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Passer Journal of Basic and Applied Sciences

Passer 8 (Issue 2) (2026) 1057-1064

Original Article

Comparative Analysis of Model Resin and Orthodontic Resins: Accuracy and Dimensional Stability of 3D Printed Models for Clear Aligners and Removable Appliances

Halo Salah Omer Salhi * [1], Arass Jalal Noori [2]

[1] *Department of Orthodontics, Kurdistan Higher Council of Medical Specialties, Sulaymaniyah 46001, Kurdistan Region, Iraq.*
[2] *Department of Pedodontics and Community Oral Health, College of Dentistry, University of Sulaimani, Sulaymaniyah 46001, Kurdistan Region, Iraq.*

Received 18 June 2026; revised 01 August 2026;
accepted 12 August 2026; available online 21 September 2026

DOI: 10.24271/PSR.2026.583048.2853

ABSTRACT

(1) Background**:** The accuracy and structural integrity of 3D-printed resin models are ultimate determinants of the quality and fit of orthodontic appliances, and therefore directly impact clinical treatment outcomes. Since there is a wide variety of photopolymer resins available in the market, each with different chemical composition, mechanical properties, and clinical indications, it is essential to evaluate their behavior for proper selection of the appropriate resin for each clinical application. (2) Objectives**:** The present study aimed at evaluating the initial printing accuracy directly after printing, thermo-mechanical dimensional stability after clear aligner thermoforming and PMMA cold-cure acrylic appliance fabrication of two commercially available 3D printing resins (KeyModel Ultra and KeyOrtho Model).(3) Methods**:** Forty standardized master dental models (N=40) were 3D printed and assigned to two main groups (n = 20) based on the resin material. Initial printing accuracy was quantified by calculating the Root Mean Square (RMS) deviation between the printed models against the master digital reference file, and each group was then further divided into two subgroups (n = 10), subjected to clear aligner thermoforming and to PMMA appliance fabrication. Post-procedure scans were superimposed onto the corresponding pre-procedure model scans to evaluate the dimensional stability after undergoing laboratory procedures. (4) Results**:** KeyModel Ultra showed RMS deviation of 0.209 ± 0.033 mm against the master digital reference file, while KeyOrtho Model showed a significantly lower mean RMS deviation of 0.161 ± 0.042 mm ($p = 0.011$). Following laboratory fabrication procedures, KeyOrtho Model demonstrated no statistically significant dimensional change after clear aligner thermoforming ($p = 0.160$) or PMMA cold-cure appliance fabrication ($p = 0.780$), whereas KeyModel Ultra showed statistically significant structural change under both conditions ($p = 0.004$). 5) Conclusion**:** KeyOrtho Model demonstrated better initial accuracy and greater dimensional stability than KeyModel Ultra under the tested laboratory conditions.

Keywords: 3D printing, Orthodontic appliances,Clear aligner,Dental models ,Dimensional stability.

1 Introduction

During the last 4 decades, 3D printing technology has turned into a fundamental tool across a variety of industries, ranging from prototyping in automotive and industrial design to advanced applications in healthcare and medicine. The field of dentistry is not an exception; incorporation of 3D printing has revolutionized clinical workflows across various specialties, including prosthodontics, oral surgery, restorative dentistry, and orthodontics, ultimately yielding improved efficiency, faster and better clinical outcomes [1]. Today, this technology is routinely used for the fabrication of clear aligners, removable orthodontic appliances, prosthodontic restorations, and surgical guides [2].

With the development of affordable 3D printing systems, an increasing number of dental clinics are beginning to use in-office printing in their day-to-day workflows [3] which allowed clinicians to produce a diverse range of models, including study casts, clear aligner models, prosthodontic restorations, and removable orthodontic appliances. The increased use of in-office 3D printing has increased focus on the accuracy, dimensional stability, and overall reliability of 3D printed appliances because differences at the micron level may result in differences in appliance fit and ultimately clinical outcomes. Numerous printing technologies using distinct photopolymerization techniques such as Stereolithography (SLA), Liquid Crystal Display (LCD), and Digital Light Processing (DLP) have been presented to the dental

* Corresponding author
E-mail address halosalah@ymail.com (Instructor).
Peer-reviewed under the responsibility of the University of Garmian.

