the lower one, nearing a perfect match in the latter. This was also supported by the study of ***Charalampakis et Al*** (38)which found a mean of 91.5% of predictability of horizontal movements in the inferior anterior sector and 77.5% in the upper anterior sector.

Nuancing our previous statements, the study performed by ***Jiang et Al*** found that torque movement was the least predictable movement among pure tipping, controlled, tipping, translation and torque movement, with a predictability percentage of 35.21% performed on n=231 incisors.(39) ***Grunheid et*** Al came to the same conclusion with their retrospective cohort study performed on 30 patient. (40)Although torque movement with clear aligners was not exhaustively described in literatures, consensus states that couple of force is mandatory to produce this type of movement. However, ***Hahn et al*** demonstrated that an effective force couple was inhibited by an unfit aligner at the level of the gingival margins, thus leading to torque movement being harder to perform by clear aligners. In this case, an initial tipping movement is produced in the tooth rather than the rotation of the roots necessary for torque movement. (41)

Rotational and torque movement were ranked as the two most predictable movement to achieve by using clear aligners when exerted on incisors. However, when applied to canines they seem to be less foreseeable by our sample. **Lower canine rotation** was graded a 7 out of 10, ranking this movement at the 11th place. **Upper canine rotation** was ranked at the 15th place with 52.5% grading it a 6 out of 10. The retrospective study of ***Kravitz et Al*** (42) supported this opinion. Indeed, when compared to the rotation of maxillary incisors, rotation of maxillary canines was found to be 32% less predictable. The same study showed that the least predictable rotational movement was found in mandibular canines. (29%). Similarly, ***Nguyen and Chen*** observed a difference of 21% between both movement.(43) Moreover, ***Proffit et Al*** stated that that both rotation and tipping movements required similar forces to be exerted, resulting in unwanted tipping movement instead of pure rotational ones hence decreasing its predictability. (44)

Those studies concluded by stating that rotational movement was indeed harder with rounded crown, including both canines and premolars. Moreover, studies showed that interproximal contacts could be a potential predictor of the predictability of canine's rotation.(45)

5.1.1 Improving the predictability of torque and rotational movements:

It is important to note that studies that found a high predictability for torque movements have specified that professionals were mostly using auxiliaries elements to increase drastically their performances.

Indeed, power ridge have been proven to help tremendously with increasing the predictability of torque movement. To create the necessary couple of force needed to produce a torque movement, power-ridge can be placed on the tooth. Supposedly, they will produce a lingual/palatal force on the cervical third of the crown. Another tool introduced to help increasing predictability of clear aligners would be the use of Hilliard Thermoplier to create a ridge on the aligner. This will also produce the necessary couple of force. (28)

Similarly, the predictability of rotational movement can be improved with auxiliaries elements. Even if most studies found that the rotation of anterior teeth was hard to produce, especially on canines, tools were created to help perfecting the achieved movement. Among them, bonding buttons placed on the buccal and palatal surfaces of the tooth can be placed to produce a couple of forces. Elastic chains can also be an effective tool. Moreover, optimised attachments were developed to cater the needs of rotational movements in rounded tooth. (Cuspids and Bicuspids). In addition, the use of IPR was showed to be clinically relevant in helping to achieve optimal rotational movements. (28) ***Kravitz et Al*** found in their studies that the use of IPR increased the predictability of the rotational movement in canines with clear aligners by 12.8%. (From 30.3% with no intervention to 43.1% with the use of IPR.)(46)

5.2 Predictability of tipping movements.

The study performed by ***Jiang et Al*** concluded by ranking tipping movements as the most predictable with a mean of 72.5% of predictability in anterior sectors.(39,47) This ranking was also supported by ***Kravitz et Al*** and ***Nguyen and Cheng***. (42)

This was also perceived by our sample, ranking the **upper anterior tipping** movement at the 4th position with a grade of 8 out of 10 (50%).

Study from supported this hypothesis by ranking the accuracy movement of tipping of maxillary incisors as the highest among other movements(n=75.94%), such as intrusion, extrusion and rotation.

Unexpectedly, **lower anterior tipping** was viewed as relatively poorly predictable by our sample when compared to other movements, ranking it at the 19th place with 60% of the sample giving it a grade of 5 out of 10. This perception clashes with most of the studies, ranking this movement as one of the most predictable. Notably, the study performed by ***Sachdev et Al*** ranked it at the second place, not too far behind upper anterior tipping movement. (73.21% of accuracy.). (47)

Likewise, ***Bilello et Al*** found in their study that the highest percentage of tooth movement predictability was indeed found in the lower anterior sector, with a mean percentage of 94.3%.(48) Not too far behind, the **upper posterior tipping movement** was given a mean predictability value of 93.2% by the same study.

