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Original Article

Evaluation of the Consistency of Two Interproximal Reduction Methods in Clear Aligner Therapy: A Preliminary Study

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Main Points

- Motor-driven 3/4 oscillating segmental disks had better consistency.
- Hand-operated abrasive strips tended to result in inadequate interproximal reduction.
- This tendency was more pronounced in the maxillary central incisors and mandibular canines.

ABSTRACT

Objective: To compare the consistency of two interproximal reduction (IPR) methods in terms of the amount of planned and performed IPR during clear aligner therapy (CAT).

Methods: Thirty-four patients who received IPR using hand-operated abrasive strips (Group 1, 20 patients, 162 teeth) and motor-driven 3/4 oscillating segmental disks (Group 2, 14 patients, 134 teeth) during CAT were included in this preliminary study. The consistency between the planned and performed IPR amounts was evaluated within and between groups for teeth and quadrants.

Results: In Group 1, the amount of IPR performed on teeth numbers 22 and 43 and in the upper left quadrant was found to be statistically less than that of planned. On the other hand, the amount of performed IPR was statistically higher on tooth number 44 and in the upper right quadrant, whereas it was statistically less on tooth number 33 when compared with the planned amount in Group 2. The inconsistency between the planned and performed IPR amounts were statistically significant only in Group 1 and for teeth numbers 11, 21, 32, 33, and 43. No significant difference was found when the same parameter was compared between the groups.

Conclusion: The consistency of IPR was found to be better with the motor-driven oscillating disk system than with the hand-operated IPR strip system.

Keywords: Abrasive strip, clear aligner treatment, consistency, oscillating disk stripping

INTRODUCTION

With the development of technology and the increase in patients' aesthetic perception, treatment options with minimal visibility have become a necessity in orthodontic practice. Ceramic, plastic, vinyl, zircon, or polycarbonate brackets combined with Teflon- coated wires have been used to meet the aesthetic demands for many years. However, these tooth-colored brackets also failed to satisfy the aesthetic demands and led clinicians to use even less visible orthodontic materials such as clear aligners.[1-4] Movement of teeth without the use of bands, brackets, and wires was first introduced in 1945 by Dr. Kesling[5], who performed orthodontic treatment using a flexible tooth positioning device. Then, in 1997, the Invisalign® system (Align Technology Inc, Santa Clara, CA,

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USA) took Kesling's[5] philosophy further and produced a range of transparent and removable devices using computer-aided design and manufacturing technology.[6,7] In this system, manual impressions or digital scans were converted into virtual models with stereolithographic technology and then processed with ClinCheck™ software (Align Technology Inc, Santa Clara, CA, USA) to simulate virtual tooth movements and decide where, when, and how much interproximal reduction (IPR) to make. A series of aligners were then produced to obtain the necessary corrections.[6,8,9] The advantages of these systems are improved esthetics, increased patient comfort and oral hygiene, and healthier periodontal tissues.[3,10,11]

Success in clear aligner therapy (CAT) depends on various patient-related factors, such as bone density and crown and root morphology of the teeth, as well as operator-related factors, such as an appropriate treatment plan, close follow-up of the treatment process, and accurate execution of the pre-planned IPR. Features such as the thickness and material of the clear aligners and the shape and position of the attachments also play an important role in the treatment success of clear aligners.[3]

IPR, also known as stripping, enamel re-proximation, slenderizing, interdental enamel re-proximation, and selective enamel reduction, is a clinical procedure commonly used in orthodontic practice to eliminate black triangles by reshaping two neighboring teeth, to treat mild to moderate crowding, to eliminate Bolton tooth size discrepancy and to stabilize dental arches.[12-17] The most preferred IPR techniques in clinical practice are hand- or motor-operated abrasive metal strips, thin diamond burs and diamond-coated discs used with a handpiece.[12,14] The hand-operated abrasive metal strips, attached to color-coded plastic frames, effectively follow the proximal contours of the teeth and bend without any deformation, while the frames provide safety for the lips and cheeks.[18] On the other hand, oscillating segmental disk systems consist of diamond-coated disks that are one-sixth (60°) the size of a standard disk and a special handpiece. Unlike stripping disks that perform 360° rotation, they work by making oscillating movements with a 30° rotation angle, thereby eliminating the need for lip or cheek protectors.[19]

As the literature lacks reliable studies investigating the consistency of IPR in CAT, this study aims to compare the consistency of planned and performed IPR amounts during CAT using two different techniques, hand-operated diamond strips and motor-driven oscillating segmental disks with an *in vivo* study design.

