

To Compare and Evaluate the Flexural Strength of Different Aligner Materials: A Randomised Clinical Study

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Abstract

Introduction:

Clear aligner therapy requires appliances to sustain mechanical integrity and continuous orthodontic forces under intraoral aging. Flexural strength is critical to withstand insertion, removal and torquing cycles, yet comparative clinical degradation data between thermoformed (PU and PETG) and direct 3D-printed polymers remain scarce. This prospective randomized clinical trial evaluated the time dependent and material dependant flexural strength of polyethylene terephthalate glycol (PETG), thermoplastic polyurethane (TPU), and 3D-printed Graphy TC-85 across clinical wear cycles after manufacturing, 7 and 14 days.

Methods

Forty-five patients were randomly allocated (n=15 per group) to receive PETG, TPU, or Graphy TC-85 aligners. Standardized specimens (5 × 40 mm) were sectioned from posterior segments at baseline (T0), Day 7 (T1), and Day 14 (T2) of intraoral wear. Flexural strength was evaluated via three-point bending tests on a universal testing machine (5 mm/min) and analyzed using repeated-measures ANOVA ($\alpha = 0.05$).

Results

Intraoral aging caused significant, time-dependent flexural strength reduction across all materials ($p < 0.001$), with approximately 80% of degradation occurring by Day 7. Graphy demonstrated the highest baseline flexural strength (14.79 ± 1.03 MPa), followed by PETG (13.39 ± 0.77 MPa) and TPU (12.46 ± 3.49 MPa). At Day 14, PETG retained significantly higher flexural strength (8.72 ± 2.29 MPa) than Graphy (4.99 ± 3.02 MPa) and TPU (3.39 ± 1.79 MPa); ($p < 0.001$), whereas TPU exhibited the lowest resistance overall.

Conclusions

While 3D-printed Graphy resin exhibits superior initial flexural strength, thermoformed PETG demonstrates significantly greater flexural retention and resistance to intraoral deformation over 14 days. Material-specific degradation kinetics should guide staging schedules and clinical selection.

INTRODUCTION

The landscape of modern orthodontics has evolved rapidly, driven by an expanding adult patient base seeking discreet, comfortable, and low-maintenance alternatives to conventional fixed appliances¹. In response, clear aligner therapy (CAT) has become a primary clinical modality, celebrated for its superior aesthetics, fewer emergency visits, and better periodontal compliance^{2,3}.

Clear aligners primarily function as class-I beam configurations during seating and unseating and active force transmission across interdental undercuts. Flexural strength also called as bend strength dictates an aligner's capacity to resist masticatory stresses, withstand repeated insertion and removal without permanent plastic deformation, and maintain planned biomechanical moments. A decline in flexural resistance directly causes premature force decay, preventing the aligner from sustaining prescribed orthodontic moments throughout the cycle.

Achieving predictable orthodontic tooth movement—typically sequenced in increments of 0.1 mm to 0.33 mm per step over a 7- to 14-day cycle—demands that the appliance maintain continuous, physiologically tolerable loads on the periodontal ligament ^{4, 5, 6, 7}.

Traditionally, aligners are produced by thermoforming—most commonly using polyethylene terephthalate glycol (PET-G) and thermoplastic polyurethane (TPU) ^{8, 9}. Although PET-G delivers high initial stiffness and optical clarity, and TPU provides flexibility and fracture resistance, the thermoforming process itself causes substantial drawing and stretching, resulting in regional thickness variations up to 30% to 35%, leading to uneven force delivery ^{10, 11}. Once subjected to intraoral stresses (continuous moisture, enzymatic action, cyclic occlusion, and thermal fluctuations between 5°C and 55°C), these thermoplastics suffer significant structural degradation, sometimes losing more than 40% to 50% of their initial force delivery within the first week ^{12–14}.