Most of our sample of professional gave a grade of 7 out of 10 for this movement (52.5%). This could be considered as a relatively positive perception of this movement's predictability. % of our sample gave a grade of 7 out of 10 for the predictability of lower posterior tipping movement, meaning that most of them seem to feel like tipping in the posterior sector is relatively predictable, independently of the arch.

5.3 Predictability of intrusion movements

When it comes to vertical movements, such as intrusion and extrusion, professionals globally seem to think that they are some of the hardest movements to achieve. **Lower anterior intrusion** was found to be the hardest movement to achieve with clear aligner alone, ranking it last in the list with 52.5 % of the sample grading it a 5 out of 10.

This perceptibility is supported by most studies, among them the prospective clinical study of ***Haouili et Al*** performed on n=38 patients. In this study, the discrepancy between the predicted and the final value of different tooth movements was the highest for the movement of intrusion on the mandibular incisors. (35% of predictability, whereas the predictability of buccal-lingual crown tip was 56%). (49)

This low predictability was not constricted to the lower anterior region. In fact, almost all intrusion movements were ranked relatively low when compared with other tooth movements. ***Kravitz et Al*** and ***Krieger et Al*** reported a great lack of predictability for vertical incisor movement in their study with a mean of 45% of achieved movements.(42,50)

Those studies confirmed our sample's perceptibility; achieving these movements are challenging, especially only with clear aligners by themselves. Indeed, **upper posterior intrusion, upper anterior intrusion** and **lower anterior intrusion** were given a mean of 6.6 out of 10 by our sample.

Alami et Al explained in their literature review that intrusion is a particularly difficult movement to perform because to intrude a tooth, the study of its vestibule lingual or palatal inclination is primordial. (28)In this way, to perform an intrusion movement one must correct its torque beforehand. Indeed, total control of torque during intrusion movement is utterly important to prevent root resorption if the apex of the root gets in contact with cortical bone, either buccally or lingually.

Moreover, ***Yang Li et Al*** noted that the intrusion movement was, more than in other cases, influenced by the movement of surrounding tooth. (51)

While exerting vertical movements, some consideration must be considered. Regarding the **intrusion** movements literature insists on the fact that the anchorage teeth must be stabilised to avoid opposite movements on them. This protection is better achieved by aligners as all teeth are covered.

5.4 Predictability of extrusion movements.

The other vertical movement studied was the extrusion one. Apart from the ***upper anterior extrusion*** (Given an 8 out of 10 by 50% of the sample), the extrusion movement performed in the **upper posterior, lower anterior and lower posterior** region was found to be difficult to obtain. Our sample gave a mean predictability of 5.6% for these movements.

This was notably reported by ***Kravitz et Al***, ranking the extrusion movement as being the overall least accurate one (29.6%). (42)Clashing with our results, this study found the maxillary anterior extrusion (18%) and the mandibular anterior extrusion (24.5%) to be the least predictable. The observational study of ***Tuncay et Al*** characterised the pure extrusion movement, meaning along the tooth's long axis, as utterly difficult to produce. This study described a wobbling (non-linear) effect instead of the aimed pure extrusion also movement. (52)

Luckily, recent studies presented different tools to improve the predictability of even the hardest movements with clear aligners. Regarding extrusion movement, power grip at the adjacent teeth and intra or inter maxillary elastic might help tremendously.

In recent studies, the use of anterior mini-screws and elastics has been proven to help achieving better results with vertical movements. (53)

5.5 <u>Predictability of arch expansion movements.</u>

Our sample ranked the **maxillary expansion movement** at the third position, with 52.2% of them giving it a grade of 8 out of 10. A study evaluating the efficacy of maxillary arch expansion with clear aligners performed by ***Gallucio et Al*** Obtained a predictability value of 70.88%. However, they concluded their study by stating that maxillary expansion was more accurate with the first premolar than in the first molar. Moreover, most studies agree upon saying that arch expansions are better achieved in anterior regions than in posterior one. This was also confirmed by the studies conducted by ***Lione et Al*** in 2021 and ***Zhao et AL*** in 2017.(54–56)