market. While the choice of 3D printers significantly affects accuracy of the models, the specific type of resin material used remains a critical determinant of the physical and mechanical reliability of the fabricated models [2,4]. Therefore, a wide range of photopolymer resins have been developed with different mechanical properties and chemical compositions for different clinical applications. Among many different resin materials two commonly used resins are: Model resin and Orthodontic model resin. Model resins are designed to be used for general purposes in various dental specialties, including prosthodontics, oral surgery, and restorative dentistry for a broad range of dental applications, including the fabrication of diagnostic study models, prosthodontic restorations, and surgical guides. While Orthodontic resins are designed to produce superior quality in terms of dimensional stability, mechanical properties and surface quality that allows to deliver more accurate outcomes[5]. In orthodontics, 3D printed models are used for many purposes ranging from making study models for diagnosis and treatment plan, splints for orthognathic surgeries, fabrication of removable appliances on the models, to fabrication of clear aligners on series of printed models. Accuracy of these models is critical on their outcome as a small deviation may lead to poor fit or unexpected result from the digital setup plan [6]. There are different resins compared in the literature. However, thorough literature reviews show that so far only few studies have focused on the influence of the resin formulation on the dimensional accuracy of the printed samples.

The current study therefore aims to compare and evaluate two commercial photopolymer resins: a general purpose model resin (KeyModel Ultra) and an orthodontic specific resin (KeyOrtho Model) (Keystone Industries, USA) across three primary parameters: Initial printing accuracy relative to the master digital reference file, dimensional stability after clear aligner thermoforming, and dimensional stability after fabrication of PMMA cold-cure removable orthodontic appliances. The results of this study are intended to provide evidence-based recommendations for the selection of 3D printing resins for clinical orthodontic workflows.

2 Materials and Methods

2. 1 Materials

KeyOrtho Model and KeyModel Ultra Resins of which composition and mechanical properties are demonstrated in (Table 1 and 2) (Keystone Industries, Gibbstown, NJ, USA), ≥97% isopropyl alcohol (Tekkim Kimya, Bursa, Turkey), Cold-Cure Orthodontic Acrylic (Orthocryl; Dentaurum, Ispringen, Germany).

Table 1: Keyortho model resin and Keymodel Ultra resin compositions[7,8].

Ingredient Name	Keyortho resin (%)	Keymodel Ultra (%)
Acrylate Monomer 1	≥10 - <25	≤3%
Acrylate Monomer 2	≥10 - ≤25	-*
Acrylate Monomer 3	-	<1
Acrylate Monomer 4	<0.2	-
Acrylic Acid	<0.1	-
Photo Initiator 1	<3	-
Photo Initiator 3	-	≤3
Titanium Dioxide	-	≤1
Urethane Oligomer 1	-	≥25 - ≤50

*: indicates that the ingredient was not listed in the composition data provided for that specific model.

Table 2: Mechanical properties of the two resin types [13,14].

Mechanical Property	Testing Standard	KeyModel Ultra	KeyOrtho Model
Flexural Strength	ASTM* D790	> 70 MPa	79.6 MPa
Flexural Modulus	ASTM D790	> 1940 MPa	2293 MPa
Maximum Tensile Strength	ASTM D638	> 50 MPa	51.0 MPa
Tensile (Young's) Modulus	ASTM D638	1700 MPa	1850 MPa
Elongation at Break	ASTM D638	5%	5.60%
Shore Hardness (Scale D)	ASTM D2240	*Not specified*	86
Viscosity @ 25°C	ASTM D2196	600–7500 cP	*Not specified*

*: American Society for Testing and Materials Standards

2. 2 Methods

2. 2. 1 Study design and Sample Size Calculation

The required sample size for this *in vitro* study was determined using G*Power software (version 3.1, Düsseldorf, Germany). Based on previous *in vitro* dental material literature evaluating dimensional accuracy, a large effect size was anticipated[2]. A priori power analysis was conducted for an Independent Samples t-test with an assumed large effect size of Cohen's d = 0.95, an alpha error probability of $a = 0.05$, and a statistical power of 0.80. The analysis showed that a minimum of 18 specimens per main group (N = 36) was required. To account for potential printing or processing errors, the sample size was rounded up to 20 specimens per main resin group, resulting in a total sample size of (N = 40) models.

The samples were divided into two groups of 20 models, based on the resin type used: Group A (n=20): Printed using KeyModel Ultra resin, Group B (n=20): Printed using KeyOrtho Model resin. Overview of the study design and workflow further illustrated in Figure 1.