To circumvent some of the structural drawbacks of thermoforming, direct three-dimensional (3D) printing has emerged as an alternative manufacturing route ¹⁵. Additive fabrication allows uniform or customized cross-sectional geometries ¹⁶. A prominent commercially approved photocurable resin in this sector is Tera Harz TC-85 (Graphy Inc., Seoul, Korea), an engineered urethane dimethacrylate (UDMA) photopolymer ¹⁷. TC-85 is characterized by thermal shape-memory behavior: when activated at oral temperatures (> 30°C), its network structure relaxes and recovers its shape, delivering gentle, sustained forces and displaying resistance to rapid mechanical degradation ^{18, 19}.

Despite the clinical deployment of direct-printed and thermoformed systems, quantitative comparisons assessing the time-dependent degradation of their flexural performance during clinical use remain extremely sparse ²⁰. Till date, there is no published data of change in flexural strength after intraoral use comparing Graphy with thermoformed materials. An optimal aligner staging protocol must also account for the mechanical degradation kinetics of the polymer shell ²¹. While tensile testing characterizes uniaxial stretching, flexural strength and flexural modulus are amongst primary mechanical properties governing intraoral performance.

Manufacturers currently recommend wear protocols ranging from 7 days (accelerated staging) to 14 days (standard staging) without robust comparative data detailing how flexural properties degrade between these two critical time points ²².

AIM OF THE STUDY

To compare the flexural strength of 3 different aligner materials at fixed interval of time during clinical wear.

OBJECTIVES OF THE STUDY

1. To evaluate the flexural strength of aligner material of PETG, TPU and Graphy (Tera Harz- TC85, DPA) after thermoforming and before delivering to patient.
2. To evaluate the flexural strength of the aligner material after 7 days of wear.
3. To evaluate the flexural strength of the aligner material after 14 days of wear.
4. To compare the flexural strength between different groups.

MATERIALS AND METHODS

The present investigation was designed as a prospective, randomized clinical study to evaluate and compare the effect of intraoral aging clinical wear on flexural strength of aligners fabricated from Polyethylene Terephthalate Glycol (PETG), Thermoplastic Polyurethane (TPU), and directly 3D-printed Graphy (TC-85 DPA) material.

The sample comprised 135 aligners from 45 patients undergoing orthodontic treatment with aligners. The study evaluated the null hypothesis that no difference in flexural strength exists among the materials at all 3 time intervals against the alternate hypothesis that a difference does exist, rejecting the null hypothesis only if statistical significance was reached.

Following confirmation of eligibility and acquisition of informed consent, participants were randomly allocated to one of the three study groups. The treatment protocol incorporated sequential aligner therapy with standardized activation protocols to minimize variability attributable to treatment mechanics. All aligners were designed with identical parameters, including uniform thickness, standardized trim line configuration, and no attachments were used. Care was taken to ensure that differences in flexural strength were attributable solely to the aligner material rather than design-related factors.

INCLUSION CRITERIA

Patients aged 18 to 30 years with mild malocclusion requiring clear aligner therapy. Participants had good oral hygiene, healthy periodontal status, and a willingness to wear the aligners for 20 to 22 hours per day. Candidates had to possess the ability to understand the study protocol and provide written informed consent to comply with the study requirements.

EXCLUSION CRITERIA

Patients presenting with active periodontal disease, smoking or tobacco consumption, or bruxism, parafunctional habits, GERD or allergies to aligner materials were excluded from the study.

STUDY GROUPS

Participants were allocated into the following three groups:

- **Group A (PETG)** -15 Patients received clear aligners fabricated from **Polyethylene Terephthalate Glycol** (DURAN+, Scheu-Dental GmbH, Iserlohn, Germany; nominal thickness 0.75 mm).
- **Group B (TPU)** – 15 Patients received aligners fabricated from **Thermoplastic Polyurethane** (Taglus PU Flex, Vedia Solutions, Mumbai, India; nominal thickness 0.75 mm).
- **Group C (Graphy)** – 15 Patients received directly three-dimensional printed aligners fabricated from **Tera Harz TC-85 DPA** (Graphy Inc., Seoul, South Korea; design thickness 0.75 mm).

