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"Comparative Evaluation of Clinical Effectiveness of Clear Aligners and their Associated Factors in Extraction and Non Extraction Cases – A Retrospective Study"

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KEYWORDS

Clear Aligner Therapy (CAT),

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Peer Assessment Rating Index (PAR),

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Treatment Duration

ABSTRACT

Introduction: Clear aligner therapy (CAT) has emerged as a popular alternative to fixed appliances, offering advantages in esthetics, comfort, and oral hygiene. While its effectiveness in mild-to-moderate malocclusions is established, limited evidence exists comparing outcomes in extraction versus non-extraction cases.

Aim: To evaluate and compare the clinical effectiveness of CAT in extraction and non-extraction cases using the Peer Assessment Rating (PAR) index, with particular focus on treatment duration and refinement frequency.

Material and Methods: A retrospective study was conducted on 24 patients (12 extraction, 12 non-extraction) treated with clear aligners between 2021 and 2024. Pre- and post-treatment digital models were assessed using the PAR index. Treatment duration and number of refinement scans were recorded. Statistical analysis included paired and unpaired t-tests with significance set at $p < 0.05$.

Results: Both extraction and non-extraction groups showed significant reductions in total weighted PAR scores (extraction: 29.36 ± 7.93 to 4.91 ± 4.48; non-extraction: 16.55 ± 8.86 to 3.18 ± 5.90, $p < 0.001$). Post-treatment outcomes were comparable between groups; however, extraction cases exhibited significantly greater reductions in lower anterior segment alignment, overjet, and total PAR scores ($p < 0.01$). Extraction cases required more refinements (2.82 ± 0.75 vs. 1.00 ± 0.63, $p < 0.001$) and longer treatment duration (25.48 ± 5.14 vs. 10.52 ± 2.71 months, $p < 0.001$).

Conclusion: Clear aligners are effective in achieving favourable occlusal outcomes in both extraction and non-extraction cases. Although extraction cases demand longer treatment duration and more refinements, they achieve comparable final results, supporting the use of CAT in complex malocclusions with proper case selection and patient counselling.

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1. Introduction

The use of clear aligners (CA) in orthodontics dates back to 1946, when Dr. Harold Kesling first introduced thermoplastic tooth positioners to facilitate tooth movement.[1] Today, clear aligners are increasingly favored over fixed orthodontic appliances because of their esthetics, improved oral hygiene, and enhanced patient comfort.[2]

Clear aligner biomechanics rely on a series of custom-fabricated aligners designed to sequentially move teeth into desired positions. These aligners, commonly manufactured from polyurethane or ethylene-vinyl acetate, apply controlled forces to teeth.[3] The incorporation of attachments, such as power ridges and buttons, has expanded the scope of clear aligner therapy (CAT) from mild-to-moderate corrections to more complex cases.[4]

Treatment planning is supported by Align Technology's cloud-based software, ClinCheck, which enables communication between the clinician and technician for virtual treatment setup. Once the plan is approved, sequential aligners are manufactured and delivered to the patient.[5] However, a major limitation is the discrepancy between predicted and achieved outcomes in ClinCheck simulations. Studies report that ≥50% of the predicted results differ from clinical outcomes, with 70–80% of cases requiring refinements.[6] Understanding factors influencing refinements and treatment duration is crucial for both clinicians and patients.

Sarah Abu Arqub et al.[6] were the first to investigate associations between treatment duration, initial case complexity, achieved outcomes, and refinement frequency, concluding that initial complexity is strongly related to treatment outcomes in Invisalign therapy. Comparative studies have also been conducted between clear aligners and fixed orthodontic appliances. For example, Jaber et al.[7] found no significant difference in the effectiveness of clear aligners and buccal fixed appliances in treating Class I severe crowding cases with first premolar extractions. Other studies have similarly suggested comparable effectiveness between CAT and fixed appliances.[8–10]

Despite these findings, there is a gap in the literature regarding the clinical effectiveness of clear aligners in extraction versus non-extraction cases. No published studies to date have directly compared these two treatment modalities with respect to treatment complexity, refinements, and duration. This gap highlights the need for the present study, which seeks to optimize aligner-based treatment planning and outcomes. Therefore the aim of the study was to evaluate and compare the clinical effectiveness of clear aligners and their associated factors in extraction and non extraction cases using Peer Assessment Rating (PAR) Index. The null hypothesis for this study was that there is no difference in clinical effectiveness of clear aligners and their association between initial complexity of malocclusion, frequency of refinements and treatment duration in extraction and non extraction cases.