METHODS

This prospective study was approved by Başkent University Institutional Review Board and Ethics Committee (project no: D-KA21/13, date: 28.04.2021) and supported by Başkent University Research Fund. Patients treated with clear aligners (Invisalign®, Align Technology, California, USA) at Başkent University between June 2021 and May 2022 were included in the study. Inclusion criteria were as follows: (1) IPR being planned for one or both jaws, (2) non-extraction treatment, (3) patients receiving mild, moderate, or comprehensive treatment packages, (4) no previous history of orthodontic treatment, (5) absence of periodontal pathology, and (6) no conservative or prosthetic restorations performed during treatment.

To achieve standardization, records of patients who were treated by the same experienced orthodontist (A.A.Ö.) were included in the study. Digital scans were taken at the beginning of treatment (T0) and after the first set of aligners/at the end of treatment (T1) using an iTero Element 5 intraoral scanner (Align Technologies Inc, San Jose, CA, USA). To capture the true size and form of the crowns, patients were asked to brush their teeth before scanning, and the teeth were dried thoroughly during the procedure.

Sample size calculation performed with 80% power and 0.35 effect size with a 10% probability of dropout suggested that 112 teeth should be included per group.[3] IPR was performed with hand-operated abrasive strips (ContacEZ-Ortho Classic®, Vancouver, WA, USA) (Figure 1) in 20 patients (162 teeth) in Group 1 and with motor-driven 3/4 oscillating segmental discs (KOMET-Sterisafe® A6, Rock Hill, SC, USA) (Figure 2) in 14 patients (134 teeth) in Group 2. A metal interproximal gauge KOMET USA, Rock Hill, SC, USA) was used after each IPR to check whether the performed amount was even with the planned amount. We assumed that equal reduction (50%) was achieved in the mesial and distal surfaces of the adjacent teeth.

The mesiodistal widths of the teeth (measured from the widest part) except for the molars were recorded at T0 and T1 using the Bolton table of the ClinCheck™ software. The difference between T1-T0 values gave the amount of IPR performed. The mean difference between the planned and performed IPR amounts was calculated by subtracting the planned

Figure 1. Hand-operated abrasive strips (ContacEZ, Ortho Classic®, Vancouver, WA, USA)

Figure 2. Motor-driven oscillating segmental discs (KOMET, Sterisafe® A6, Rock Hill, SC, USA)

amount from the performed amount. The reliability of the Bolton function of the ClinCheck™ software was evaluated by calculating intraclass correlation coefficients (ICC) for the 282 teeth that were not subjected to IPR using T0 and T1 values for comparison.

Statistical Analysis

Statistical analyses were performed using the SPSS software package (SPSS for Windows 22.0, SPSS Inc, IL, USA). The Shapiro-Wilk test was used to test the normality of distributions. Due to the non-normal distribution of the data, the Mann-Whitney U test was used for comparisons between paired groups, and the Kruskal-Wallis H and Wilcoxon signed rank tests were used for comparisons between three or more groups.

Descriptive statistical methods (mean, median, standard deviation, and minimum-maximum) were used while evaluating the study data. The significance level was set at 0.05.

RESULTS

A total of 34 patients and 296 teeth were used for data analysis. The ICC value calculated to confirm the reliability of the Bolton function of the ClinCheck™ software was found to be 0.996 (mean difference= -0.09 mm, median= -0.07 mm), indicating that the measurement system was reliable with good repeatability.

Table 1 shows the difference between the amounts of planned and performed IPR within the groups. The overall amount of performed IPR was significantly less than the planned amount in Group 1 but similar in Group 2. Furthermore, the amount of IPR performed in Group 1 in the upper left quadrant and

Table 1. Comparison of the planned and performed amounts (mm) of interproximal reduction (IPR) on quadrant- and tooth-level