CLINICAL PROTOCOL

Following fabrication, each participant received the assigned aligner corresponding to the randomized allocation. Three sets of aligners were fabricated on the first day of orthodontic treatment (0 day aligner), one set was used for study purpose and the second one was delivered to the patient. The first fabricated set of aligners was retained as T0. The second set was delivered to the patient. Retracted aligners were collected on Day 7 (T 1) and Day 14 (T 2).

The cleaned specimens were individually labelled with participant identification number, study group, and retrieval interval before being stored in sterile airtight containers at room temperature until laboratory testing. Test specimens required for mechanical evaluation were prepared from predetermined regions of the aligners using standardized cutting templates to ensure dimensional uniformity.

Immediately upon retrieval, each aligner was rinsed under running distilled water and subsequently stored in a sterile airtight container until laboratory testing. specimens then underwent laboratory evaluation to determine the effect of intraoral aging on their flexural strength. Mechanical testing was carried out under standardized laboratory conditions in accordance with internationally accepted testing protocols for polymeric dental materials.

All specimens were tested by the same operator using calibrated equipment to minimize operator-dependent variability. Prior to testing, the equipment was calibrated according to the manufacturer's recommendations.

FLEXURAL STRENGTH EVALUATION

Flexural strength was evaluated in accordance with using the same Universal Testing Machine employing the three-point bending test. Three-Point Bending Test for flexural strength- posterior buccal flat segment (5 x40 mm) from mesial of first premolar to distal of second molar to was cut with a disc to measure flexural strength as that area faces maximum flexural force. The sample was placed in the aligned and calibrated Universal Testing Machine. The flexure strength of each specimen was measured using a universal testing machine (Instron Electropulse E3000) with a crosshead speed of 5mm/min (Fig. 7). The specimen was positioned on two parallel supporting pins spaced at a span length (L) of 15 mm. A centralized loading nose deflected the specimen at a crosshead speed of 5mm/min. Force (F) was measured at deflection points $d_1=0.5\text{mm}$ and $d_2 = 1.0\text{mm}$. The flexural load at maximum deflection was used to calculate the overall flexural strength (MPa) which was recorded automatically by the testing software. Three-point bending was selected because it closely simulates the repeated bending forces experienced by clear aligners during insertion, removal and mastication.

SAMPLE SIZE ESTIMATION

Sample size was calculated using **G*Power 3.1** with an a priori **one-way ANOVA (fixed effects, omnibus)**, assuming an effect size (f) of **1.07**, $\alpha = 0.05$, **80% power**, and **3 groups**.

The analysis yielded a minimum sample size of **36 participants (12 per group)**. To provide a larger and balanced sample, the study included **45 participants, with 15 participants in each group** (PETG, TPU, and Graphy TC-85).

RESULTS

Table 1
Descriptive Statistics of Flexural Strength

Group	N	Baseline		Day 7		Day 14	
		Mean	SD	Mean	SD	Mean	SD
PETG	15	13.3853	0.77181	9.5087	1.77763	8.7153	2.28767
TPU	15	12.4560	3.49033	4.5440	2.32677	3.3933	1.78979
Graphy	15	14.7907	1.02799	7.9200	2.57134	4.9933	3.01767

Table 1 presents the descriptive statistics of Flexural Strength for the three aligner materials (PETG, TPU, and Graphy) evaluated at baseline, Day 7, and Day 14. The table provides the mean Flexural Strength, standard deviation, and sample size for each material at the respective time intervals. At baseline, Graphy demonstrated the highest average Flexural Strength, followed by PETG and TPU, indicating superior initial resistance to fracture. Following artificial aging, all three materials exhibited a progressive reduction in Flexural Strength, suggesting that prolonged exposure adversely affected their mechanical integrity. Among the tested materials, TPU showed the greatest decline over time, whereas PETG

retained comparatively higher fracture resistance after aging. These descriptive findings indicate that Flexural Strength decreases with increasing aging duration, although the extent of deterioration varies among the different aligner materials.