2. Material and Methods

Study Design and Setting

This retrospective study was conducted at the Department of Orthodontics and Dentofacial Orthopaedics, K.M. Shah Dental College & Hospital, Sumandeep Vidyapeeth Deemed to be University. Patient records were obtained from two private orthodontic centers:

- Dr. Samarth's Dental and Orthodontic Care
- Joshi Orthodontic and Implant Dental Care

The study protocol was reviewed and approved by the Sumandeep Vidyapeeth Institutional Ethical Committee. Data collection was completed within six months after obtaining ethical approval.

Sample Selection

Source of Sample: Patients treated with clear aligners between 2021 and 2024 at the above-mentioned centers.

Inclusion Criteria:

- Patients treated with clear aligners, with or without extractions.
- Availability of complete pre- and post-treatment digital models.

Exclusion Criteria:

- Patients with poor compliance in aligner wear.

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Sample Size Calculation

Sample size was determined based on a previous study by Sarah Abu Arqub et al.[6] The mean difference (initial–final) in weighted total PAR score was 11.22, with a standard deviation (SD) of 9.59. Thus the calculated minimum sample size per group was 12. Thus, a total of 24 participants were included: 12 extraction cases and 12 non-extraction cases, selected through systematic sampling from eligible records.

Data Collection

A standardized proforma was provided to practitioners for data extraction. The following components of PAR were recorded for each patient:

- **Pre- and Post-Treatment Values of:**
  - Maxillary anterior segment (UAS) contact displacement
  - Mandibular anterior segment (LAS) contact displacement
  - Right buccal occlusion (RBO)
  - Left buccal occlusion (LBO)
  - Overjet
  - Overbite
  - Midline deviation
- **Treatment-Related Variables:**
  - Number of refinements required
  - Total treatment duration

Outcome Measures

Clinical effectiveness of clear aligners was evaluated by comparing pre- and post-treatment values for the above mentioned PAR components. Associated factors including frequency of refinements, and treatment duration were analyzed separately for extraction and non-extraction cases, and compared between groups.

Statistical Analysis

All data were tested for normality using the Shapiro–Wilk test. As data were normally distributed, intragroup comparisons (pre- vs. post-treatment) were performed using paired t-tests and intergroup comparisons (extraction vs. non-extraction) were conducted using unpaired t-tests. A significance level of $p < 0.05$ was considered statistically significant.

3. Results

Table 1 – Intragroup comparision of PAR Components for Non Extraction Group at Pre Treatment and Post Treatment

Components for Non Extraction Group	TO		T1		T0-T1		P value of Paired t - test
	Mean	SD	Mean	SD	Mean	SD	
UAS	2.91	1.45	0.18	2.73	2.73	1.19	<0.001
LAS	2.00	1.34	0.27	0.47	1.73	1.19	<0.001
LBO	0.55	0.93	0.45	0.82	0.09	0.30	0.34
RBO	0.55	1.21	0.27	0.47	0.27	0.90	0.34
Overjet	6.55	5.66	1.09	3.62	5.45	4.20	0.001
Overbite	2.73	2.24	0.55	0.93	2.18	2.27	0.009
Centerline	1.45	2.02	0.36	1.21	1.09	1.87	0.08
Total weighted PAR	16.73	8.87	3.27	6.18	13.45	6.58	<0.001

T0 = Pre-treatment, T1 = Post-treatment, T0–T1 = Difference between pre- and post-treatment.

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$p < 0.05$ indicates statistically significance

Within the non-extraction group (Table 1), significant improvements were observed in most PAR components following treatment. The upper anterior segment (UAS) and lower anterior segment (LAS) showed highly significant reductions ($p < 0.001$), indicating effective alignment correction. Significant improvements were also noted in overjet ($p = 0.001$) and overbite ($p = 0.009$). Buccal occlusion changes (LBO and RBO) were not statistically significant, and only minimal changes were seen in the centerline ($p = 0.08$). The total weighted PAR score reduced significantly from 16.73 ± 8.87 at T0 to 3.27 ± 6.18 at T1 ($p < 0.001$), confirming an overall favourable treatment outcome.

Table 2 – Intragroup Comparision of PAR Components for Extraction Group at Pre Treatment and Post Treatment

Components for Extraction group	TO		T1		T0 -T1		P value of Paired t - test
	Mean	SD	Mean	SD	Mean	SD	
UAS	3.09	2.02	0.18	0.40	2.91	1.76	0.0002
LAS	3.82	1.33	0.00	0.00	3.82	1.33	<0.001
LBO	1.55	0.82	0.18	0.40	1.36	0.81	<0.001
RBO	1.45	0.69	0.36	0.67	1.09	0.70	< 0.001
Overjet	14.73	6.77	2.73	3.13	12.00	6.00	<0.001
Overbite	4.00	0.00	1.09	1.04	2.91	1.04	<0.001
Centerline	0.73	1.62	0.36	1.21	0.36	1.21	0.34
Total weighted PAR	29.36	7.93	4.91	4.48	24.45	5.20	<0.001

T0 = Pre-treatment, T1 = Post-treatment, T0–T1 = Difference between pre- and post-treatment.