	Group 1 (ContacEZ)						Group 2 (KOMET)					
	n	Planned		Performed		p value†	n	Planned		Performed		p value†
Measurement		Mean	SD	Mean	SD			Mean	SD	Mean	SD	
Quadrant												
Upper right	33	0.24	0.10	0.20	0.13	0.074	24	0.19	0.07	0.27	0.18	0.021*
Upper left	37	0.28	0.13	0.23	0.15	0.023*	23	0.22	0.12	0.21	0.14	0.553
Lower right	46	0.22	0.08	0.20	0.12	0.115	41	0.24	0.11	0.24	0.16	0.638
Lower left	46	0.21	0.08	0.19	0.13	0.249	46	0.24	0.10	0.23	0.18	0.299
Tooth number												
11	12	0.26	0.11	0.21	0.15	0.209	10	0.21	0.07	0.32	0.25	0.139
12	10	0.25	0.10	0.23	0.10	0.444	7	0.21	0.07	0.23	0.08	0.553
13	8	0.21	0.12	0.16	0.14	0.080	6	0.14	0.06	0.21	0.08	0.092
21	12	0.30	0.13	0.23	0.16	0.158	10	0.23	0.10	0.22	0.15	0.799
22	11	0.32	0.15	0.25	0.16	0.004*	7	0.26	0.15	0.28	0.14	0.307
23	9	0.27	0.14	0.26	0.16	0.889	5	0.19	0.12	0.14	0.06	0.501
31	14	0.25	0.07	0.24	0.12	0.850	13	0.27	0.10	0.30	0.15	0.289
32	13	0.23	0.06	0.22	0.14	0.753	13	0.27	0.10	0.28	0.17	1
33	11	0.21	0.07	0.13	0.11	0.068	12	0.23	0.10	0.11	0.11	0.021*
34	8	0.12	0.03	0.13	0.10	1	7	0.17	0.10	0.11	0.13	0.091
41	14	0.24	0.08	0.21	0.11	0.177	12	0.27	0.11	0.26	0.14	0.635
42	12	0.24	0.05	0.25	0.10	0.844	10	0.29	0.09	0.35	0.15	0.213
43	11	0.21	0.08	0.12	0.08	0.041*	11	0.21	0.10	0.12	0.11	0.068
44	8	0.14	0.07	0.21	0.18	0.260	7	0.16	0.11	0.22	0.16	0.027*
Overall	162	0.23	0.10	0.20	0.13	0.001*	134	0.23	0.10	0.24	0.16	0.713

*Indicates statistical significance p<0.05
†Wilcoxon signed rank test
SD, standard deviation

Table 2. Intragroup and intergroup comparisons of the mean difference between the planned and performed amounts (mm) of interproximal reduction (IPR) on quadrant- and tooth-level

	Group 1 (ContacEZ)				Group 2 (KOMET)				Between groups
Measurement	n	Mean	SD	p value†	n	Mean	SD	p value†	p value‡
Quadrant									
Upper right	33	0.09	0.07	0.786	24	0.12	0.15	0.877	0.621
Upper left	37	0.10	0.08		23	0.10	0.07		0.819
Lower right	46	0.09	0.09		41	0.09	0.08		0.664
Lower left	46	0.08	0.07		46	0.11	0.10		0.208
Tooth number									
11	**12**	**0.12**	**0.09**	**0.032***	10	0.18	0.22	0.534	0.692
12	10	0.07	0.04		7	0.05	0.05		0.522
13	8	0.06	0.03		6	0.09	0.04		0.132
21	**12**	**0.13**	**0.09**		10	0.11	0.07		0.716
22	11	0.07	0.07		7	0.06	0.06		0.926
23	9	0.08	0.07		5	0.11	0.07		0.349
31	14	0.05	0.04		13	0.09	0.06		0.223
32	**13**	**0.11**	**0.05**		13	0.10	0.06		0.797
33	**11**	**0.12**	**0.09**		12	0.13	0.11		1
34	8	0.05	0.06		7	0.08	0.05		0.288
41	14	0.06	0.06		12	0.07	0.08		0.140
42	12	0.06	0.06		10	0.11	0.08		0.274
43	**11**	**0.13**	**0.08**		11	0.12	0.07		0.598
44	8	0.09	0.15		7	0.07	0.06		0.815

*Indicates statistical significance p<0.05
†Kruskal-Wallis H test
‡Mann-Whitney U test
SD, standard deviation

on teeth numbers 22 and 43 was significantly less than that planned. The amount of IPR performed in Group 2 in the upper right quadrant and on tooth number 44 was significantly higher than that planned; however, it was significantly less in tooth number 33.

Table 2 shows intra- and inter-group comparisons of the mean differences between planned and performed amounts of IPR. Intra-group evaluations showed that the performed amount of IPR was similar to the planned amount at the quadrant level in both groups. When the mean differences were evaluated at the tooth level, the difference values of teeth numbers 11, 21, 32, 33, and 43 in Group 1 were significantly higher than the other teeth in the same group (p=0.032). Inter-group comparisons, on the other hand, showed that there was no statistically significant difference between the two methods in terms of quadrants and teeth.