Table 2
Mixed Repeated Measures ANOVA for Flexural Strength

Tests of Within-Subjects Effects						
Source	Type III Sum of Squares	Df	Mean Square	F	p value	Effect size (Partial Eta Squared)
Time	1542.592	2	771.296	200.105	< 0.001, S	.827
time * Group	133.817	4	33.454	8.679	< 0.001, S	.292
Tests of Between-Subjects Effects						
Group	324.160	2	162.080	20.747	< 0.001, S	.497

Table 2 presents the results of the mixed repeated measures ANOVA evaluating the effects of aging time, aligner material, and their interaction on Flexural Strength. The analysis demonstrated a highly significant effect of time, indicating Flexural Strength changed significantly during the aging period irrespective of the material tested. The significant interaction between time and material suggests that the magnitude of **Flexural Strength** reduction differed among PETG, TPU, and Graphy during aging. The large partial eta squared values indicate that both time and material exerted strong effects on Flexural Strength and accounted for a substantial proportion of the observed variability. Consequently, the null hypothesis stating that aging and material type have no effect on Flexural Strength is rejected.

Table 3
Pairwise comparisons of Flexural Strength among aligner material groups

Pairwise Comparisons						
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p value ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
PETG	TPU	3.739*	.589	< 0.001, S	2.269	5.208
	Graphy	1.302	.589	.098	– .168	2.771
TPU	PETG	-3.739*	.589	< 0.001, S	-5.208	-2.269
	Graphy	-2.437*	.589	< 0.001, S	-3.906	– .968
Graphy	PETG	-1.302	.589	.098	-2.771	.168
	TPU	2.437*	.589	< 0.001, S	.968	3.906
Based on estimated marginal means						
*. The mean difference is significant at the .05 level.						
b. Adjustment for multiple comparisons: Bonferroni.						

Table 3 presents the Bonferroni-adjusted pairwise comparisons of Flexural Strength among PETG, TPU, and Graphy. Following the identification of a significant overall group effect by ANOVA, pairwise analysis was performed to determine which specific material pairs differed significantly. The results demonstrated that PETG exhibited significantly greater Flexural Strength than TPU, indicating superior resistance to fracture under mechanical loading. Similarly, Graphy also demonstrated significantly higher Flexural Strength than TPU. However, no statistically significant difference was observed between PETG and Graphy, suggesting that these two materials possess comparable fracture resistance when averaged across all evaluation periods. Collectively, these results indicate that TPU exhibits significantly lower Flexural Strength than both PETG and Graphy, whereas PETG and Graphy perform similarly with respect to fracture resistance.

Table 4
Pairwise comparisons of Flexural Strength among different time points

Pairwise Comparisons						
(I) time	(J) time	Mean Difference (I-J)	Std. Error	p value ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
Baseline	Day 7	6.220*	.441	< 0.001, S	5.120	7.320
	Day 14	7.843*	.487	< 0.001, S	6.628	9.058
Day 7	Baseline	-6.220*	.441	< 0.001, S	-7.320	-5.120
	Day 14	1.624*	.286	< 0.001, S	.910	2.337
Day 14	Baseline	-7.843*	.487	< 0.001, S	-9.058	-6.628
	Day 7	-1.624*	.286	< 0.001, S	-2.337	-.910
Based on estimated marginal means						
*. The mean difference is significant at the .05 level.						
b. Adjustment for multiple comparisons: Bonferroni.						