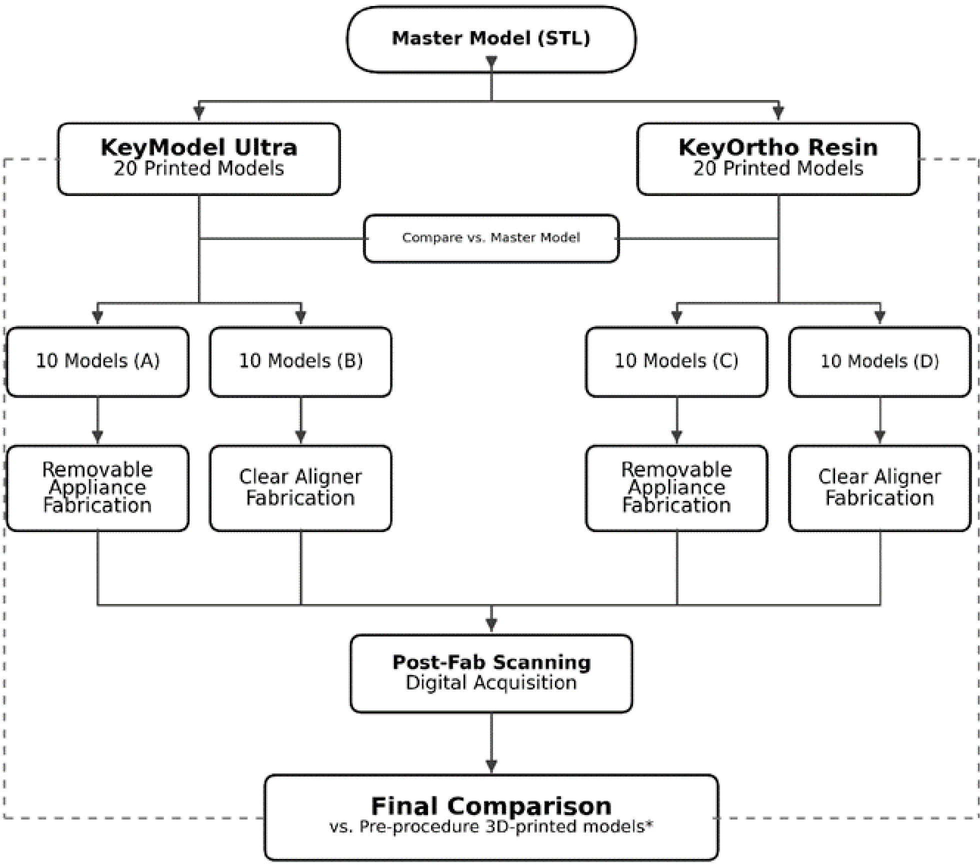
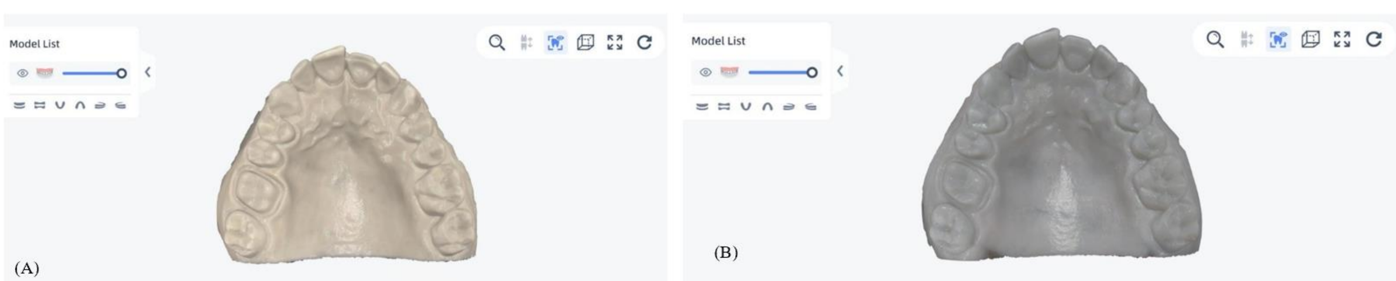


Figure 1: Overview of the study design and workflow *(Models prior to undergoing laboratory procedures).

2. 2. 2 Model Design and printing process.

