



**EVALUATION OF KNOWLEDGE, AWARENESS AND  
ATTITUDE ABOUT CLEAR ALIGNER THERAPY  
AMONGST ORTHODONTIC POST-GRADUATE  
STUDENTS: A CROSS-SECTIONAL  
QUESTIONNAIRE BASED SURVEY**

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**Abstract**

**Introduction:** Clear aligners have emerged in the field of Orthodontics in an attempt to change the face of Orthodontics. With the increased awareness of aligner treatment options, it is important that the present day Orthodontist is well aware of the biomechanics and limitations of the same. The growth of aligners in the field of Orthodontics has made it vital that Orthodontists are well versed with the workflow of aligners and are able to successfully treat at least mild to moderate malocclusions.

**Aim and Objective:** The aim of this study was to evaluate the knowledge, awareness and attitude about clear aligner therapy amongst post-graduate orthodontic students.

**Materials and Method:** A google form questionnaire of 18 questions were designed and distributed amongst 120 Orthodontic post-graduate students via WhatsApp messenger and email. The responses were recorded, organised and evaluated.

**Results:** Students were aware of the type of tooth movement exerted with clear aligners, materials used, workflow, anchorage system, types of attachments used in clear aligner therapy. However, they were unaware of the tooth movement caused by power ridges, placement of precision bite ramps and order of staging in terms of distalization. Majority of the students agreed that clear aligners have a definite aesthetic advantage over other modalities of treatment.

**Conclusion:** There is adequate knowledge and awareness about clear aligner therapy amongst Orthodontic post-graduate students.

**Keywords:** Attitude, Awareness, Clear aligners, Knowledge, Orthodontics, Post-graduate students.

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## 1. Introduction

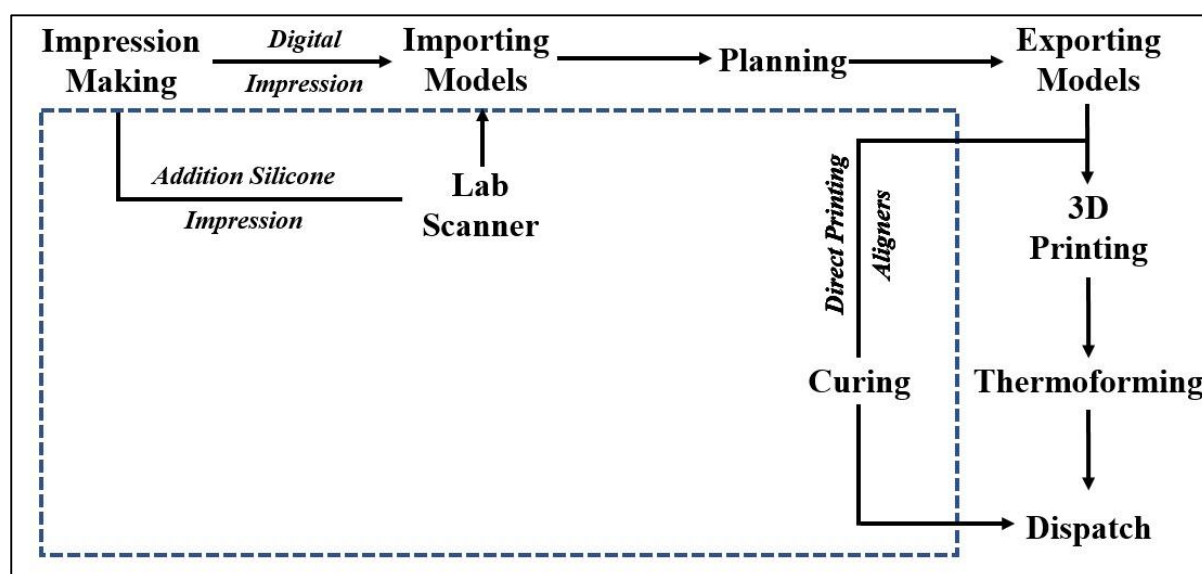
Advancement in technology invariably causes the advancement of dentistry. One would think that the birth of clear aligners is nothing but an advancement in dentistry, especially Orthodontics. However, the precursor of the clear aligner treatment was the well-known Tooth Positioning appliance which was introduced by Dr. Harold Kesling in 1945 which was used for final positioning and detailing post fixed appliance therapy.<sup>9</sup>

The refurbishment of this appliance was done by Align Technology with the help of the Computer Aided Design and Computer Aided Manufacturing (CAD-CAM) and was introduced into the market as Invisalign in 1997. This caused a ripple effect in the field of Orthodontics. Extensive research and

development has been done to improve the aligner in terms of biomechanics and material properties.<sup>17</sup>

The increased demand for the clear aligners are simply due to the fact that it offers better aesthetics, increased comfort, convenience and does not involve any food restrictions all of which could be said as the shortcomings of fixed appliance. In terms of operator convenience, aligner therapy involves less chairside time and reduced visits which allows the operator to treat more patients.

The fabrication of the clear aligner is a multi-step process. The chart below explains the steps involved in the fabrication of clear aligners.<sup>5</sup>



**Fig 1:** Workflow of clear aligner therapy

Based on the workflow, each aligner is customised to the patient and tooth movements are progressively done at about 0.2- 0.5 mm per aligner.<sup>4</sup> During the initial days of clear aligners they were cautiously used only for simple cases such as spacing or mild crowding which could be treated by IPR. However, with the improvement of technology and increased accuracy they are used today in various cases including but not limited to extraction, along with mandibular advancement (through precision wing attachments) and even mild Class III cases.<sup>29</sup>

With clear aligners introduced in the field of Orthodontics, its vital that upcoming Orthodontists are familiar and understand the mechanics of this appliance and are well aware with the advancements with this particular treatment modality.

Thus, the aim of this study was to assesses the knowledge, awareness and attitude of clear aligner therapy amongst post graduate orthodontic students.