Table 4 presents the Bonferroni-adjusted pairwise comparisons of Flexural Strength across the three evaluation periods: baseline, Day 7, and Day 14. This analysis identifies the specific time intervals during which significant changes in Flexural Strength occurred. The results revealed highly significant reductions in Flexural Strength from baseline to Day 7 and from baseline to Day 14, indicating that the aging process produced a marked deterioration in the mechanical properties of the aligner materials. Furthermore, a statistically significant reduction was also observed between Day 7 and Day 14, demonstrating that degradation continued beyond the initial week of aging. These findings indicate that flexural strength declined progressively throughout the experimental period rather than stabilizing after the first phase of aging.

Table 5
Simple effects (materials compared at each time point) for Flexural strength

Time	Comparison	p-value
Day 0	PETG vs TPU	0.728, NS
Day 0	PETG vs Graphy	0.241, NS
Day 0	TPU vs Graphy	0.014, S
Day 7	PETG vs TPU	< 0.001, S
Day 7	PETG vs Graphy	0.180, NS
Day 7	TPU vs Graphy	0.001, S
Day 14	PETG vs TPU	< 0.001, S
Day 14	PETG vs Graphy	< 0.001, S
Day 14	TPU vs Graphy	0.231, NS

Table 5 presents the analysis comparing Flexural Strength among the three aligner materials separately at baseline, Day 7, and Day 14. At baseline, Flexural Strength was comparable between PETG and Graphy as well as between PETG and TPU, whereas a significant difference was observed between TPU and Graphy, indicating superior initial fracture resistance of Graphy over TPU. After seven days of aging, both PETG and graphy demonstrated significantly greater Flexural Strength than TPU. PETG and Graphy were comparable during this period . By Day 14, PETG demonstrated significantly higher Flexural Strength than both TPU and Graphy, whereas no significant difference was observed between TPU and Graphy. Clinically, these results suggest that PETG may provide greater durability and resistance to fracture during extended orthodontic treatment, making it a more mechanically stable aligner material following aging.

Time: 1-Baseline; 2-Day 7; 3-Day14

Group: 1-PETG; 2-TPU; 3-Graphy

Figure1 : The figure demonstrates a progressive decline in the estimated marginal means of the flexural strength across the three time points (baseline, Day 7, and Day 14) in all three groups. At baseline, Graphy showed the highest mean value, followed by PETG and TPU. By Day 7 and Day 14, all groups showed a marked reduction, with PETG retaining relatively higher values, while TPU showed the greatest overall decline. Graphy demonstrated an intermediate pattern, with values remaining higher than TPU at Day 7 and Day 14. The fall was highest in initial 7 days but continued deterioration happened in next 7 days but at lesser rate. Graphy started with highest flexural strength but at days 7 and 14 days of intra oral use it showed intermediate flexural strength between PETG and PU.

DISCUSSION

Intraoral environments expose clear aligner materials to continuous biochemical and physical stressors, including human saliva, temperature fluctuations, dietary factors, masticatory forces, microbial activity, and routine insertion and removal cycles. These factors induce water sorption, plasticization, stress relaxation, hydrolytic degradation, thermal aging, and surface wear, resulting in progressive changes in polymer mechanical properties²³. In the present study, comparative evaluation of Polyethylene Terephthalate Glycol (PETG), Thermoplastic Polyurethane (TPU), and direct-printed photopolymer Graphy TC-85 revealed that baseline flexural strength, intraoral degradation rates, and post-aging stability are strongly dependent on polymer chemistry and structural configuration.

At baseline, Graphy TC-85 demonstrated the highest mean flexural strength, followed by PETG and TPU. This superior initial fracture resistance aligns with recent evaluations of cross-linked resin networks formulated for direct 3D printing²⁴. Unlike linear thermoformed polymers, 3D-printed photopolymers form covalently cross-linked acrylic networks during photocuring, which effectively resist initial deformation under mechanical loading²⁵. This high initial performance is compatible with investigations describing the mechanical behaviour and shape-memory characteristics of TC-85, which combine flexibility and mechanical strength at oral temperatures^{24, 26}.