A master digital test model was obtained from Shining 3D (Hangzhou, China) and imported into the Microform Slicer software (Microlay, Madrid, Spain) as shown in Figure 2 . All models were oriented vertically at 100-micron layer thickness with the pre-loaded printing profiles for Keystone resins for Microlay DLP 3D printer (Microlay, Madrid, Spain). 20 models were printed using Keyortho model resin and another 20 models were printed using Keymodel ultra resin. A total of eight print sessions were conducted at 30 Celsius chamber temperature with all printing sessions run under identical printing conditions. The printing sessions were balanced across groups with four printing sessions per resin groups.



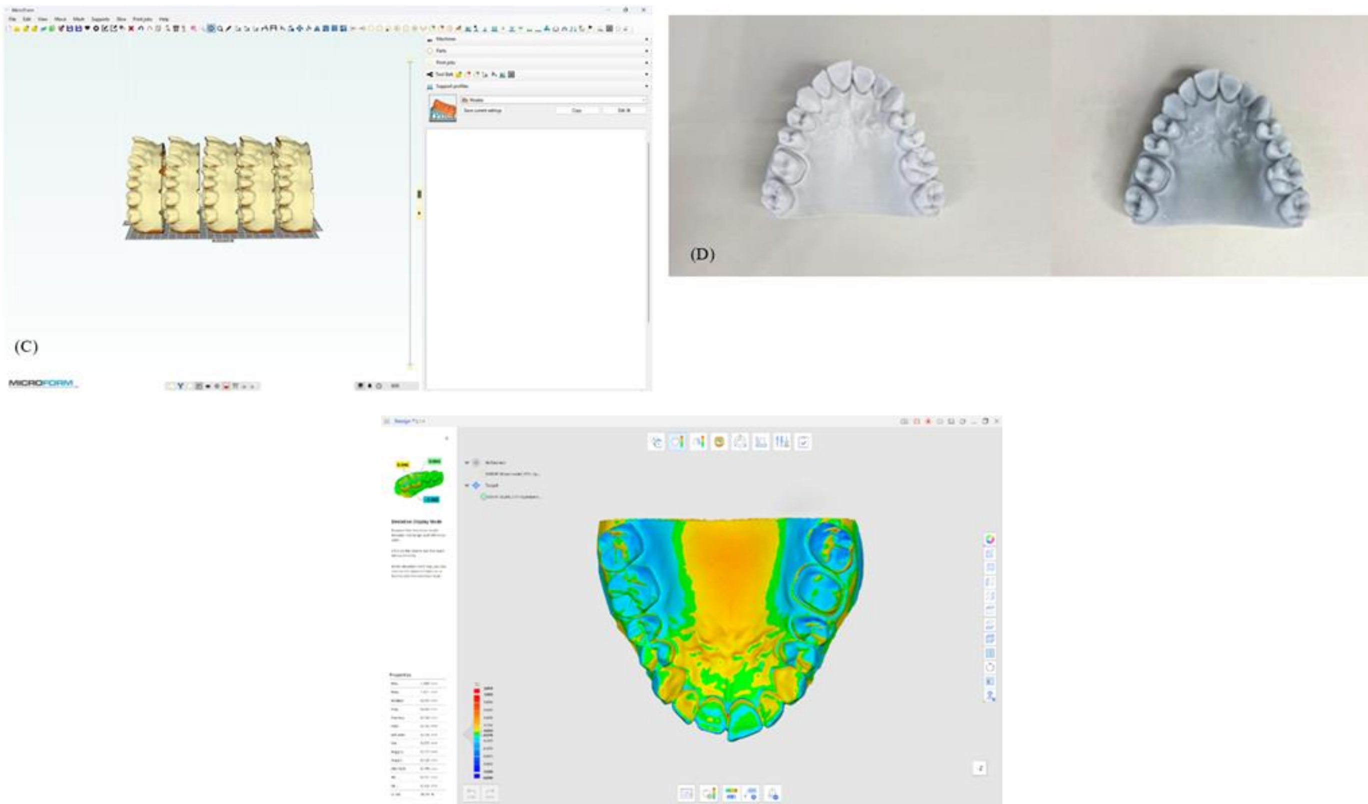


Figure 2: Scanned models with Aeoral scan 3 wireless (A) Scanned model of Keymodel Ultra resin (B) Scanned model of Keyortho model resin. (C) Models in the Microform slicer software. (D) Printed models. (E) Superimposition of models inside Medit link software.