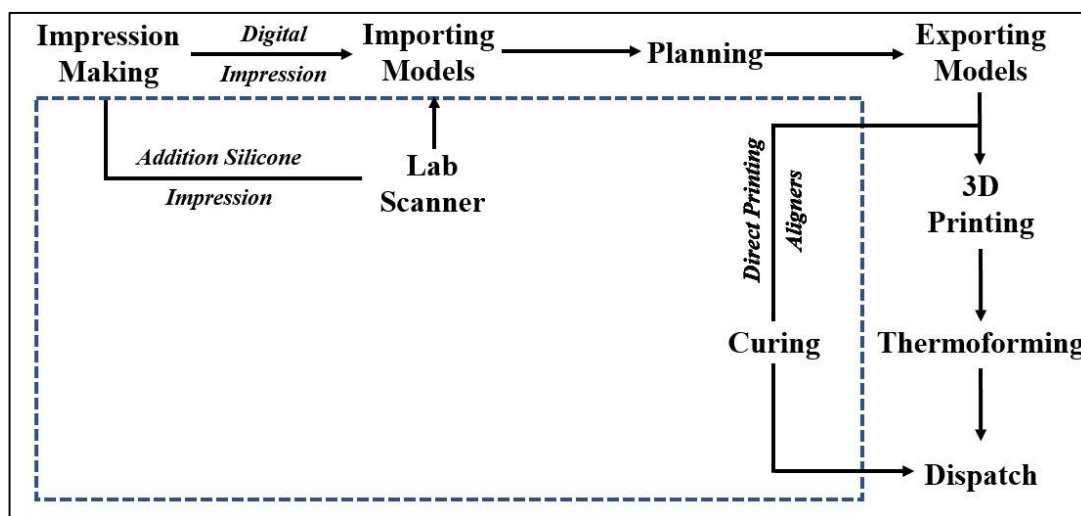
## 2. Materials and Methods

This was a cross-sectional descriptive study carried out in 2023. A multiple-choice questionnaire containing 16 questions was distributed via Google forms amongst Orthodontic post-graduate students. The respondents were reached using email and WhatsApp messenger. A total of 120 students responded. The questionnaire focused on the knowledge about clear aligner therapy and techniques involved. The data was then organized in the form of pie-charts and graphs and was tabulated to calculate the percentage score for each question.

1. What is the type of tooth movement exerted by clear aligners? • Push type • Pull type • Both Push and Pull type
2. Which material is used for the fabrication of clear aligners? • Polyurethane • Polyethylene terephthalate glycol (PET-G) • Polyvinyl chloride • All of the above
3. What is required for fabrication of clear aligners? • Intra-oral 3D scanners • 3D printers • Pressure moulding machines • All of the above
4. What is the anchorage system used in clear aligners? • Predetermined anchorage • Reciprocal anchorage • No anchorage system required • None of the above
5. Which attachment/ attachments is/are used for used for retention or anchorage? • Rectangular attachments • Vertical attachments • Ellipsoid attachments • All of the above
6. Easiest orthodontic movement with aligner? • Intrusion • Extrusion • Derotation • Torquing
7. What are aligner chewies? • They are given in children to help accustom to the aligner. • They are given to seat the aligner, engage the attachments, and extrude the teeth into position. • They are given to make children more compliant to wearing aligners
8. When is IPR performed in clear aligner therapy? • At the beginning of the treatment • As and when required during the treatment • At the end of the treatment
9. What is assessed during tooth tracking? • Fit of current aligner • Fit of previous aligner • Fit of attachments • Both A & C • Both B & C
10. Reducing the angle formed by the active surface of the attachment and the buccal surface of the tooth results in? • An increased resultant force • A decrease resultant force • Has no effect
11. Power ridges are effective in proving • Rotational movement • Labial root torque • Lingual root torque • Extrusion
12. Precision bite ramps are placed on the following teeth • Maxillary central incisors • Maxillary central incisors, lateral incisors and canines • Maxillary central and lateral incisors only • Mandibular central incisors, lateral incisors and canines
13. Function of aligner attachments • Avoid aligner slippage • Provide aligner retention • Provide predetermined force vectors • All of the above
14. Order of staging in cases where distalization is required? • Distalization followed by arch expansion • Expand the arch followed by distalization • Both movements occur simultaneously
15. Method/ Methods to produce torque in clear aligners? • By using power ridges • By constraining crown position while moving the crown in a direction opposite to root movement • Move crown in opposite direction of intended direction of root • All of the above • Only A & C
16. What according to you are the advantages of clear aligners over conventional fixed mechanotherapy? • Esthetics • Reduced clinical chair side time • Ease of treatment for Orthodontist • Reduced appointments • Better control over tooth movement • More patient compliant

Fig. 1: Sample Questionnaire

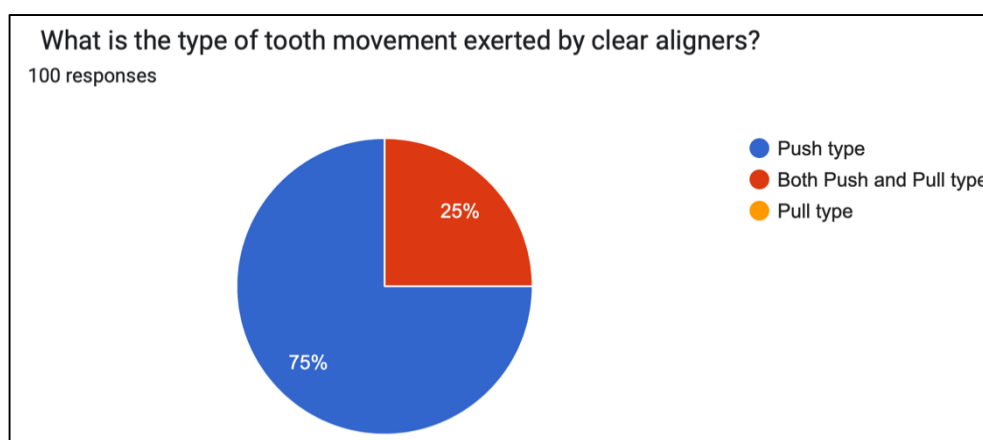
### 3. Result



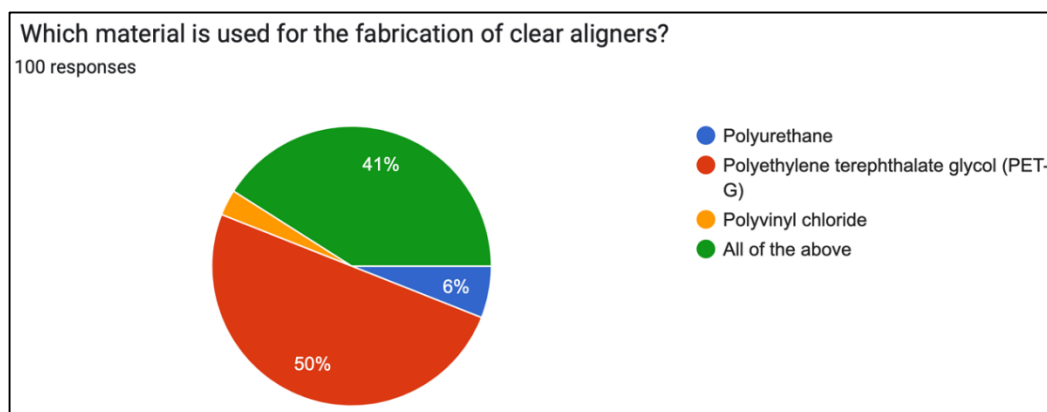
**Fig 2:** Workflow of clear aligner therapy

A total of 120 Orthodontic post-graduate students responded to the form. The questionnaire has been tabulated (**Fig.1**). The questions were based on the advanced knowledge an Orthodontic post-graduate

student is expected with the increased aligner usage. This included the biomechanics, type of material used as well as the specific attachments used.



