What percentage of patients switch from Invisalign to braces? A retrospective study evaluating the conversion rate, number of refinement scans, and length of treatment

Neal D. Kravitz,[a] Bassel Dalloul,[b] Yara Aba Zaid,[c] Chandani Shah,[d] and Nikhilesh R. Vaid[e]
South Riding, Va, Abu Dhabi and Dubai, United Arab Emirates, and Mumbai and Chennai, India

Introduction: This retrospective clinical study aimed to determine what percentage of patients switched from Invisalign to braces to finish treatment. We also examined the number of refinement scans per treatment and the estimated vs actual length of treatment. **Methods:** Records from 500 patients (average age 33.6 years) that started with Invisalign Full or Invisalign Teen were gathered from 2 orthodontic offices and evaluated. Data was collected from the doctors' consultation notes, treatment notes, and Invisalign Web site databases. There were 2 independent variables: gender (male and female) and age groups (aged <20 years, 20-30 years, and >30 years). **Results:** One in every 6 patients (17.2%) switched from Invisalign to braces. Invisalign treatment required an average of 2.5 refinement scans, and only 6.0% of patients could complete their treatment without a single refinement scan. The average length of Invisalign treatment was 22.8 months, this was 5.1 months more than the estimated length. The average number of aligners was 64.1, but for the patients that switched to braces, the average number of aligners was 80.6 plus an additional 6.9 months of braces. There was no statistical difference between gender or age group and the conversion to braces. However, patients in the oldest age group had a significantly greater number of refinement scans. **Conclusions:** We are likely overestimating an office's efficiency using Invisalign. On average, an Invisalign patient will require approximately 2-3 refinement scans and 2 years of treatment, and there should be a reasonable expectation that braces may be needed. (Am J Orthod Dentofacial Orthop 2023;163:526-30)

A general perception is that incorporating more Invisalign improves an office's efficiency. The reasons most often mentioned include greater delegation, less chair time, fewer visits, and extended appointment intervals.[1,2] Although the potential benefits are undeniable, if the teeth fail to track in the aligners, then even simple malocclusions can result in multiple refinement scans or the switch to braces. Therefore, in reality, an office's improvement in efficiency by using Invisalign is only as good as its effectiveness.

To date, orthodontists have measured Invisalign's effectiveness through tooth movement studies.[3-10] All of these studies used a similar methodology that involved superimposing the posttreatment scans over the final ClinCheck digital models to determine the differences between the predicted and achieved tooth movements. Their results indicated that Invisalign was less accurate with rotation of canines and premolars,[3-8] mandibular incisor intrusion,[3,6-10] and translation into extraction spaces.[11]

The first tooth movement study was published in 2009 by Kravitz et al.[3] At that time, the authors reported that Invisalign's mean accuracy of anterior tooth movement was only 41%. Not surprisingly, the most accurate movement was lingual constriction, as the aligner's

[a]Private practice, South Riding, Va.
[b]Private practice, Abu Dhabi, United Arab Emirates.
[c]Private practice, Dubai, United Arab Emirates.
[d]Private practice, Mumbai, India.
[e]Adjunct Professor, Department of Orthodontics, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences, Chennai, India.
All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
Address correspondence to: Neal D. Kravitz, 25055 Riding Plaza, Ste 110, South Riding, VA 20152; e-mail, nealkravitz@gmail.com.
Submitted, February 2022; revised and accepted, March 2022.
0889-5406

https://doi.org/10.1016/j.ajodo.2022.03.016

material primarily flexes in a buccal-lingual direction. However, one notable finding was that the accuracy of canine rotation declined significantly when the prescribed movement was >15°.

Haouili et al[6] recently provided a follow-up to the 2009 study to determine whether the accuracy of Invisalign had improved with newer technology. The authors reported that the mean accuracy had increased to 50%. Although Invisalign had improved, many of its strengths and weaknesses regarding tooth movements remained the same. Specifically, Invisalign was most accurate with the buccal-lingual crown tip and the least accurate with rotation.

Despite the consistency of the data over the years, tooth movement studies have limitations. Notably, they likely underestimate the clinical effectiveness of Invisalign. As such, a reported 50% accuracy of predicted tooth movements does not mean that Invisalign is only 50% effective. For example, in a 0.1 mm context, 50% accuracy is only 0.05 mm, which is clinically irrelevant. In contrast, these studies tested only compliant patients over a short duration. Perhaps, we must step back and evaluate other parameters to better assess Invisalign's effectiveness.

The primary purpose of this research was to determine what percentage of patients needed to switch from Invisalign to braces to complete their treatment. We also examined the number of refinement scans per treatment and the estimated vs actual length of treatment for those who successfully finished their Invisalign. By looking beyond the accuracy of individual tooth movements, we hope to provide a clearer picture of an office's efficiency using Invisalign.