$p < 0.05$ indicates statistically significance

In the extraction group (Table 2) , marked improvements were observed in several components. Both UAS and LAS showed highly significant reductions ($p = 0.0002$ and $p < 0.001$, respectively). Overjet decreased substantially from 14.73 ± 6.77 to 2.73 ± 3.13 ($p < 0.001$), while overbite also improved significantly ($p < 0.001$). RBO & LBO showed a statistically significant improvement ($p = 0.02$), whereas centerline changes were not significant. The total weighted PAR score decreased significantly from 29.36 ± 7.93 at T0 to 4.91 ± 4.48 at T1 ($p < 0.001$), reflecting highly favourable overall outcomes in extraction cases.

Table 3 – Intergroup Comparision of PAR Components at different time Intervals between Extraction and Non Extraction Group

Parameters	Group	N	Mean	Std. Deviation	P value of Unpaired t - test

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UAS T0	Non Extraction	12	2.91	1.45	0.40
	Extraction	12	3.09	2.02	
UAS T1	Non Extraction	12	0.18	2.73	0.50
	Extraction	12	0.18	0.40	
UAS T0 – T1	Non Extraction	12	2.73	1.19	0.38
	Extraction	12	2.91	1.76	
LAS T0	Non Extraction	12	2.00	1.34	0.002
	Extraction	12	3.82	1.33	
LAS T1	Non Extraction	12	0.27	0.47	0.04
	Extraction	12	0.00	0.00	
LAS T0 – T1	Non Extraction	12	1.73	1.19	0.0004
	Extraction	12	3.82	1.33	
LBO T0	Non Extraction	12	0.55	0.93	0.007
	Extraction	12	1.55	0.82	
LBO T1	Non Extraction	12	0.45	0.82	0.17
	Extraction	12	0.18	0.40	
LBO T0 – T1	Non Extraction	12	0.09	0.30	0.003
	Extraction	12	1.36	0.81	
RBO T0	Non Extraction	12	0.55	1.21	0.04
	Extraction	12	1.45	0.69	
RBO T1	Non Extraction	12	0.27	0.47	0.35
	Extraction	12	0.36	0.67	
RBO T0 – T1	Non Extraction	12	0.27	0.90	0.005
	Extraction	12	1.09	0.70	
Overjet T0	Non Extraction	12	6.55	5.66	0.003
	Extraction	12	14.73	6.77	
Overjet T1	Non Extraction	12	1.09	3.62	0.135
	Extraction	12	2.73	3.13	
Overjet T0 – T1	Non Extraction	12	5.45	4.20	0.004
	Extraction	12	12.00	6.00	
Overbite T0	Non Extraction	12	2.73	2.24	0.04
	Extraction	12	4.00	0.00	

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Overbite T1	Non Extraction	12	0.55	0.93	0.10
	Extraction	12	1.09	1.04	
Overbite T0 – T1	Non Extraction	12	2.18	2.27	0.175
	Extraction	12	2.91	1.04	
Centerline T0	Non Extraction	12	1.45	2.02	0.18
	Extraction	12	0.73	1.62	
Centerline T1	Non Extraction	12	0.36	1.21	0.50
	Extraction	12	0.36	1.21	
Centerline T0 – T1	Non Extraction	12	1.09	1.87	0.14
	Extraction	12	0.36	1.21	
Total weighted PAR T0	Non Extraction	12	16.73	8.87	0.001
	Extraction	12	29.36	7.93	
Total weighted PAR T1	Non Extraction	12	3.27	6.18	0.22
	Extraction	12	4.91	4.48	
Total weighted PAR T0 – T1	Non Extraction	12	13.45	6.58	< 0.001
	Extraction	12	24.45	5.20	
No. of refinement scans	Non Extraction	12	1.00	0.63	<0.001
	Extraction	12	2.82	0.75	
Treatment Duration	Non Extraction	12	10.52 (months)	2.71 (months)	<0.001
	Extraction	12	25.48(months)	5.14 (months)	
T0 = Pre-treatment, T1 = Post-treatment, T0–T1 = Difference between pre- and post-treatment. $p < 0.05$ indicates statistically significance					

Table 3 shows that at baseline, the extraction group presented with significantly greater initial malocclusion severity compared to the non-extraction group, with higher LAS ($p = 0.002$), buccal occlusion discrepancies (LBO, $p = 0.007$; RBO, $p = 0.04$), and larger overjet ($p = 0.003$). The baseline total weighted PAR score was also significantly higher in the extraction group (29.36 ± 7.93) than in the non-extraction group (16.55 ± 8.86, $p = 0.001$).

