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Effectiveness of Clear Aligner Therapy in Rotational Tooth Movement

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SUMMARY

Background/Aim: *The present study investigates the effectiveness of Invisalign (Align Technology, San Jose, Calif) in rotational tooth movement. The aim of this research is to assess the accuracy of the predicted rotational movements in the digital treatment plan (Clincheck, Align Technology, San Jose, CA) compared to the actual achieved results following treatment completion.* **Material and Methods***: A retrospective analysis was conducted on a cohort of orthodontic patients who underwent clear aligner therapy for rotational tooth movements. Digital treatment plans and 3D models were used to predict the anticipated degree of rotation for each tooth. Post treatment, the achieved, rotational movements were measured in the same way and assessed quantitively.* **Results:** *Preliminary findings revealed a significant correlation between the predicted rotational movements and the actual outcomes. The variations were observed among different tooth types and degree of rotation, which were influenced by the complexity of the rotations and the type of teeth involved. Teeth with mild to moderate rotations demonstrated higher accuracy rates in alignment with the digital treatment plan, while more complex rotations exhibited slight discrepancies. The most accomplished tooth movement was found with 80 % accuracy in lower central incisors, 74.29 % accuracy in lower laterals, 71.43 % accuracy in upper central incisors and lower second premolars whereas the least accuracy was found with 28 % in lower canines.* **Conclusions:** *These results reveals the potential of Invisalign orthodontic treatment to accurately predict and achieve rotational movements. The study emphazises the importance of precise treatment planning and patient selection for optimal outcomes. Further research is warranted to explore factors contributing to the variations observed and to refine treatment protocols to enhance the accuracy of rotational tooth movements with Invisalign.*

Keywords: Clear Aligner Therapy, Rotation, Effectiveness

ORIGINAL PAPER (OP)
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Introduction

The increased demand for clear aligner therapy has become significant. Invisalign (Align technology, San Jose, Calif) is one of the most preferred aligner system in the market. Specific tooth movements have been identified as most prone to failure with clinical outcomes and digital plans. In essence, this is also related to tooth type and direction of movement[1-4]. Rotational tooth movement with clear aligners is reported to be one of the least accurate tooth movement[2,5,6]. But most of the studies existing in the literature dealt with specific tooth types, mostly the anterior teeth or canines or multiple tooth movement types together[7]. The present study investigates the effectiveness of Invisalign in rotational tooth movement. The aim of this research is to assess the accuracy of the predicted rotational movements in the digital treatment plan (Clincheck Pro Software ,

Align Technology, San Jose, CA) compared to the actual achieved results following completion in the first set of aligners.

Material and Methods

A retrospective preliminary analysis was conducted on 43 orthodontic patients with Angle Class I anomaly who underwent clear aligner therapy with Invisalign (Align technology, San Jose, Calif) between 2019-2022. Eight of them were excluded from the study due to non compliance. All the patients were treated in a single private practice. A total of 35 individuals in the study; 15 were male and 20 were female. Average age of the patients were 25,61 years and average number of aligners was 18,45. The patients were told that they were part of a research study and were instructed to wear their aligners for 20-22 hours per day and change their aligners every 2 weeks as recommended by Align technology. The study protocol was conducted in accordance with the principles outlined in the Declaration of Helsinki, including all relevant amendments and revisions. Access to the collected data was restricted to the investigators only. The study protocol was reviewed and approved by the Health Sciences Ethics Committee of the Final International University (IRB No: 100/050/REK.001).

All digital data was collected using the Itero intraoral scanner, which generated precise 3D digital models of the patients' teeth and oral structures. All patients underwent Invisalign treatment with SmartTrack material system. The data for the study were obtained from the rotation tab within the Invisalign tooth movement table of the ClinCheck Pro software, developed by Align Technology as at the begining (t_0) and at the refinement phase (t_1). Percentage of accomplished rotation values were calculated as follows: planned tooth movement at the beginning of treatment (t_0)-planned tooth movement at the refinement phase (t_1) / t_0 X 100[1,7]. The data collected involves the direction of rotation of a tooth, whether it rotated distally or mesially. In the context of orthodontic treatment, it was ensured that the treatment plan maintained the same final tooth position that was previously approved in the ClinCheck treatment plan. Consequently, it was emphasizing the importance of adhering to the original treatment goals and not deviating from the established plan, except for necessary refinements or adjustments.