In contrast, TPU exhibited lower baseline flexural strength compared to Graphy and PETG. This observation agrees with the characteristic molecular architecture of polyurethane systems, which consist of alternating soft and hard polymer segments that deliver a lower flexural modulus and higher elastic resilience rather than rigid resistance to bending forces²⁷. Lower flexural strength should not automatically be interpreted as inferior clinical performance; high elastic compliance and resilience enhance initial patient comfort, facilitate ease of insertion, and minimize severe force spikes upon appliance seating^{23, 27}.

Following 7 and 14 days of intraoral wear, all three materials demonstrated progressive, statistically significant reductions in flexural strength. Mixed repeated measures ANOVA confirmed significant main effects of both time and material, along with a significant material–time interaction. This demonstrates that intraoral exposure dynamically degrades fracture resistance and that different polymer matrices decay at variable rates.

The present findings demonstrated that flexural strength is governed by both intrinsic material composition and duration of aging, leading to the rejection of the null hypothesis. The significant interaction between aging time and material type indicates that mechanical degradation does not progress uniformly across materials; rather, PETG, TPU, and Graphy exhibited distinct patterns of reduction in fracture resistance over time. Furthermore, the large effect sizes underscore that intraoral aging is a primary determinant of aligner mechanical stability, highlighting the need to account for time-dependent degradation when selecting clear aligner materials for clinical use. These findings align with earlier investigations by Eliades and Bourauel (2005)¹² and Schuster et al. (2004)¹³, who reported that

intraoral conditions—namely cyclic loading, temperature swings between 5°C and 55°C, and continuous moisture—rapidly compromise polymer integrity compared to dry, ex vivo storage.

The evaluation of estimated marginal means across the entire 14-day cycle in Table 3 demonstrated marked differences in bend resistance among the three polymers. PETG exhibited significantly higher overall flexural strength than TPU, and Graphy TC-85 similarly demonstrated significantly greater flexural strength than TPU. However, when pooled across all time intervals, PETG and Graphy were statistically comparable. This demonstrates that TPU consistently exhibits the lowest overall resistance to flexural deformation under continuous clinical use. This outcome is consistent with mechanical evaluations conducted by Zhang et al. (2016)⁹ and Condò et al. (2021)⁸, who reported that polyurethane-based aligners naturally yield lower flexural strength and elastic modulus relative to polyester-based matrices. As Alexandropoulos et al. (2015)⁶ noted, the molecular structure of TPU consists of alternating soft and hard segments; while this architecture imparts high resilience, toughness, and patient comfort, it provides lower rigid resistance against flexural bending compared to amorphous polyesters or highly cross-linked acrylics.

Table 4 interprets that approximately 80% of the total cumulative mechanical deterioration occurred during the first 7 days of clinical wear. This rapid initial deterioration strongly corroborates observations by Papadopoulou et al. (2021)⁷, Simon et al. (2014)⁵, and Kohda et al. (2013)¹⁴, who demonstrated that clear thermoplastics lose a substantial portion of their force-delivery and stiffness within the initial days of intraoral placement. Water sorption breaks secondary interchain hydrogen bonds within the polymeric matrix, increasing free volume and accelerating hydrolytic plasticization. When combined with cyclic masticatory deformation and repeated insertion-removal cycles, this initial plasticization produces pronounced early stress relaxation.