2. 2. 3 Print post processing

Each model was cleaned to remove residual uncured resin in a two-stage bath of ≥97% isopropyl alcohol for each stage lasting 3 minutes, as recommended by the manufacturer to avoid structural degradation, and then dried with compressed air. Post-curing was performed in a Sprint Ray ProCure unit (SprintRay, Los Angeles, CA, USA) using the manufacturer-validated settings for each resin. KeyModel Ultra models (Group A) were post-cured for 30 minutes at 50°C, while the KeyOrtho Model models (Group B) were post-cured for 15 minutes at 50°C, as recommended by the manufacturer.

2. 2. 4 Printed model Scanning and superimposition

All physical models, as demonstrated in Figure 2, were digitized using a Shining 3D Aeoralscan 3 wireless intraoral scanner , Figure 2. To ensure accuracy, the scanner was calibrated with the manufacturer's designated calibration block immediately prior to each scanning session, and all scans were then captured by a single operator using the scanner's standard-resolution settings. To assess dimensional accuracy, the scanned models from Group A were superimposed onto the original digital reference model using the Medit Design software module within Medit Link software (Medit Corp., Seoul, South Korea) as shown in Figure 2, and the Root Mean Square (RMS) deviations were recorded. The exact superimposition and measurement protocol were then repeated for Group B models.

2. 2. 5 Method errors

For method error, the same operator re-scanned the same models after one-week interval, and RMS values were recorded as deviation measurements. The agreement between the first and second measurements was determined using the Intraclass Correlation Coefficient (ICC), which was 0.92, indicating excellent intra-operator measurement repeatability.

2. 2. 6 Orthodontic removable appliance fabrication and Clear Aligner thermoforming

To facilitate further analysis, both main resin groups are subdivided into two subgroups of 10 models each (n=10) according to the laboratory procedure performed. In Group A (KeyModel Ultra), half of the models were used for clear aligner thermoforming, while the remaining half were used to fabricate orthodontic acrylic appliances. Group B (KeyOrtho Model) was divided following the exact same protocol. This standardized distribution ensured accurate and consistent comparison across both materials.

The thermoforming was conducted with 0.76 mm (Iconic Align) thermoplastic sheets from DB Orthodontics (DB Orthodontics, Silsden, UK) using a Biostar positive-pressure thermoforming machine (Scheu-Dental, Essen, Germany), with 220 Celsius, Heating time 45 seconds, and cooling time of 80 seconds thermoforming parameters.

The remaining 10 models from each main group were used to fabricate removable orthodontic appliances. Imprimo (Schei dental, Essen, Germany) separating medium was applied to the models to allow removal of the appliances. Standardized amount of orthodontic acrylic (Dentaurum, Germany) was applied to the models using sprinkling technique and then put in a pressure pot at 30 psi for 15 minutes to allow polymerization.

After the removal of clear aligners and acrylic appliances, all the models were washed with water to remove the remaining debris and dried with compressed air, and then they were scanned by the Shining 3D Aeoralscan 3 wireless scanner.

2. 2. 7 Post-procedure scanning

To evaluate the dimensional changes from the laboratory procedures only, scans were compared against the respective scans of the printed models rather than against the original master STL (standard tessellation language) file, this was carried out deliberately to exclude the initial inaccuracies associated with 3D printing and to isolate the effects of the thermomechanical fabrication processes. Scans were superimposed using MeditLink software and RMS values were recorded for both subgroups.

2. 2. 8 Statistical analysis

All data were analyzed using SPSS software version 30 (IBM Corp., Armonk, NY, USA). Descriptive statistics (means and standard deviations) of the RMS deviation values were computed for all groups. Before performing any comparative test, all data sets were checked for normality using the Shapiro-Wilk test ($\alpha = 0.05$). For the inter-group comparison of the initial accuracy, the data were normally distributed, and Levene's test showed that the variances of the groups were equal; therefore, the Independent Samples t-test was used to compare the mean RMS values between the KeyOrtho Model and KeyModel Ultra resins. For the intra-group comparison of the dimensional changes before and after the laboratory procedures (clear aligner thermoforming and appliance fabrication test selection depended on the normality of each paired dataset. When data were normally distributed, a Paired Samples t-test was applied; otherwise, the Wilcoxon Signed-Rank test was used. For all analyses, the level of statistical significance was set at ($p < 0.05$).