**Fig. 3:** Type of tooth movement exerted



**Fig. 4:** Type of material used

Majority of participants were clear that the type of tooth movement exerted by aligners is the push type (75%) (Fig. 3). About 50% participants thought that clear aligners were

only made of PET-G whereas clear aligners are fabricated from polyurethane as well as polyvinyl chloride (Fig. 4).

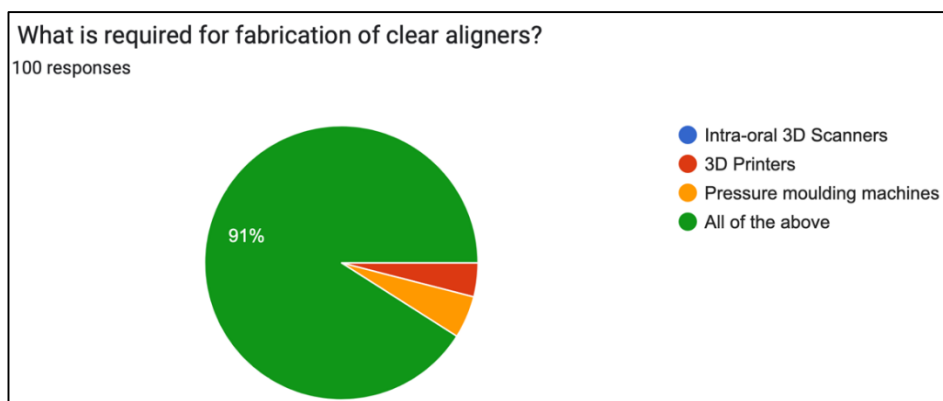


Fig. 5: Equipment for aligner fabrication

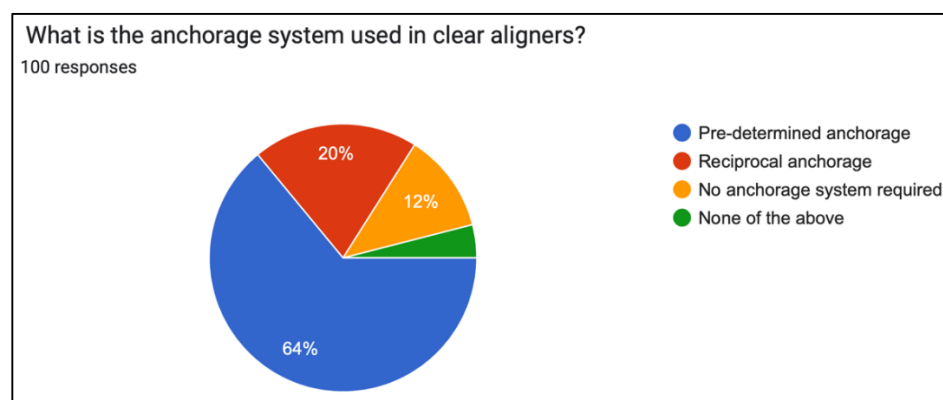


Fig. 6: Anchorage system

Upon questioning upon the requirements for fabrication of clear aligners, 91% of the participants answered correctly (Fig. 5). We then moved the questioning to the biomechanics of aligners. The anchorage system of aligners was questioned about with about 64% answering correctly that pre-determined anchorage is used (Fig. 6).

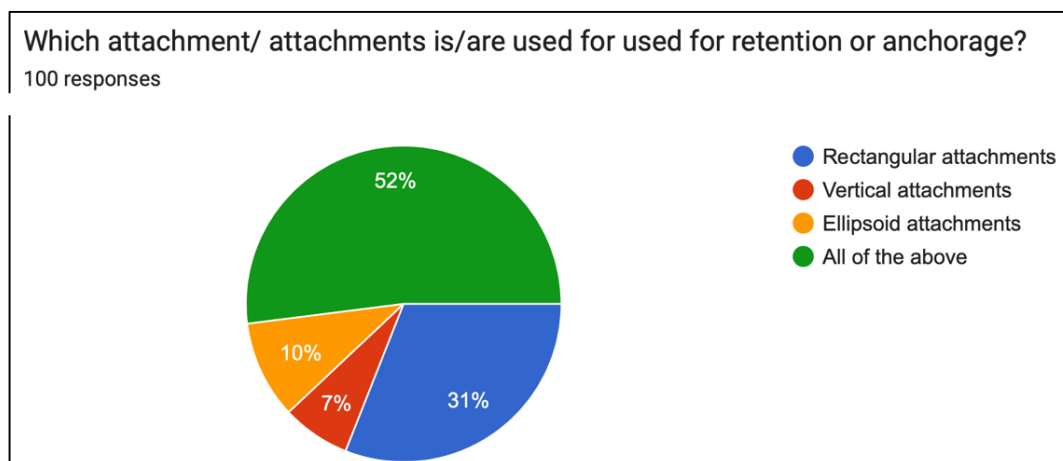
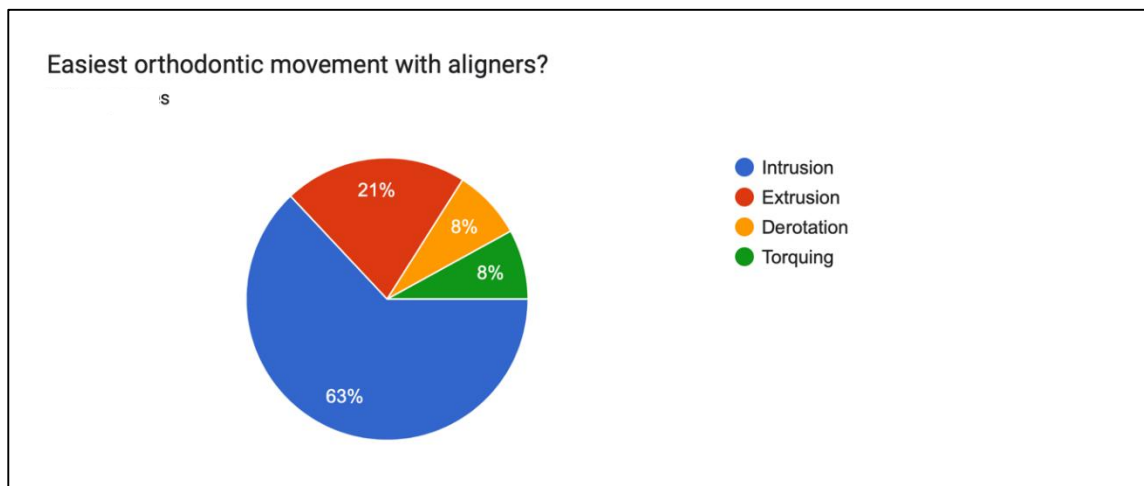