In Table 5, analysis suggest that at Baseline (Day 0) Directly 3D-printed Graphy resin exhibited significantly greater flexural strength than thermoformed TPU ($p = 0.014$), while differences between PETG and TPU ($p = 0.728$) and between PETG and Graphy ($p = 0.241$) were not statistically significant. Graphy's high initial bend resistance stems from the dense, covalently cross-linked urethane dimethacrylate (UDMA) acrylic network formed during additive photocuring. This finding corroborates investigations by Can et al. (2022)[17], Zinelis et al.¹⁸, and Jindal et al.¹⁶, which demonstrated that 3D-printed aligners avoid the drawing and thinning artifacts (up to 30%–35% thickness loss) induced by conventional thermoforming, thereby exhibiting superior initial structural rigidity and dimensional uniformity. At Day 7 (Short-Term Aging): Both PETG and Graphy maintained significantly higher flexural strength than TPU ($p < 0.001$ and $p = 0.001$, respectively), whereas PETG and Graphy remained statistically comparable ($p = 0.180$). By Day 7, TPU suffered an acute decline of approximately 64% from its baseline strength. This rapid early decay reflects accelerated hydrolytic plasticization and continuous stress relaxation under masticatory loading, aligning with in vitro relaxation studies by Lombardo et al. (2017)¹⁰ and Zhang et al. (2016)⁹. At day 14 (Extended Aging): A significant divergence occurred at Day 14, where PETG retained significantly greater flexural strength (8.72 ± 2.29 MPa) than both TPU ($3.39 \pm$

1.79 MPa, $p < 0.001$) and Graphy (4.99 ± 3.02 MPa, $p < 0.001$). Furthermore, TPU and Graphy became statistically comparable ($p = 0.231$). Although Graphy displayed superior initial rigidity and shape-memory potential, prolonged exposure to intraoral moisture and cyclic occlusal fatigue degraded its cross-linked matrix. This aligns with recent evaluations of direct-printed aligners by Edelmann et al. (2023)²⁰, Lee et al. (2022)¹⁹, and Tartaglia et al. (2021)¹⁵, who noted that photocurable resins exhibit drops in surface hardness and flexural modulus after extended fluid immersion due to progressive water sorption in micro-voids, network relaxation, and leaching of unreacted monomer components.

PETG's superior long-term flexural retention is attributed to its amorphous, glycol-modified polyester configuration, which demonstrates lower water absorption and greater hydrolytic stability over extended periods compared to polyurethane elastomers or photocured methacrylate matrices. Clinically, while TPU's elastic compliance provides initial comfort and ease of insertion, and Graphy offers robust initial rigidity, PETG provides the structural stability necessary to prevent appliance sagging, tracking loss, and micro-fracture during extended 14-day aligner wear protocols.

Strengths and limitation of the Study

The major strengths were the prospective in vivo design and direct comparison of flexural strength of three contemporary materials under identical clinical conditions with longitudinal assessment at 0, 7 and 14 day. Inclusion of the emerging directly printable Graphy TC-85 adds novelty and clinical relevance. Short observation period and patient related biological variation could be considered some limitations

CONCLUSION

1. Although intraoral aging induced a progressive decline in mechanical properties across all materials, PETG preserved a significantly higher proportion of its baseline flexural strength. So though it started below graphy but at day 14 the flexural strength was highest amongst 3 materials.
2. Graphy had the highest initial flexural strength but the final flexural strength was highest of PET G and lowest of PU
3. PU had the lowest Flexural strengths of all the 3 materials at day 0,7 and 14 days. The fall was similar to that of graphy.

DECLARATIONS

Author Contribution

V.G.and C.A.wrote main manuscript textD.B.supervise the articleAll authors reviewed the manuscript.