2. 2. 9 Use of AI

The authors have used (Grammarly; Grammarly Inc., USA) for the improvement of the language and grammar of this manuscript, and all contents were then reviewed and edited by the authors.

3 Results and Discussions

3. Results

3. 1 Initial Printing accuracy

An Independent Samples t-test revealed a statistically significant difference in initial accuracy between the two resin formulations (p = 0.011). The KeyModel Ultra (Group A) exhibited a mean RMS deviation of 0.209 ± 0.033 mm. In comparison, the KeyOrtho Model (Group B) recorded a mean Root Mean Square (RMS) deviation of 0.161 ± 0.042 mm as demonstrated in Table 3.

Table 3: Initial Printing accuracy (Comparison to Master Digital File).

Resin Material	Sample Size (n)	Mean RMS Deviation (mm) ± SD	p-value*	Result
KeyModel Ultra (Group A)	20	0.209 ± 0.033	**0.011**	Lower initial accuracy
KeyOrtho Model (Group B)	20	0.161 ± 0.042		Superior initial accuracy

*Independent Samples t-test. Significance threshold set at P = 0.05.

3. 2 Dimensional Stability Following Clear Aligner Thermoforming

Following the thermomechanical procedure of the clear aligner fabrication process (high heat and positive pressure), post-procedure scans of the clear aligner subgroups were superimposed onto their respective printed model scans. Intra-group analysis revealed that the KeyOrtho Model showed no statistically significant dimensional shift from its initial geometry (p = 0.160). The KeyModel Ultra subgroup exhibited statistically significant structural change and collapse (p = 0.004) as demonstrated in Table 4.

3. 3 Dimensional Stability Following Removable orthodontic Appliance Fabrication

The second set of subgroups was evaluated for dimensional changes after contact with the chemical solvents and exothermic heat of cold-cure PMMA appliance fabrication. The KeyOrtho Model subgroup exhibited no significant volumetric changes compared to pre-procedure state (p = 0.780). However, the KeyModel Ultra exhibited measurable dimensional shrinkage with a mean deviation of -0.061 mm (p = 0.004) as shown in Table 4.

Table 4: Dimensional Stability Following Laboratory Stresses.

Laboratory Procedure	Resin Material	Subgroup (n)	Mean Change (mm) ± SD	*p*-value	Outcome Assessment
Clear Aligner Thermoforming	KeyModel Ultra	10	0.082 ± 0.024	0.004 *	Significant Deformation
	KeyOrtho Model	10	0.014 ± 0.011	0.160 **	Dimensionally Stable
PMMA Appliance Fabrication	KeyModel Ultra	10	0.061 ± 0.019	0.004 *	Significant Deformation
	KeyOrtho Model	10	0.003 ± 0.012	0.780 *	Dimensionally Stable

*: Paired Samples t-test; **: Wilcoxon Signed-Rank test. (Significance threshold set at p = 0.05).

4 Discussion

The use of three-dimensional (3D) printing technologies has resulted in a paradigm shift in orthodontic laboratory workflows, transitioning from analog plaster casts to highly customized digital resin models[9]. Within this digital ecosystem, the dimensional stability and initial printing accuracy of photopolymer resin-based dental models form the foundation for the successful fabrication of well-fitting orthodontic appliances [10]. The primary objective of the current *in vitro* investigation was to assess and compare the initial dimensional accuracy and subsequent thermomechanical stability of two commercially available orthodontic resins, KeyOrtho Model and KeyModel Ultra, when subjected to routine laboratory procedures. According to the deviation values of Root Mean Square (RMS), the null hypothesis was firmly rejected. The data demonstrated that the KeyOrtho Model resin exhibited significantly better initial accuracy and a significantly higher resistance to deformation from laboratory procedures compared to the KeyModel Ultra resin across all tested parameters.