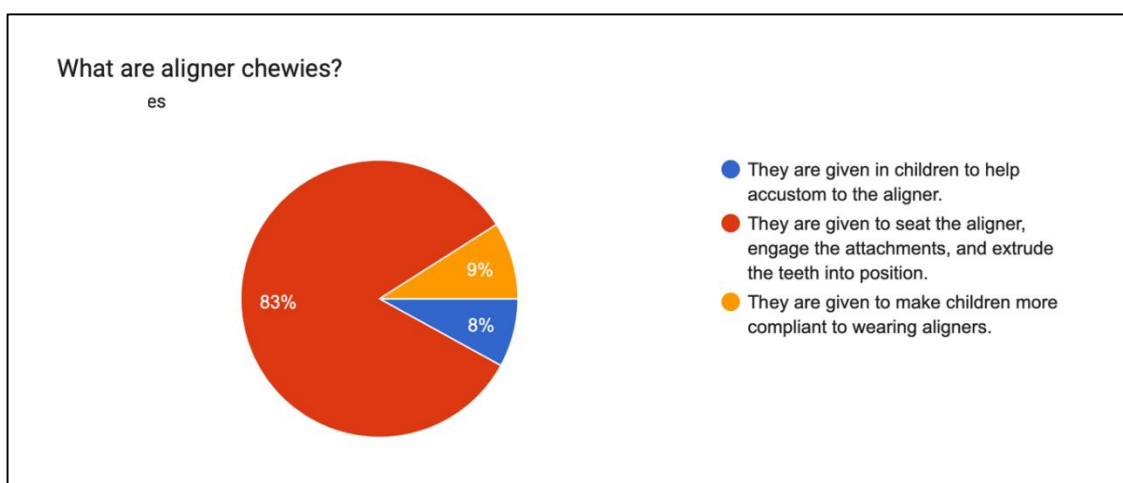
Fig. 7: Use of attachments



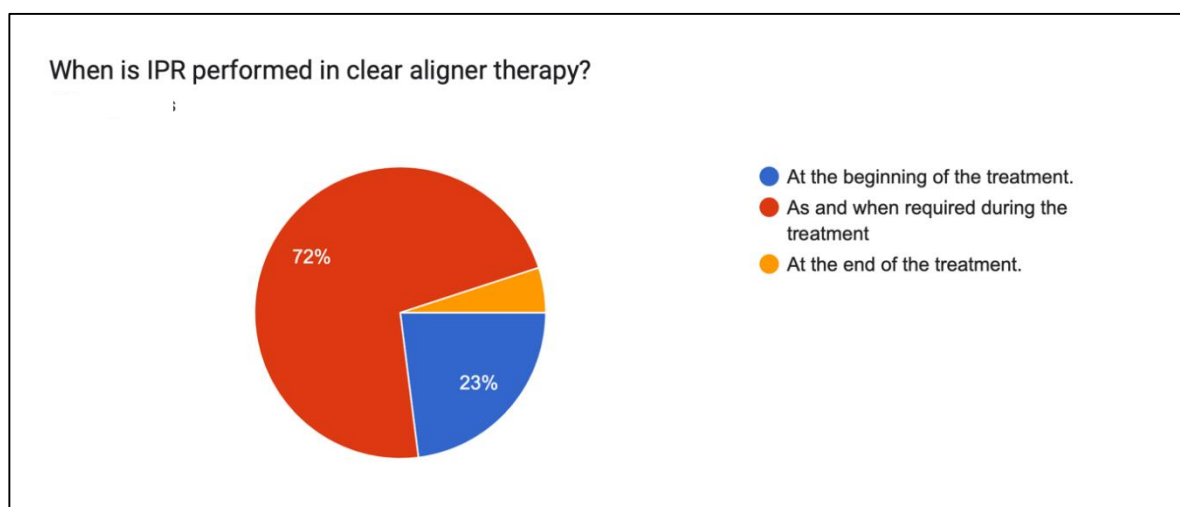
**Fig. 8:** Types of tooth movement

The attachments used for retention were asked about and 52 % of participants answered right (Fig. 7) Intrusion is the easiest orthodontic

movement with aligners and majority participants answered it right (Fig. 8).



**Fig. 9:** Use of aligner chewies



**Fig. 10:** Inter proximal reduction

Aligner chewies are given to seat the aligners and engage the attachments. Majority participants (83%) of them answered correctly (Fig. 9). IPR is a major modality in clear

aligner treatment and is done as and when required. 72% of the participants answered correctly indicating that they're clear on the concept of IPR (Fig. 10).