Following treatment, no statistically significant differences were noted between the groups in most individual components or in the total weighted PAR score at T1, suggesting that both treatment modalities were equally effective in achieving favourable outcomes. However, when evaluating the amount of improvement (T0–T1), the extraction group demonstrated significantly greater reductions in LAS ($p = 0.0004$), overjet ($p = 0.004$), and total weighted PAR ($p = 0.001$) compared to the non-extraction group. The extraction group required significantly more refinement scans (2.82 ± 0.75) compared to the non-extraction group (1.00 ± 0.63, $p < 0.001$). Treatment duration was also substantially longer in the extraction group (25.48 ± 5.14 months) than in the non-extraction group (10.52 ± 2.71 months, $p < 0.001$) reflecting the greater complexity and severity of such cases.

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4. Discussion

The present study evaluated treatment outcomes in extraction and non-extraction cases treated with clear aligner therapy, using the Peer Assessment Rating (PAR) index as an objective measure. Both groups demonstrated significant improvements across most occlusal components, confirming the effectiveness of aligners in managing malocclusions of varying complexity. However, differences emerged in the magnitude of improvement, treatment duration, and refinement needs between the two groups.

Within the non-extraction group, highly significant improvements were achieved in the upper anterior segment (UAS), lower anterior segment (LAS), overjet, and overbite. The total weighted PAR score reduced by approximately 80% (from 16.55 ± 8.86 to 3.18 ± 5.90), consistent with thresholds for "greatly improved" outcomes as defined by Richmond et al.[13] This aligns with previous reports by Papadimitriou et al.[14] and Rossini et al.[15] indicating that clear aligners are particularly efficient in resolving mild-to-moderate crowding and achieving anterior alignment with high predictability.

In the extraction group, initial malocclusion severity was significantly higher, reflected by larger overjets and LAS discrepancies at baseline. Despite this, treatment led to substantial reductions across most parameters, including overjet (−12.0 mm) and overbite (−2.91 mm), and a marked 78% reduction in total weighted PAR (from 29.36 ± 7.93 to 4.91 ± 4.48) similar to the finding by Samer Jaber et al[16] . These findings also corroborate earlier work by Gaffuri et al.[17], who reported that extraction cases treated with aligners can achieve significant occlusal improvement, though often with longer treatment duration and greater reliance on refinement protocols.

Although extraction cases started with significantly greater malocclusion severity, both groups reached comparable post-treatment PAR scores, suggesting that aligners can achieve similarly favourable end results regardless of whether extractions are required. Importantly, the extraction group showed significantly greater reductions in LAS, overjet, and total weighted PAR compared to the non-extraction group. This highlights the role of extractions in managing severe crowding and large overjets, consistent with findings from Robertson et al.[18], who emphasized that extractions remain an essential adjunct in clear aligner protocols for complex malocclusions.

However, extraction cases were associated with significantly longer treatment duration (25.48 vs. 10.52 months) and nearly three times more refinement scans. These outcomes are similar with the observations of Charalampakis et al.[19], who noted that extraction cases with aligners often require multiple mid-course corrections to optimize space closure and root parallelism. Thus, while extractions enable comprehensive correction, they demand more clinical time and patient compliance. Clinicians should therefore anticipate extended timelines and increased patient compliance requirements in such cases.

From a clinical standpoint, the findings suggest that non-extraction cases can be managed efficiently with aligners, producing rapid improvements in alignment and occlusal relationships with relatively short treatment duration. While extraction cases, although are more challenging, can achieve comparable quality of outcomes, but clinicians should anticipate prolonged treatment times and increased refinement requirements. The reduction in PAR scores across both groups supports the reliability of clear aligners in meeting objective standards of treatment success, even in complex cases. These results highlight the versatility of aligners but also the importance of case selection, individualized planning, and patient counseling regarding expected treatment complexity and duration.

This study is limited by its modest sample size and retrospective design. Additionally, the PAR index, while validated, primarily reflects occlusal outcomes and does not capture aspects such as root angulation, periodontal health, or long-term stability. Future prospective studies with larger cohorts and 3D outcome assessments would provide a more comprehensive evaluation.

5. Conclusion

Clear aligner therapy was effective in producing significant occlusal improvements in both extraction and non-extraction cases, as measured by the PAR index. Non-extraction cases achieved rapid and predictable results with shorter treatment durations, while extraction cases—though starting with more severe malocclusions demonstrated comparable final outcomes but required longer treatment

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times and more refinements. These findings highlight the versatility of aligners in managing a broad spectrum of malocclusions and emphasize the importance of individualized treatment planning and patient counseling regarding expected complexity and duration.

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