A critical design element in the current study was the testing of both resins under two different fabrication protocols; clear aligner thermoforming and PMMA cold-cure removable appliance fabrication, which was a purposeful, clinically motivated decision. In the routine orthodontic practice, a single brand of 3D printing resin is typically used in a variety of laboratory applications because it is not practical or economically viable for the average dental laboratory to stock separate resins for each application. Thus, from a translational perspective, it was directly relevant to determine whether each resin could withstand the different mechanical and chemical stress profiles of these procedures, because thermoforming subjects the printed model to extreme thermal stress from the heated thermoplastic sheets, while PMMA processing subjects it to both exothermic heat and the solvent effect of the liquid monomer, which are two distinct types of stress. The testing of both protocols for each material allowed for a more complete, and clinically relevant characterization of material performance, The consistency of the findings across both protocols is itself remarkable, and it suggests that the dimensional superiority of KeyOrtho Model was not procedure-specific, but rather a more robust and generalizable material reliability, which further supports the clinical recommendation of KeyOrtho Model as the more suitable resin for orthodontic laboratory applications.

The initial printing accuracy is critical, as any discrepancy present immediately after post-curing will inevitably compound during subsequent appliance manufacturing stages[2,11]. When assessing the pre-procedure datasets, The independent samples t-test showed that the 3D printed models obtained from KeyOrtho resin were significantly closer to the original digital reference file with a mean RMS deviation of 0.161 ± 0.042 mm, which was compared to 0.209 ± 0.033 mm for the KeyModel Ultra resin, and this comparison yielded a p-value of (0.011). In the field of orthodontics, an RMS discrepancy below 0.25 mm is generally acceptable as the clinical threshold for accurate clear aligner and appliance production[6,12]. Therefore, while both resins theoretically fall within clinically acceptable parameters, KeyOrtho provides a mathematically stricter tolerance and a more accurate replication of the patient's intraoral anatomy.

The superior initial accuracy observed in the KeyOrtho group may be attributed to the chemical composition and photopolymerization characteristics of the resin and photopolymerization process[13]. Liquid 3D printing resins are composed of monomers, oligomers, and photo initiators that undergo rapid chemical cross-linkage when exposed to specific wavelengths of ultraviolet (UV) light[14]. During this stage transition from a liquid state to a solid polymer network, nonhomogeneous dimensional changes inevitably occur. The chemical basis for the differences in physical performance of the two resins can be inferred from the Safety Data Sheets, and the increased dimensional stability of the KeyOrtho Model resin may arise from its denser and more complex monomeric framework, which includes 10% to 25% of Acrylate Monomer 1 and 10% to 25% of Acrylate Monomer 2, as demonstrated in Table 1 [8]. In contrast, the KeyModel Ultra formulation is devoid of this highly cross linkable monomer network, containing no more than 3% of Acrylate Monomer 1, but does contain a higher concentration of Urethane Oligomer (25% to 50%),as shown in Table 1 [7,8]. This chemically robust, multi-monomer blend in the KeyOrtho resin likely generates a highly crosslinked polymer network that minimizes shrinkage vectors during both the active printing process and the UV post curing protocol [15].

Beyond initial accuracy, orthodontic models must demonstrate high resilience against severe chemical and physical procedural stresses, chiefly during the fabrication of removable appliances. When exposed to this demanding acrylic fabrication protocol, the KeyOrtho resin maintained its structural integrity remarkably well, the Paired Samples t-test showed no statistically significant deformation between the pre-procedure and post-procedure states (p = 0.780). In contrast, the KeyModel Ultra resin was highly susceptible to these stresses, undergoing a statistically significant dimensional change (p = 0.004) characterized by an average dimensional change of -0.061 mm. KeyModel Ultra is composed of a large amount of Urethane Oligomer (25-50%) and a very small amount of acrylate monomer (≤3%) and may not have the cross-link density required to resist the two stresses placed on the model by PMMA processing: the exothermic heat of polymerization and solvent action of the liquid PMMA monomer. These composition differences may translate the difference in mechanical properties of the two materials as shown in Table 2. Consequently, under these thermal and chemical stresses, a possible mechanism is that the polymer network of the more flexible KeyModel Ultra resin relaxes, allowing latent internal stresses in the model from the initial 3D-printing process to be relieved as visible distortion [16]. For the practicing orthodontist, the higher chemical and thermal resistance of KeyOrtho may warrant better appliance fabrication accuracy in which may remove the need for expensive, time-consuming chairside adjustments during the delivery appointment of the appliance [2,17].