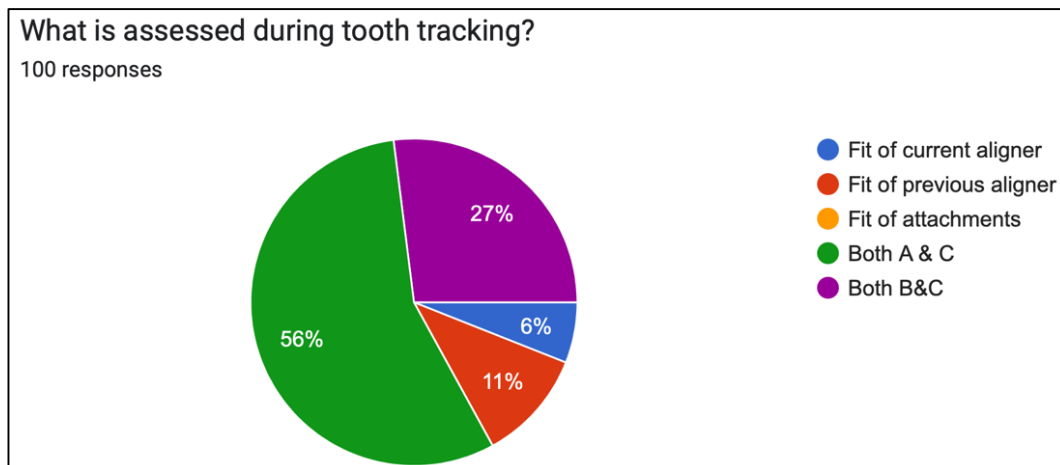


Fig. 11: Tooth tracking

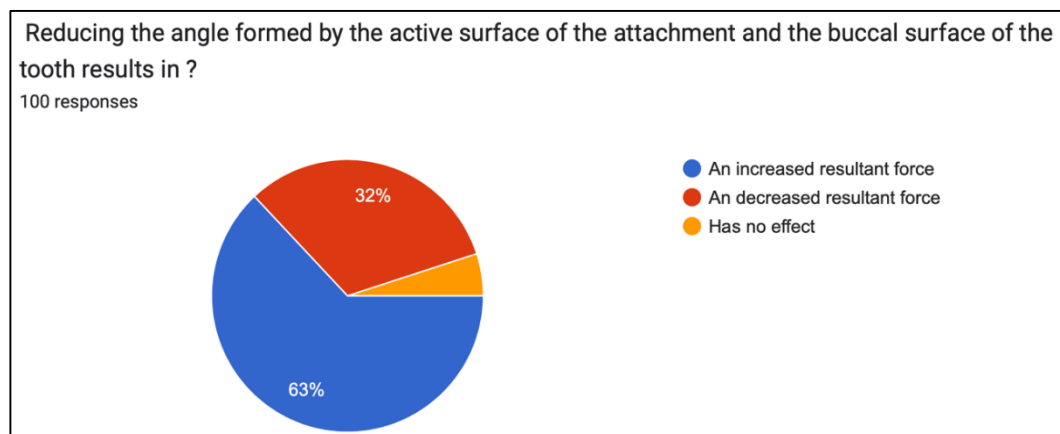


Fig. 12: Reducing angle

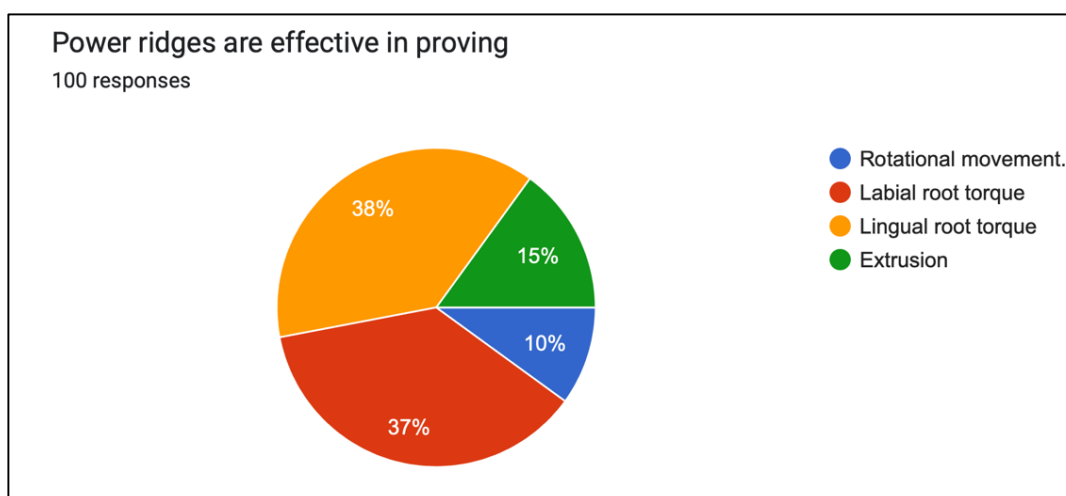
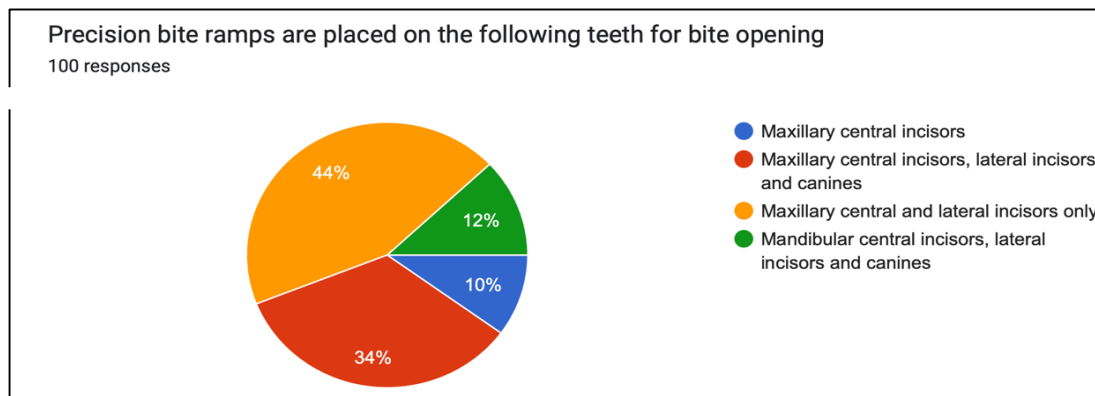


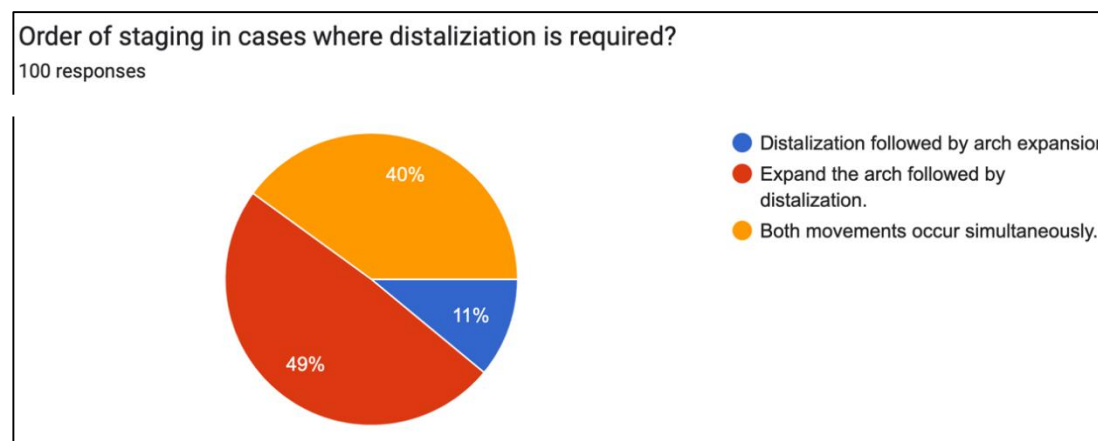
Fig. 13: Power ridges

Tooth tracking and power ridges were also mentioned in the questionnaire. While the concept of tooth tracking was clear (Fig. 11), about only 37% of the participants were able

to answer correctly that power ridges are effective in proving lingual root torque (Fig. 13).



