

SLA-based relief matrix production in contemporary printmaking: Material performance, detail fidelity, and print consistency*

Çağdaş baskiresimde SLA tabanlı yüksek baskı kalıbı üretimi: Malzeme performansı, detay aktarım doğruluğu ve baskı tutarlılığı

Gönderim Tarihi / Received: 13.01.2026

Burçak BALAMBER¹

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ABSTRACT: This study examines the technical potentials and limitations of SLA-based three-dimensional printing technology for the production of relief printing matrices within contemporary printmaking practice. The research evaluates the process through which digitally designed linear compositions are transformed into physical matrices via photopolymer-based SLA printing, using criteria such as structural durability, fidelity of detail transfer, ink retention and distribution characteristics, and print consistency. Within the scope of the study, SLA-printed matrices produced at different thicknesses were tested under traditional relief printmaking workshop conditions. Their mechanical and surface behaviors during inking, press pressure, and repeated printing were comparatively observed. The findings indicate that SLA matrices produced at sufficient thickness maintain structural stability during printing, enable the high-fidelity transfer of digitally designed compositions with dense linear structures into physical form, and support ink distribution compatible with conventional relief printing techniques. Print outputs obtained through repeated impressions exhibited a high degree of consistency in terms of line quality, tonal balance, and edge sharpness, demonstrating that SLA-based matrices offer a functional alternative for editioned relief print production. The study argues that SLA technology should be regarded not merely as a digital fabrication tool but as a distinct method for matrix production within contemporary printmaking practice, and it provides a practice-based contribution to ongoing discussions on post-digital printmaking.

Keywords: Relief printmaking, 3D printing, SLA printing, Post-digital printmaking, Photopolymer matrix

ÖZ: Bu çalışma, SLA tabanlı üç boyutlu baskı teknolojisinin çağdaş baskiresim pratiğinde yüksek baskı kalıbı üretimi açısından sunduğu teknik olanakları ve sınırlılıkları incelemektedir. Araştırma, dijital olarak tasarlanan çizgisel kompozisyonların fotopolimer esaslı SLA baskı yoluyla fiziksel baskı kalıplarına dönüştürülmesi sürecini; yapısal dayanıklılık, detay aktarım doğruluğu, mürekkep tutma ve dağılım özellikleri ile baskı tutarlılığı ölçütleri üzerinden değerlendirmektedir. Çalışma kapsamında, farklı kalınlıklarda (2 mm ve 4 mm) üretilen SLA baskı kalıpları, geleneksel yüksek baskı atölye koşullarında test edilmiş; mürekkepleme, pres basıncı ve tekrar eden baskılar sırasında gösterdikleri mekanik ve yüzeysel davranışlar karşılaştırmalı olarak gözlemlenmiştir. Bulgular, yeterli kalınlıkta üretilen SLA baskı kalıplarının baskı sırasında yapısal stabiliteyi koruduğunu, yüksek çizgisel yoğunluğa sahip dijital tasarımların fiziksel ortama yüksek sadakatle aktarılabilirdiğini ve mürekkep dağılımının geleneksel tekniklerle uyumlu biçimde gerçekleştirilebildiğini göstermektedir. Tekrarlanan baskılar sonucunda elde edilen çıktılar, çizgi kalitesi, tonal denge ve kenar netliği açısından yüksek düzeyde tutarlılık sergilemiş; bu durum SLA tabanlı baskı kalıplarının edisyonlu baskı üretimi için işlevsel bir alternatif sunduğunu ortaya koymuştur. Çalışma, SLA teknolojisini yalnızca dijital bir üretim aracı değil, çağdaş baskiresim pratiğinde özgün bir baskı kalıbı üretim yöntemi olarak değerlendirilebileceğini ileri sürmekte ve post-dijital baskiresim tartışmalarına uygulamaya dayalı bir katkı sunmaktadır.

Anahtar Kelimeler: Yüksek baskiresim, 3 boyutlu baskı, SLA baskı, Post-dijital baskiresim, Fotopolimer baskı kalıbı

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¹ Doç. Dr., Balıkesir Üniversitesi/Güzel Sanatlar Fakültesi/Baskı Sanatları Bölümü, burcak.balamber@balikesir.edu.tr, <https://orcid.org/0000-0003-1098-6128>

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GENİŞLETİLMİŞ ÖZET

Literatür taraması

Baskıresim sanatı, tarihsel olarak çoğaltılabilirlik, aktarım ve görüntünün fiziksel bir kalıp ve baskı yüzeyi aracılığıyla üretilmesini esas alan maddi aracılık ilkeleri üzerine kurulu bir üretim alanı olarak değerlendirilmiştir. Baskıresim ile teknoloji arasındaki ilişki tarihsel olarak durağan değildir. Ağaç baskıdan gravüre, litografiden fotomekanik yöntemlere uzanan her teknik dönüşüm, baskıresmin hem maddi üretim süreçlerini hem de kavramsal konumunu yeniden şekillendirmiştir. Walter Benjamin'in mekanik yeniden üretim kuramı, bu dönüşümü estetik ve toplumsal bağlamda ele alarak, teknolojik çoğaltmanın sanat yapısının algılanma biçimini dönüştürdüğünü ortaya koymuştur. Benjamin'in yaklaşımı, baskıresim pratiğinde teknolojik aracılığın yalnızca bir kayıp değil, aynı zamanda yeni üretim olanakları yaratan bir süreç olduğunu göstermektedir.