MATERIAL AND METHODS

This retrospective study was approved by the Institutional Review Board at the European University College (approval no. EUC-IDB-20.01.18). Treatment was provided at 2 office locations in the United States by 4 highly experienced orthodontists (N.D.K.) with Invisalign (Diamond Plus providers). The patients were obtained from each office's Invisalign Web site database, divided equally, and then randomly selected by an independent research assistant. All patients were treated between 2011 and 2021.

The sample consisted of 500 patients with an average age of 33.6 years. A convenience sample was selected. The inclusion criteria for patients were as follows: aged ≥14 years, started their treatment with Invisalign Teen or Invisalign Full and completed their treatment with either Invisalign or braces. The exclusion criteria were patients who started Invisalign treatment with partially fixed appliances, required extractions or surgical exposure, or interrupted treatment (ie, new dental restorations) because these factors would influence the conversion rate and the number of refinement scans.

Once the final sample was gathered, the data were collected from the offices' practice management software and the Invisalign Web site database. The consultation notes provided each patient's malocclusion and the estimated treatment time. The treatment notes determined if and when a patient switched to braces and the total length of treatment. The Invisalign Web site database provided information on the number of refinement scans and active aligners.

Statistical analysis

The data had 2 independent variables: gender (male and female) and age groups (group A: aged <20 years; group B: aged 20-30 years; and group C, aged >30 years).

The statistical analysis was performed with SPSS software (version 20; IBM, Armonk, NY). P values of <0.05 were considered statistically significant. A Kolmogorov-Smirnova test was used to determine the distribution, independent t tests compared gender, a 1-way analysis of variance evaluated the 3 age groups, an LSD post hoc test confirmed the results of the analysis of variance, and a Pearson's correlation (r) measured the linear relationship between variables.

RESULTS

The average age of the sample was 33.6 years. The largest age group consisted of patients above 30 years (group C). The second largest age group comprised patients aged <20 years (group A).

The descriptive statistics included: 163 males and 337 females; 359 Invisalign Full and 141 Invisalign Teen; 328 Caucasians, 60 Indians, 55 Asians, 34 African Americans, and 23 Hispanics; as well as 375 Class 1 malocclusions, 98 Class 2 malocclusions, and 27 Class 3 malocclusions (Table I).

The conversion rate from Invisalign into braces was 17.2%, which equates to approximately 1 in 6 patients (Table II).

Invisalign required an average of 2.5 refinement scans per treatment. Furthermore, 18.0% of the patients needed 3 refinement scans, 10.4% needed 4 refinement scans, and 8.4% needed 5 refinement scans. Only 6.0% completed their Invisalign treatment without a single refinement scan, and these patients had an average of 22 aligners. Nine patients immediately converted to braces before their first refinement scan. Three patients had 8 refinement scans, which was the highest number.

The actual average length of treatment with Invisalign was 22.8 months. This was 5.1 months more than

Table I. Descriptive statistics for the sample

Characteristics	*n*
Gender	
Males	163
Females	337
Invisalign type	
Invisalign Full	359
Invisalign Teen	141
Malocclusion	
Class 1	375
Class 2	98
Class 3	27
Race	
White	328
Indians	60
Asians	55
African Americans	34
Hispanics	23
Age, y	
<20	140
20-30	78
>30	282

Table II. Results of sample evaluation

Characteristics	*Mean*
Age (y)	33.6
Conversation rate (%)	17.2
Refinements per treatment	2.5
Conversion rate to braces by gender (%)	
Male	5.2
Female	12.0
Conversion rate to braces by age (%)	
<20	5.2
20-30	2.2
>30	9.8
Refinements by gender (n)	
Male	2.6
Female	2.4
Refinements by age (n)	
<20	2.3
20-30	2.1
>30	2.7*
Aligners per treatment (n)	
Average total (Invisalign only)	64.1
Average total (Invisalign and braces)	80.6
Treatment length (mo)	
Estimated treatment length	17.7
Actual treatment length	22.8

*Statistical significance.

Table III. No. of refinement scans per treatment

Refinement scans per treatment	*%*
0 refinement scans	6.0*
1 refinement scan	22.4
2 refinement scans	28.8
3 refinement scans	18.0
4 refinement scans	10.4
5 refinement scans	8.4
6 refinement scans	3.2
7 refinement scans	0.4
8 refinement scans	0.6

*1.8% converted to braces before their first refinement.

the estimated length of treatment presented during the consultation. The average total number of aligners was 64.1. But for the patients who switched to braces, the average total number of aligners was 80.6. They also averaged an additional 6.9 months of braces.

There was no statistical difference between gender or age group and the conversion to braces. However, patients in the oldest age group (group C; $P = 0.25$) had a significantly greater number of refinement scans than the younger age groups (Table III).

There was also no linear relationship between the number of refinement scans and the conversion to braces. In other words, a greater number of refinement scans did not equate to a higher probability that the patient would switch to braces.