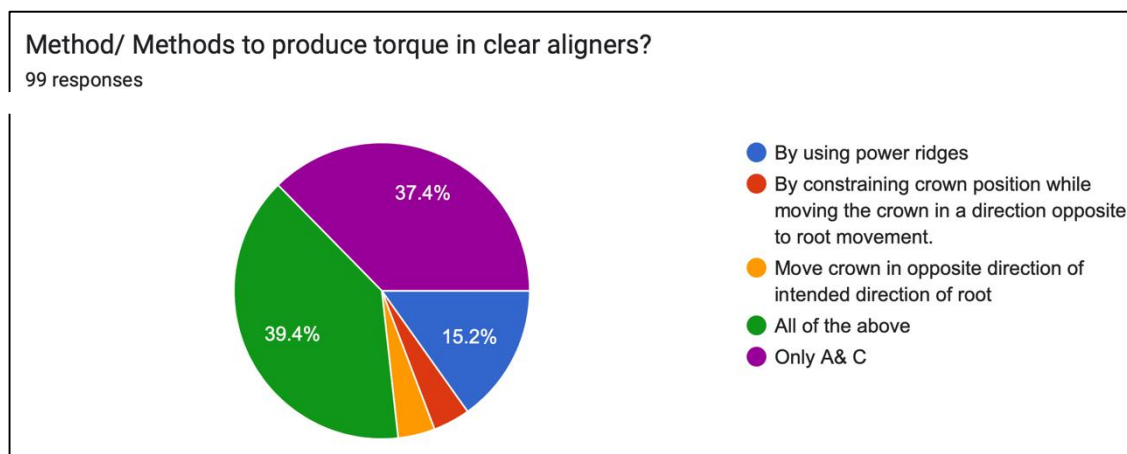
**Fig. 14:** Precision bite ramps



**Fig. 15:** Staging of aligners

Distalization is a time consuming procedure in orthodontics and was initially thought to be difficult with clear aligners. About 49%

percentages answered correctly that arches need to be expanded prior to distalization (Fig. 15).



**Fig. 16:** Torque expression



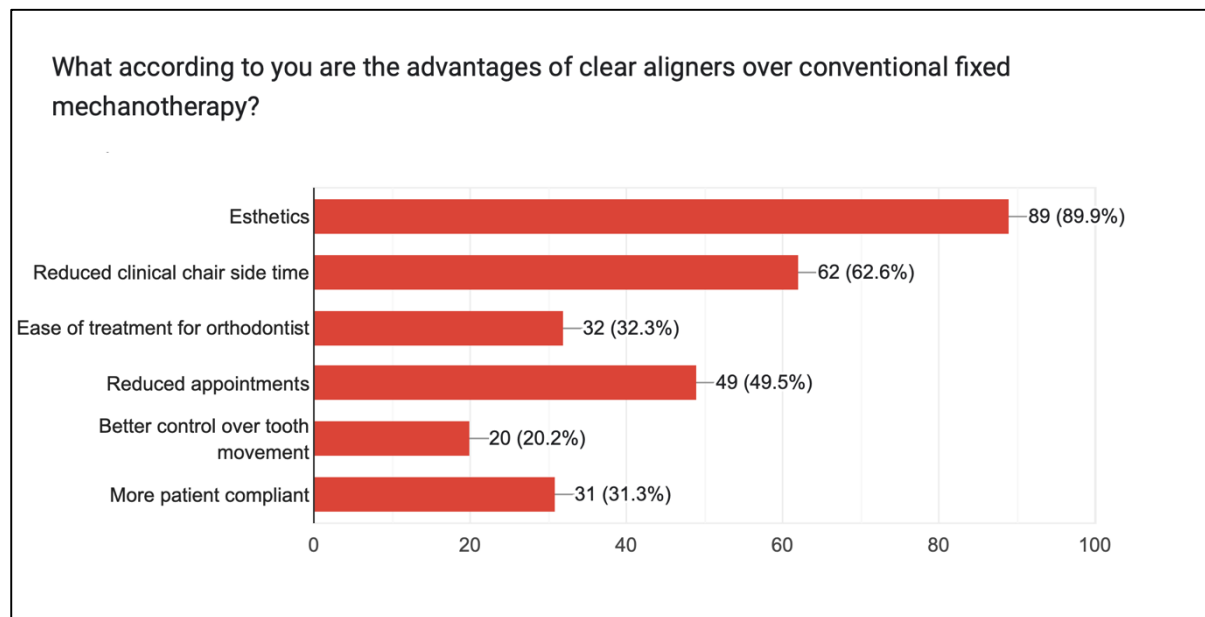


Fig. 17: Advantages of clear aligners

The attitude towards clear aligner was assessed by asking what according to the participants were the advantages of clear aligners over fixed conventional mechanotherapy. 87% of participants said aesthetics, 53.6% agreed with reduced clinical chair side time. 33% of participants said ease of treatment, 44% said reduced appointments. Only 20.3% participants felt that there was better control over tooth movement and about 33.3% participants felt that it was more patient compliant (Fig. 17).

#### 4. Discussion

Clear aligner therapy has taken over the field of Orthodontics in the past few years. It began, with the introduction of Invisalign (Align Technology, San Jose, California, USA), in 1997 and numerous other aligner companies have entered the market to offer this convenient and aesthetic solution for the correction of malocclusion.