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Figures

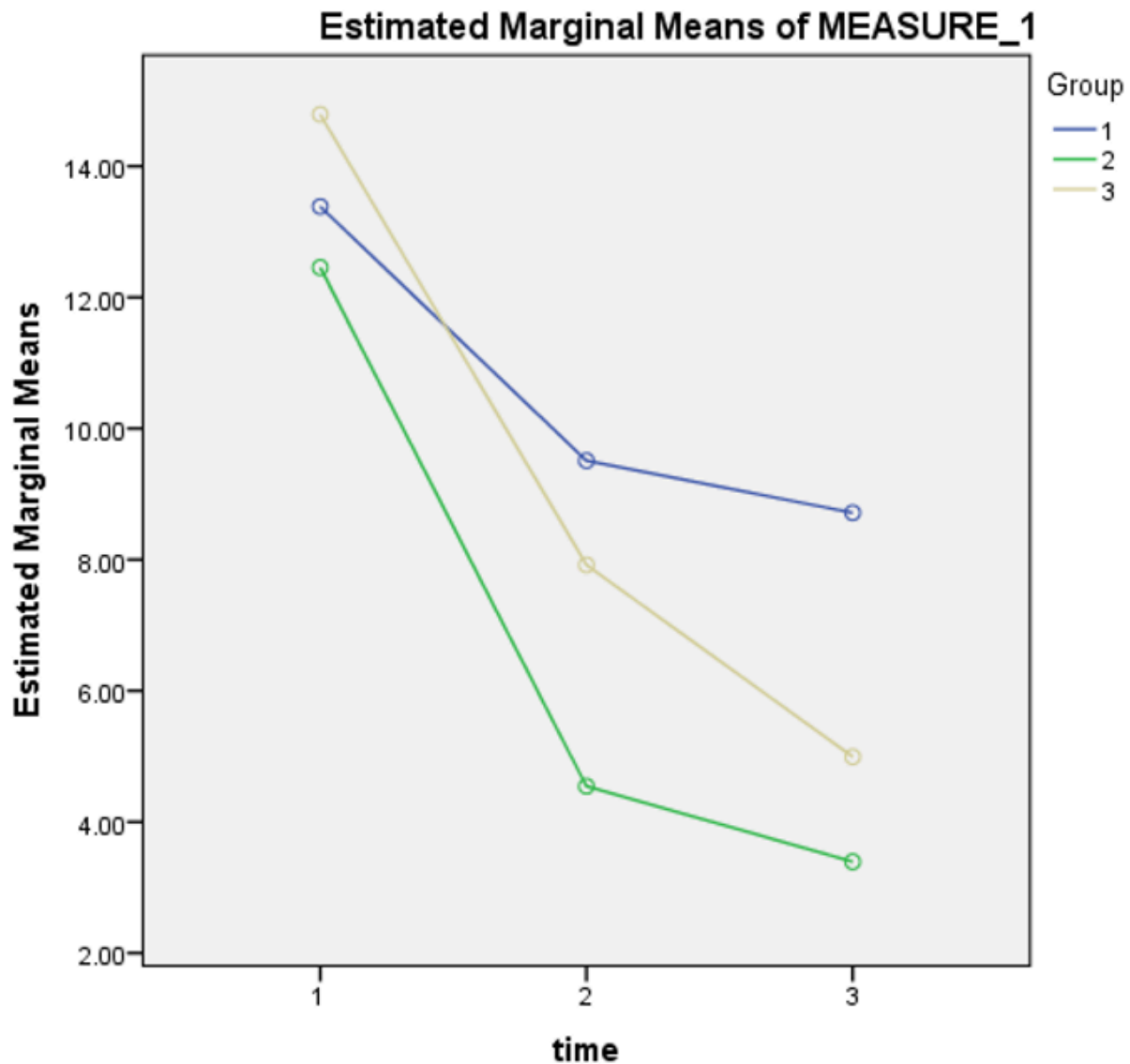


Figure 1

The figure demonstrates a progressive decline in the estimated marginal means of the flexural strength across the three time points (baseline, Day 7, and Day 14) in all three groups. At baseline, Graphy showed the highest mean value, followed by PETG and TPU. By Day 7 and Day 14, all groups showed a marked reduction, with PETG retaining relatively higher values, while TPU showed the greatest overall decline. Graphy demonstrated an intermediate pattern, with values remaining higher than TPU at Day 7 and Day 14. The fall was highest in initial 7 days but continued deterioration happened in next 7 days but at lesser rate. Graphy started with highest flexural strength but at days 7 and 14 days of intra oral use it showed intermediate flexural strength between PETG and PU.