DISCUSSION

For over a decade, orthodontists have used tooth movement studies to quantify Invisalign's effectiveness. Despite their limitations, these studies were valuable in highlighting which movements were less predictable. We aimed to evaluate the conversion rate to braces, the number of refinement scans, and the estimated vs actual treatment lengths to better assess Invisalign's effectiveness. By doing so, we also hoped to quantify an office's efficiency using Invisalign.

The conversion rate to braces was 17.2%. Essentially, 1 in every 6 patients switched from Invisalign to braces to finish treatment. This high conversion rate was understandable given Invisalign's lower predictability of certain tooth movements[5] and struggle to correct common malocclusions.[12,13] Our results indicate that patients accepting Invisalign treatment should have a reasonable expectation that braces may also be needed.

Patients should also be prepared to receive 2 to 3 refinement scans. Only 6.0% completed their Invisalign treatment without a single refinement scan, and only 22.4% did so after 1 refinement scan. These data correspond with the 50% accuracy of tooth movement reported after the initial aligners.[6] Whether refinement scans validate Invisalign's inferiority to braces or merely a fundamental step equivalent to bracket repositioning, they appear to be a necessary component of treatment.

However, a higher number of refinement scans did not correlate to a higher probability of switching to

braces. Presumably, an Invisalign patient would have a certain number of scans before becoming fatigued and switching over. We found that there was no threshold number. For example, some switched almost immediately, whereas others persisted through 7 or 8 scans over an extended treatment duration—for both types of patients, Invisalign was the incorrect choice.

Part of the problem is that we are underestimating the length of treatment during the consultation. The actual length of Invisalign treatment was approximately 2 years, which is identical to what has been reported for braces.[14-16] Our data refute any marketing claims that Invisalign works faster. Providing realistic expectations will help patients make a proper decision, and their reaction to the estimated treatment length may forewarn noncompliance.

Unfortunately, predicting a patient's compliance with Invisalign is not straightforward. If we use the conversation rate as a marker of compliance, we found that gender and age do not provide any indications. Men and women of all ages were equally likely to switch from Invisalign to braces. The data corresponds with previous studies,[17,18] and disproves another general perception of Invisalign that females are more compliant than males and adults are more compliant than teenagers.

Although increased age did give us an indication of the number of refinement scans. The oldest age group, which was the largest group, had a significantly greater number of refinement scans. This tells us that most of the Invisalign patients will require the most effort and total doctor time, as previously reported.[1] Furthermore, once these older patients start their Invisalign treatment, they will be the slowest to switch to braces.

All of these factors ultimately impact the value of Invisalign's material costs, which is another important component of efficiency. We know that orthodontists will spend a substantial portion of their case fee for technologies that enhance efficiency,[19] but our results show that Invisalign does not finish faster, and many patients eventually switch to braces for 6-7 months. In such patients, the value of Invisalign's material costs, and an office's efficiency, is lessened.

So, does incorporating more Invisalign improve an office's efficiency? The answer still appears to be only when the Invisalign works.

Incidentally, our results—the high conversion rate to braces, the need for multiple refinement scans, and the underestimated treatment duration—show the fallacy of direct-to-consumer aligner products. A single round of 20 aligners is unlikely to be successful in any capacity, and there are still the overriding ethical concerns of unsupervised treatment. These results should also give pause to orthodontists who operate Invisalign scan shops or choose to provide their in-office mail-order aligner services.

The primary limitation of our study was that it was restricted to 2 orthodontic offices. The results would have been strengthened with a larger multicenter sample population. Other notable limitations were the exclusion of Invisalign First patients because this treatment was not provided at both offices and the uncertainty of whether the orthodontist or the patient prompted the switch to braces on the basis of the treatment notes, but this likely had little influence on the decision.

CONCLUSIONS

1. One in every 6 patients (17.2%) needed to switch from Invisalign to braces to finish their treatment.
2. Invisalign treatment required an average of 2.5 refinement scans. Only 6.0% of the patients completed their Invisalign treatment without a single refinement scan.
3. The average length of Invisalign treatment was 22.8 months, this was 5.1 months more than the estimated length presented during the consultation. The average total number of aligners was 64.1.
4. Patients aged >30 years had a significantly greater number of refinement scans, but they were no more likely to switch to braces than the younger age groups.
5. In summary, we are likely overestimating an office's efficiency using Invisalign. On average, an Invisalign patient will require approximately 2-3 refinement scans and 2 years of treatment, and there should be a reasonable expectation that a short duration of braces may be needed.

AUTHOR CREDIT STATEMENT

Neal D. Kravitz contributed to clinical research, data collection, and original draft preparation; Bassel Dalloul contributed to manuscript review and editing and visualization; Yara Aba Zaid contributed to formal data analysis; Chandani Shah contributed to formal analysis; and Nikhilesh R. Vaid contributed to supervision and validation.

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