While it started out to correct simple malocclusions such as spacing, today's aligners are used in conjunction with TADs, BMX expanders, Benesliders, Mesialsliders, W-intrusion arch, Yin-yang attachments, mini-pin supported mesialisation for the treatment of complex malocclusions. This makes it a necessity for the post-graduate student to be well versed with clear aligner therapy before

he/she start their professional journey as an Orthodontist.<sup>4</sup>

The type of tooth movement exerted by clear aligners is the push type as mentioned by **Henessy J et al**<sup>12</sup>. The accuracy of tooth movement based on a study by **Sachdeva et al**, concluded saying that about only 56.18% of accuracy was obtained overall with the most accurate tooth movement being mesiodistal (72.33%) and least accurate movement was found to be intrusion (43.28%)<sup>26</sup>. **Rossini et al** in their systematic review on efficacy of clear aligners mentioned that upper molar distalization revealed the highest predictability (88%) whereas extrusion was the most difficult movement to predict (30% accuracy) followed by rotation.<sup>25</sup> **Kravitz et al**, in their clinical study studied the efficacy of tooth movement and found that the most accurate movement was lingual tipping (47.1%) and least accurate was extrusion (29.6%) specifically extrusion of maxillary (18.3%) and mandibular (24.5%) central incisors followed by mesiodistal tipping of maxillary canines (26.9%).<sup>18</sup>

The material used in the fabrication {Polyethylene terephthalate glycol (PET-G), Polyurethane (PU), polyvinyl chloride} significantly influences the colour stability, mechanical properties and resiliency of the aligner. **Daniele V et al** evaluated the

physiochemical and mechanical characteristics of thermoplastic disks and concluded that PU exhibited higher mechanical and thermal resistance when compared to PET-G.<sup>6</sup> In a recent comparison **Daniele V et al** assessed the colour stability, chemico-physical and optical features of these materials. The results obtained from this study revealed that both PET-G and PU aligners show a change in color corresponding to loss of translucency. This is due to deposition of impurities on the surface. In terms of water absorption which is an important parameter to predict mechanical degradation, the worst performance was given by PU aligner.<sup>7</sup> **Alam MK et al** in a systematic review and network meta-analysis on the impact of various aligner materials and attachments concluded that Invisalign had a higher mean value than other types of materials analysed which suggested a potentially greater impact on tooth movement<sup>1</sup>

The fabrication of clear aligners requires intraoral scanning, planning software, 3D printer for printing 3D models and a pressure moulding machine. The digital workflow of aligners was well described by **Da Cunha et al** in their article on devices and applications of the orthodontic digital workflow. They enumerated three pillars in CAD-CAM technology, i.e., digital image acquisition of patients' dental arches, the visualization and manipulation of these images in the software and the 3D printing of these files.<sup>5</sup> Recently, direct 3D printed aligners have been introduced by Graphy (Seoul, Korea) in 2021. They have developed their own 3D printing material, Tera Harz which exhibit flexibility and wear resistant properties. They possess a shape memory effect thus its shape can be restored when it comes into contact with warm water.<sup>23</sup>

The anchorage system used in clear aligners is pre-determined anchorage as given by Nanda. Pre-determined anchorage basically works on the principle that all activations are pre-determined and compensations are made before movements are done. In clear aligner treatment, the anchorage segments can be predetermined and may change at different stages in treatment. Clear aligners offer good control of anchorage because the anchorage

teeth can be made immovable at different stages of treatment.<sup>22</sup>

Various attachments are used in clear aligner therapy and numerous studies have been done to assess the effectiveness of the same. While **Kravitz ND et al** says that attachments have no role on accuracy of rotational movements, a systematic review by **Jedlinski et al** concluded that the use of attachments significantly improves the expression of orthodontic movement.<sup>17,14</sup>

A FEA study by **Hong K et al** predicted the efficacy of bodily tooth movement with no/general/and overhanging attachments and concluded that the overhanging attachment can effectively reduce the crown tipping and prevent axial rotation for the distal displacement of the incisor.<sup>13</sup> On understanding about efficacy of wear protocol and rotations, **Stephens et al** in a retrospective cohort study concluded that vertical rectangular attachments were associated with least accurate expression of prescribed movement whereas one with optimised rotation attachments showed better accuracy, however **Karras et al** concluded that there was no statistical nor clinical significant difference between the conventional and optimized attachments.<sup>16</sup>

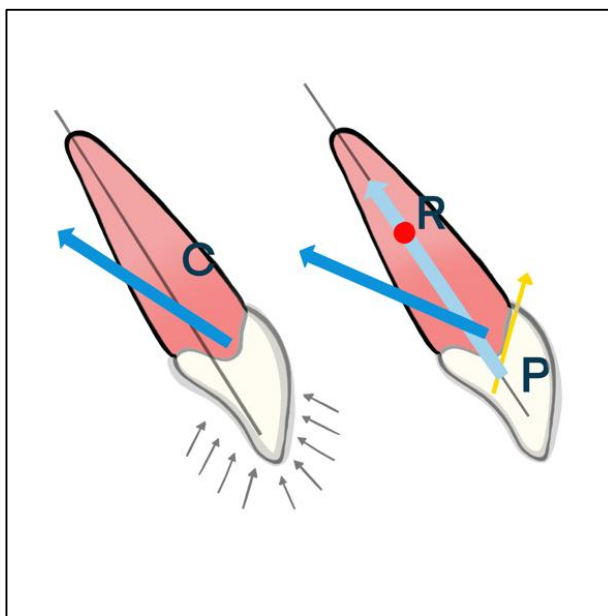
The simplest orthodontic movement with aligners is intrusion.<sup>30</sup> A study by **Bilello G et al** predicted the orthodontic movements with aligners to be in range of 70.4%-86.0% in terms of rotational movement.<sup>3</sup> However, **Upadhyay M et al**, spoke about the biomechanics of aligners and mentioned that about only 50% of accuracy of tooth movement vs predicted movement is seen with clear aligners.<sup>31</sup> In a retrospective study by **Lombardo L et al** on the predictability of orthodontic movement with aligners the authors concluded that mesiodistal tipping showed the most predictability (82.5%), followed by vestibulolingual tipping (72.95%) and rotation (66.8%).<sup>21</sup>

A common procedure in aligner technique is IPR, which should be limited to 0.5 mm per interproximal point in the anterior region and up to 1 mm in the posterior region to avoid a

large enamel reduction. IPR is done for relieving crowding and control incisor inclination, compensate for Bolton's discrepancy and to create symmetric dimension between right and left side.<sup>30</sup>

Aligners have the ability to simultaneously engage the occlusal, buccal and lingual surfaces of the teeth, this provides ability to apply compressive forces from all direction.