Among the various procedural stresses, thermoforming is one of the most mechanically demanding exposures for 3D-printed dental models. Thermoforming includes heating a thermoplastic foil—typically polyethylene terephthalate glycol (PETG) or thermoplastic polyurethane (TPU)—to temperatures exceeding 220°C before adapting it firmly over the printed model using high-velocity vacuum suction machine with positive pressure[18]. This extreme transmission of heat may force the 3D-printed resin to approach its internal Glass Transition Temperature (Tg). The Glass Transition Temperature is the critical thermal threshold point at which a hard, glassy polymer starts to lose its molecular rigidity, transitioning into a soft, rubbery, and highly deformable state[19]. After the thermoforming cycle, the Wilcoxon Signed-Rank test showed no significant deformation in the KeyOrtho aligner models ($p = 0.160$), because a high glass transition temperature (Tg) resists the thermal shock from the molten plastic. On the other hand, the KeyModel Ultra models showed a statistically significant dimensional change under the same conditions ($p = 0.004$), indicating that the thermal energy applied during the thermoforming process exceeded the thermal resistance of the KeyModel Ultra resin, causing softening, melting, and distortion of the fine anatomical details, especially at the incisal edges under vacuum pressure.

A model that undergoes distortion during thermoforming may produce clear aligners that are systematically inaccurate, with potentially detrimental consequences for patient treatment outcomes [20]. Clear aligner therapy depends on highly precise, microscopic geometric divergences between the aligner plastic and the tooth surface to produce the biomechanical forces needed for orthodontic tooth movement [21]. If the 3D-printed model underlying the aligner sheet shrinks or melts during the thermoforming process, the resulting clear aligner will be systematically undersized or inaccurate [22]. When a patient tries to seat an undersized aligner, it will fail to fully engage the composite attachments, resulting in immediate loss of tracking of the treatment plan, longer treatment times, localized ischemic pain in the periodontal ligament, and the costly and labor-intensive necessity of mid-course clinical refinements [23].

Collectively, the results of the current study indicate that the choice of resin material has the most significant effect on both initial printing accuracy and dimensional stability under subsequent fabrication procedures, irrespective of the intended clinical application, the specific laboratory application for which the model is being produced, and the consistent superior performance of KeyOrtho Model in both the thermoforming and PMMA fabrication protocols suggest that this material may be more universally reliable for orthodontic model production.

Although the data may suggest the superiority of the KeyOrtho Model resin, it is important to acknowledge the inherent limitations of this research. Mainly, this research was conducted as an *in vitro* laboratory study, meaning the tested parameters cannot entirely reproduce the dynamic, complex environment of the human oral cavity where these appliances will ultimately function[24]. Additionally, the study employed a highly standardized workflow, depending on a single brand of 3D printer, a fixed layer height during printing, and a particular UV post-curing unit. Differences in slicing software algorithms, printer light engine types, or different post-curing times could yield different dimensional stability outlines for both resins [25,26].

Future studies could complement the present results in several possible ways, first, FEA (finite element analysis) could be used to create more accurate maps of stress and strain throughout the models during thermoforming [27]. Secondly, *in vivo* clinical trials could compare aligners fabricated on KeyOrtho models to those fabricated on other resins and brands, evaluating variables such as seating accuracy, retention forces, biocompatibility, and patient-reported comfort [28].Thirdly, long-term studies of the dimensional stability of 3D-printed models during storage in various humidity and UV light conditions would be valuable to clinicians and laboratories that store models for future retainer fabrication[29].

5 Conclusion

Within the limitations of this *in vitro* study, KeyOrtho Model demonstrated better initial accuracy and greater dimensional stability than KeyModel Ultra under the tested laboratory conditions.

Finally, the choice of 3D printing material is a critical factor that directly influences the accuracy of orthodontic appliances and clear aligners. KeyOrtho Model resin was found to be better than KeyModel Ultra in all the parameters evaluated and hence was found to be more suitable and reliable material for the fabrication of orthodontic appliances under the tested laboratory conditions.

Funding

This research received no external funding from funding agencies in the public, commercial, or non-profit sectors.

Acknowledgements

Thanks to my family, colleagues and everyone who helped me with their support.

Authors contribution

Halo Salah Omer Salhi (Writing—original draft, Conceptualization, Visualization, Investigation, Data collection, Formal analysis, Software, Methodology, Validation). Arass Jalal Noori (Writing—review & editing, Data curation, Conceptualization, Methodology, Validation, Formal analysis, Supervision).

Conflict of interests

The authors declare no conflicts of interest.

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