Statistical Analyses

All data from t_0 and t_1 rotational tooth movements were reported by accuracy of median values (%). The accuracy of a single tooth rotational movement values were assessed by Wilcoxon signed rank test. A p-value < 0.05 was considered as statistically significant.

Results

The median rotation values for each tooth are shown in Table1. The values were all in ranges valid for tooth movement categories defined by Invisalign system.

Table1. Median values of rotation amount for each tooth

tooth number	median value (t_0)	median value (t_1)	median value (t_0-t_1)	p
11	6.3°	2.9°	3.9°	*
12	9.2°	4.4°	3.4°	*
21	6.9°	1.9°	4.9°	*
22	8.9°	2.0°	6.7°	*
31	9.5°	3.0°	5.9°	*
32	7.8°	3.2°	4.3°	*
41	6.1°	1.9°	3.3°	*
42	5.8°	2.1°	2.8°	*
13	9.7°	3.1°	6.4°	*
23	7.7°	4.4°	4.4°	*
33	7.3°	5.1°	2.4°	*
43	10°	2.7°	7.6°	*
14	4.6°	1.5°	2.4°	*
15	5.1°	1.7°	2.6°	*
24	5.3°	2.2°	3.5°	*
25	4.0°	1.5°	1.4°	*
34	6.2°	1.5°	3.6°	*
35	8.2°	3.8°	5.4°	*
44	5.1°	2.7°	2.3	*
45	4.4°	1.2°	3.2°	*
16	5.5°	1.0°	3.1°	*
17	1.9°	1.3°	0.6°	*
26	4.9°	1.4°	2.6°	*
27	1.4°	0.7°	0.3°	*
36	4.3°	1.6°	1.8°	*
37	2.5°	2.5°	0°	<0.199
46	2.7°	1.3°	1.5°	*
47	1.5°	1.3°	0°	<0.168

t_o (at the start of treatment), t_1 (refinement phase), t_0-t_1 (amount of rotation achieved with therapy). Wilcoxon signed rank test results *p<0.05

Wilcoxon signed rank test results revealed that tooth rotation is statisticaly significantly and effectively corrected with Invisalign aligners except 37 and 47 (Table 1).

Accuracy percentage of each tooth achieved with clear aligner therapy is given in Figure 1a, 1b, 1c, 1d. According to our results; the most accomplished rotation control with Invisalign was 80% accuracy in lower central incisors, 74.29% accuracy in lower laterals, 71.43% accuracy in upper central incisors and lower second premolars whereas the least accuracy was found with 28% in lower canines (Figure1 b).

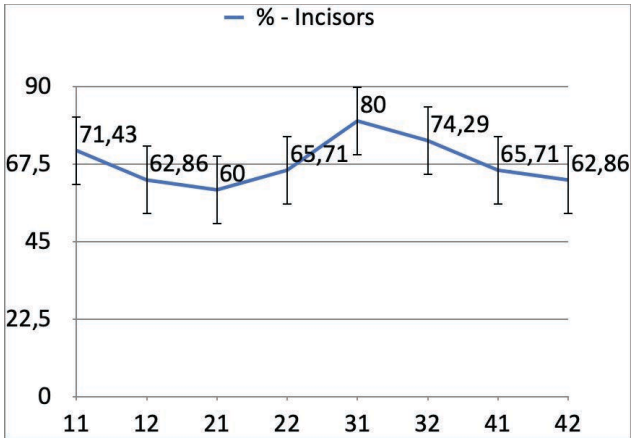


Figure 1a. Accuracy percentage of each incisor tooth achieved with clear aligner therapy

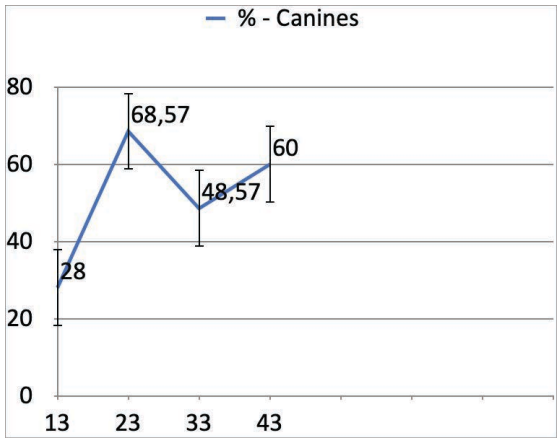


Figure 1b. Accuracy percentage of each canine tooth achieved with clear aligner therapy