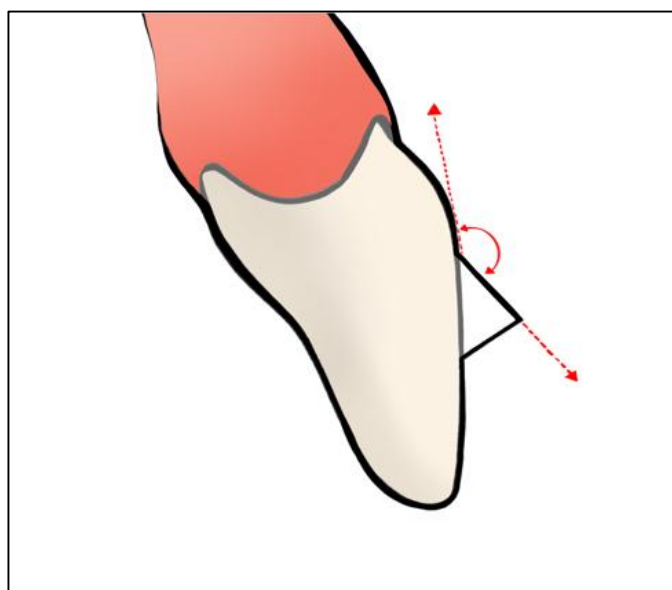
This phenomenon is known as “watermelon-seed effect” (**Fig. 17**). The resultant vector passes through the centre of resistance of the tooth. Plastic deformation and inconsistent force levels results in loss of coincidence between the attachment and its corresponding aligner and this is referred to as loss of tracking. Tooth tracking is a vital part of aligner treatment as loss of track indicates only partially effective tooth movement.<sup>31</sup>



**Fig. 17:** Watermelon-seed effect

A question was asked about the reduction of the angle formed by the active surface of the attachment and the buccal surface of the tooth

(**Fig. 18**). A reduction in angle causes an increased resultant force.<sup>22</sup>



**Fig. 18:** Angle formed by active surface of attachment

Power Ridges™, previously available only with Invisalign Teen™, are used in place of attachments to provide additional force in cases where lingual root torque is required.<sup>32</sup>

Precision bite ramps (Fig. 19) are lingual prominences incorporated into the aligner at the cingulum area of maxillary teeth. They are given in deep bite cases. They disocclude the

posteriors. The depth of these bite ramps are up to 3.0mm to accommodate overjet and is adjusted to maintain anterior contact throughout all stages of movement. **Greco M et al** studied the effect of precision bite ramps and concluded that the use of bite ramps is a valid option for the successful treatment for deep bite with aligners along with lower anterior intrusion and controlled proclination.<sup>27</sup>

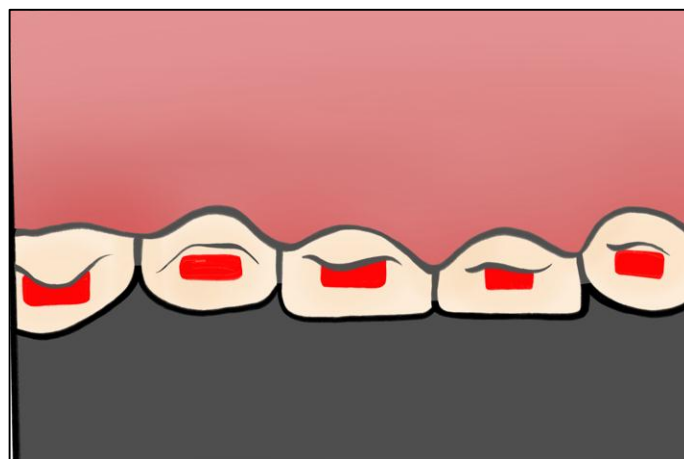


Fig. 19: Precision Bite ramps

Sequential distalization (fig 20) is also commonly referred to as “V pattern” staging. Ideally, aligners push teeth (expansion of arch) followed by distalization. The method of Distalization should be carried out by

expansion followed by distalization.<sup>22</sup> **Ravera S et al** on maxillary molar distalization with aligners found that about 2.25 mm of molar distalization can be done along with composite attachments and class II elastics.<sup>24</sup>

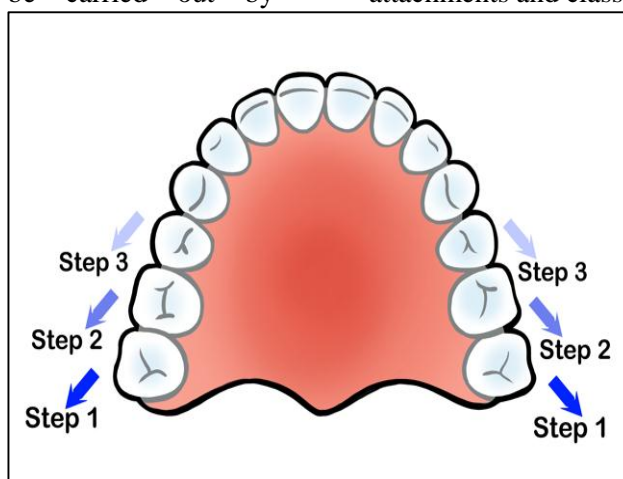


Fig. 20: Sequential distalization protocol with aligners

Control of root movement with aligners has been a constant concern due to the fact that crown of the tooth may slip away from the surface of aligner. Thus, torquing ridges were given to enhance forces for lingual root torque. Torquing can be done by various methods, i.e.,

by using power ridges, by moving the crown in opposite direction of intended direction of root.<sup>30</sup>

The last question was directed towards the attitude of post-graduate towards the

advantage of clear aligners over fixed mechanotherapy. 89% of participants agreed that an advantage was that it is aesthetic. 62% agreed that there was reduced chair time involvement, 32% felt that ease of treatment was present for the orthodontist, 49% felt that reduced appointments were encountered and 31% felt that it was more patient compliant. The main concern was control of tooth movement and only 20% felt that there was better control over tooth movement as compared to fixed mechanotherapy.

Overall it was understood that majority of participants were well aware of the fundamentals, basics of biomechanics and are clear on the concepts of clear aligner therapy.

## 5. Conclusion

Thus, we can conclude that, there is a good amount of knowledge and awareness about clear aligner therapy amongst Orthodontic post-graduate students. With the increase demand for clear aligner therapy amongst patients, it is vital that budding Orthodontists learn about this treatment modality during residency.

From the results obtained from this questionnaire survey it is evident that majority of post-graduate students are well aware of the workflow of aligner production, material sciences involved, biomechanics of aligners as well as technical nuances involved in clear aligner therapy.

## Declaration of Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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