Our sample proved to be a little bit more reluctant with the performance of clear aligners regarding **mandibular expansion movement,** giving it a grade of 6 out of 10. (60%). ***Kravitz et Al*** conducted a study comparing aimed and final tooth movement achieved by clear aligners. In their studies, they attributed a predictability value of 40% for expansion movement, with a higher probability for mandibular arch expansion. Moreover, ***Charalampakis et Al*** found a concordance between predicted and obtained expansion movement, with a higher predictability in the lower arch. (95-97%). This could be explained by the fact that the lower arch requires less tooth movement than the upper one. (36,42)

When it comes to transversal studies, malocclusions can be corrected by aligners through a dento-alveolar point of view. Skeletal origins are hardly rectified by such appliances. Clear aligners have been proven to expand mostly by torque movement in posterior teeth. (57)

It is interesting to note that the vast majority of our sample did not attribute a grade lower than 5 for each movement. In fact, more than half of all movements were attributed a grade equal or higher than a 7 out of 10. This could lead us to say that clear aligners are globally perceived as predictable by our Spanish and french sample.

6 CONCLUSION

Spanish and French practicians have an overall positive view on CAT's predictability, attributing generally half of the movement studied a grade equal or superior to 7 out of 10. They found the rotation of the upper incisors as the most predictable movement and the intrusion of the lower anterior sector as the least predictable. Rotation movements in canines and premolars were found more difficult because of their rounded shapes.

Overall, horizontal movement were found more predictable than the vertical ones. Movement in the anterior sector were also ranked as more predictable than in the posterior one. Our null hypothesis is accepted. Vertical movements were found more difficult to achieve because there are more complex and often produce unwanted movements.

Our results mostly got along those found in literature. Some discrepancies can be attributed to our study's limitation, among them; the number of patients treated by each practician and the small sample studied.

Several tools have been introduced to help increasing the predictability of clear aligners according to the problems encountered while performing the movements. Power ridges has been proven to create a force couple necessary to achieve torque movement. Inter and intra maxillary elastics as well as mini-screws could help tremendously with demanding vertical movements. Bonding buttons, elastics and IPR are tools that can help managing the challenging rotation of canines and premolars.

7 Annexes

7.1 Abbreviations

CAT = Clear Aligner Therapy

IPR = Interproximal reduction

UI = Upper incisors

LI= Lower Incisors

UA = Upper anterior

LA = Lower anterior

LP= lower posterior

UP= Upper posterior

7.2 Questionnaire

Tooth movement predictability with clear aligners

This questionnaire aims to add qualitative information to complete a medical thesis.
This questionnaire intend to evaluate dentist's perception on tooth movement predictability with clear aligners in orthodontics.

Do you give your consent to participate to this study and for my answers to be used for this intend.

- ◯ Yes
- ◯ No

Are you a dentist, an orthodontist or do you practice another speciality?

- ☐ Dentist
- ☐ Orthodontist
- ☐ Autre : ____________

Have you ever used clear aligners in your patients?

- ☐ Yes
- ☐ No

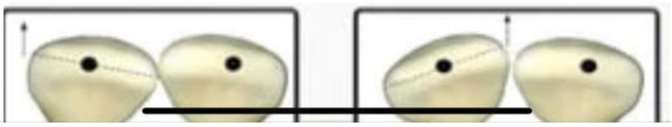
If you have answered yes, what were the brands of said aligners?

How many patient have you treated with clear aligners?

- ☐ 1-50
- ☐ 50-100
- ☐ 100-150
- ☐ 150-200
- ☐ More than 200

The following questions are about the predictability of clear aligners in adult patients. We kindly ask you to give a predictive value to each movement, going from 0 to 10. (0 being the lowest and 10 being the highest predicting value).
The predictive value is subjective and proper to each practician, but it mostly depends on how achievable you think a movement could be by using clear aligners.

ROTATION MOVEMENT



Upper incisor rotation:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Lower incisor rotation:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Upper canine rotation:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Lower canine rotation:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Upper posterior intrusion:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Lower posterior intrusion:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Upper posterior extrusion:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Lower posterior extrusion:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Upper incisor torque:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Lower incisor torque:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Maxillary expansion:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Mandibular expansion:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Upper anterior intrusion:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Lower anterior intrusion:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Upper anterior extrusion:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Lower anterior extrusion:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Upper posterior tip correction:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Upper anterior tip correction:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Lower posterior tip correction:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

Lower anterior tip correction:

	0	1	2	3	4	5	6	7	8	9	10	
Low predictability	○	○	○	○	○	○	○	○	○	○	○	High predictability

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