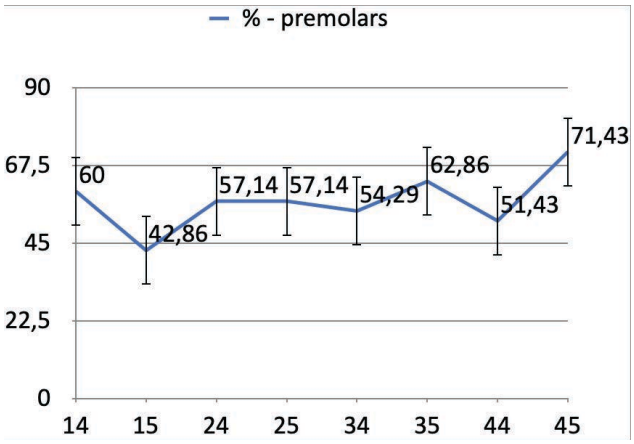


Figure 1c. Accuracy percentage of each premolar tooth achieved with clear aligner therapy

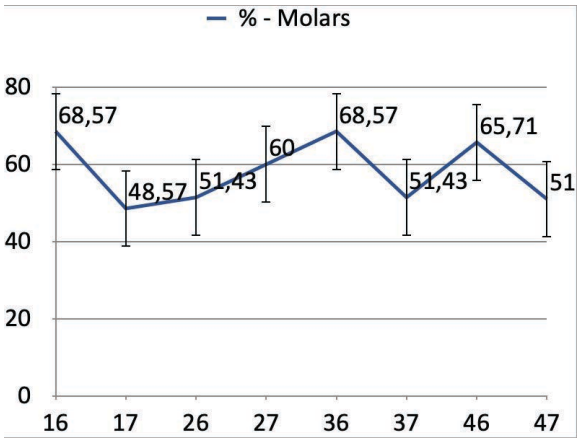


Figure 1d. Accuracy percentage of each molar tooth achieved with clear aligner therapy

Discussion

The median rotation values for each tooth were all in ranges valid for tooth movement categories defined by Invisalign system (table1). Our results revealed that tooth rotation is statisticaly significantly and effectively corrected with Invisalign aligners except 37 and 47. This can be explained by the fact that molars are terminal teeth and aligner displays plastic deformation due to the alignment and removal of the aligner from this region.

In our study the most accomplished rotation control was 80% accuracy in lower central incisors, 74.29% accuracy in lower laterals and 71.43% accuracy in upper central incisors. The lower and upper incisors has rectangular shape this helps the aligner have a larger and flatter surface area and apply more appropriate force.

We found that Invisalign system is capable of correcting lower second premolar rotation with 51.43%-71.43% accuracy. However former studies reported that lower premolars are round shaped teeth and lack of undercuts impeds the force distribution and this leads to insufficient rotation control in aligners[8,9].

In the study the least predictable movement was rotation of lower canines. This was attributed to the lack of undercuts to enhance aligner retention due to the conical shape of canines and also canines have long roots[5,10,11]. Besides canines are situated at the corner of the dental arch and as so in the aligners. The anchorage system might be thought to be weakened at this side than as at the anterior region or posterior region. But further investigation should be done. This might also be explained by the contact area of the canines with premolars on the distal side. The contact area displays a friction that impeds the tooth movement. At that point interproximal reduction and its effects on tooth movement in aligner therapy should be investigated.

As a limitation of this current study is not dedicated to investigating pure rotational movement and it is a retrospective clinical study encompassing various tooth movements. Therefore, the aligners potentially losing anchorage when subjected to various forces on a tooth, not just rotations, is a valid consideration.

Conclusions

This is a preliminary study. These results reveals the potential of clear aligner orthodontic treatment to accurately predict and achieve rotational movements. The study emphasizes the importance of precise treatment planning and patient selection for optimal outcomes. Further research is warranted to explore factors contributing to the variations observed and to refine treatment protocols to enhance the accuracy of rotational tooth movements with clear aligners.

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Animal Rights Statement: None required.

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