DISCUSSION

This study was conducted to compare the consistency of two IPR techniques commonly used in clinical practice, hand-operated abrasive diamond strips and motor-driven oscillating segmental disks in CAT. The first important feature of the study was that all IPRs were performed by a single orthodontist with more than 20 years of clinical experience, ensuring standardization. The second important feature was the *in vivo* nature of the study, which is rare in the literature. In addition, the accuracy of the IPR was checked with an interproximal metal gauge after each IPR.

IPR is crucial for the full realization of planned tooth movements in CAT. The consistency between the planned and performed IPR amounts depends on dental characteristics such as enamel hardness, tooth position, and crown morphology, as well as technical factors such as pressure applied during IPR, particle size and hardness of the abrasive material, and operator's experience.[8,14,20,21] In addition, applying excessive pressure with the interproximal gauge may create false spaces, resulting in inadequate IPR.[20]

The results showed that the overall amount of IPR performed was similar to that planned with the motor-driven oscillating disk system; however, it was less with the hand-operated abrasive strip system. Consistent with theses findings, De Felice et al.[3] demonstrated that the amount of IPR performed with single-sided manual strips could not reach the prescribed amount; however, the oscillating disk system effectively executed it. However, their study included patients treated by 10 different orthodontists, whereas the current study offers the advantage of standardization in which IPRs were performed by a single experienced orthodontist. Laganà et al.[8] and Kalemaj and Levrini[13] also reported that oscillating segmental disks had better consistency. The findings of this study together with the existing literature indicate that mechanical and manual methods differ with consistency between the planned and performed amounts of IPR, and that mechanical methods have better consistency than manual methods. This may be attributed to the incremental use of manual strips, which may displace the teeth and lead to false readings on the interproximal gauge, making it clinically more tiring and time-consuming, especially for marked amounts of IPR. Furthermore, this technique is clinically more tiring and time consuming, especially when a marked amount of IPR is planned, which may give the clinician a false impression that the targeted amount is reached.

Mandibular canines received significantly less IPR than the planned amount. A similar finding was demonstrated by Kalemaj and Levrini[13] who used burs, single-sided abrasives, and contra-angle mounted strips for IPR. This is likely due to the position of the mandibular canines on the arch, which are usually proclaimed, crowded, and in tight interproximal contact with the adjacent teeth.

Johner et al.[22] tested the accuracy of two mechanical and one manual IPR methods (oscillating segmental disks, motor-driven abrasive strips and hand-operated strips) with an *in vitro* study design and found that the amount of IPR performed was less than that planned for all 3 methods. This contrasts with our findings, showing consistent IPR amounts performed with the mechanical method was consistent with the planned amount, whereas the manual method was not efficient enough to fully achieve the prescribed amount.

Based on the findings of this study, it may be advised to use an interproximal gauge with minimal pressure after each application and to perform slightly more IPR on mandibular canines and maxillary central incisors when using manual methods.

Study Limitations

One limitation of the study was the use of the Bolton function of the ClinCheck™ software which is claimed to be prone to measurement errors. However, our results showed that the ICC value was 0.996, proving that the repeatability was high and the outcomes were reliable.

CONCLUSION

The following conclusions are drawn from this clinical study:

- The consistency between the planned and performed amounts of IPR is high with the mechanical (motor-driven 3/4 oscillating segmental disks) method.
- The manual method (hand-operated abrasive strips) failed to fully realize the planned amount of IPR, especially on the maxillary central incisors and mandibular canines.

Ethics

Ethics Committee Approval: This prospective study was approved by Başkent University Institutional Review Board and Ethics Committee (project no: D-KA21/13, date: 28.04.2021).

Informed Consent: Written informed consent was obtained from all individual participants included in the study.

Author Contributions: Concept - P.G.E., A.A.Ö., A.A.K., N.İ.T.; Design - P.G.E., A.A.Ö., A.A.K., N.İ.T.; Supervision - A.A.Ö., A.A.K., N.İ.T.; Fundings - P.G.E.; Materials - A.A.K.; Analysis and/or Interpretation - P.G.E., A.A.Ö., A.A.K., N.İ.T.; Literature Review - P.G.E.; Writing - P.G.E.; Critical Review - A.A.Ö., A.A.K., N.İ.T.

Declaration of Interests: All authors declare that they have no conflict of interest.

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