Dijital teknolojilerin sanat üretimine dâhil olmasıyla birlikte baskıresim, post-dijital olarak tanımlanan genişletilmiş bir üretim alanı içinde değerlendirilmeye başlanmıştır. Bilgisayar destekli tasarım, dijital görüntü işleme, CNC üretim ve eklemeli imalat teknikleri, geleneksel baskıresim yöntemleriyle birlikte kullanılabilen hibrit iş akışlarının ortaya çıkmasına olanak tanımıştır. Post-dijital yaklaşım, dijital ve analog üretim süreçleri arasındaki karşıtlıkların geçerliliğini yitirdiğini, bunun yerine maddi ve hesaplamalı süreçlerin iç içe geçtiği bir üretim ortamının oluştuğunu savunmaktadır.

Bu bağlamda üç boyutlu baskı teknolojileri, baskıresimde kalıp üretimi açısından önemli bir potansiyel taşımaktadır. Mevcut literatür ağırlıklı olarak FDM ve CNC tabanlı yöntemlere odaklanırken, stereolitografi (SLA) teknolojisinin baskıresim bağlamındaki kullanımına ilişkin çalışmaların sınırlı olduğu görülmektedir. Oysa SLA, yüksek yüzey çözünürlüğü ve homojen malzeme yapısı sayesinde, baskıresimde detay aktarımı ve baskı tutarlılığı açısından özgün olanaklar sunmaktadır. Türkiye'deki güncel çalışmalar post-dijital baskıresim pratiklerine dikkat çekmekle birlikte, belirli bir üç boyutlu baskı teknolojisinin uygulamaya dayalı ayrıntılı analizini sunmamaktadır. Bu çalışma, söz konusu boşluğu SLA tabanlı kalıp üretimi üzerinden ele almayı amaçlamaktadır.

Yöntem

Bu çalışma, uygulamaya dayalı araştırma yaklaşımını benimseyerek, SLA tabanlı üç boyutlu baskı teknolojisi ile üretilen yüksek baskı kalıplarının geleneksel baskıresim üretim süreçleri içindeki performansını incelemektedir. Uygulama temelli yöntem, dijital üretim teknolojilerinin baskıresim pratiğiyle kurduğu ilişkiyi soyut varsayımlar üzerinden değil, doğrudan malzeme davranışı ve baskı çıktıları üzerinden değerlendirmeyi amaçlamaktadır. Bu bağlamda araştırma, tekrarlanan baskı uygulamalarına dayalı gözlemsel analiz ve karşılaştırmalı değerlendirme yoluyla yürütülmüştür.

Araştırma süreci, dijital tasarım ve modelleme, SLA tabanlı kalıp üretimi ve yüksek baskı uygulamaları olmak üzere üç ana aşamada yapılandırılmıştır. İlk aşamada, geleneksel manuel oyma teknikleriyle üretilmesi güç olan, yüksek çizgisel yoğunluğa ve tekrarlı yapılara sahip dijital kompozisyonlar tasarlanmıştır. Bu tasarımlar, vektör tabanlı görsellerden üç boyutlu rölyef formlara dönüştürülmüş, çizgisel elemanların derinlik, aralık ve yükseklik değerleri kontrollü biçimde belirlenmiştir. Bu aşama, dijital ortamda yapılan tasarım kararlarının fiziksel kalıp üretimine nasıl yansıdığını gözlemek amacıyla kurgulanmıştır.

İkinci aşamada, dijital olarak modellenen rölyef yüzeyler SLA teknolojisi kullanılarak fotopolimer reçine malzeme ile üretilmiştir. Kalıplar, farklı kalınlık değerlerinde (2 mm ve 4 mm) basılarak, kalınlığın yapısal dayanıklılık üzerindeki etkisi karşılaştırmalı olarak incelenmiştir. Baskı parametreleri, yüzey çözünürlüğünü ve detay aktarımını maksimize edecek biçimde belirlenmiş, katman yüksekliği düşük tutulmuş ve baskı sonrası kürleme işlemleri uygulanmıştır. Bu süreçte amaç, SLA teknolojisinin sağladığı yüzey hassasiyetinin yüksek baskı kalıbı üretimine ne ölçüde katkı sağladığını değerlendirmektir.

Üçüncü aşamada, üretilen kalıplar geleneksel yüksek baskı atölye koşullarında test edilmiştir. Kalıplar, yağ bazlı yüksek baskı mürekkepleri kullanılarak elle mürekkeplenmiş ve geleneksel baskı presinde

basılmıştır. Baskı sürecinde pres basıncı kademeli olarak ayarlanmış, kalıpların basınca verdiği tepkiler, mürekkep tutma ve dağılım davranışı ile tekrar eden baskılar boyunca gösterdikleri performans gözlemlenmiştir. Her bir kalıp, birden fazla baskı alımında kullanılarak, yüzey aşınması, detay kaybı ve baskı tutarlılığı açısından değerlendirilmiştir.

Araştırmada kalıp performansı, yapısal dayanıklılık, detay aktarım doğruluğu, mürekkep dağılımının homojenliği ve baskı çıktılarındaki görsel tutarlılık gibi ölçütler üzerinden ele alınmıştır. Değerlendirme sürecinde, SLA tabanlı kalıpların geleneksel ahşap ya da linolyum kalıplarla birebir karşılaştırılması amaçlanmamış, bunun yerine, bu kalıpların baskıresim pratiği içinde kendine özgü bir malzeme kategorisi olarak sunduğu olanaklar ve sınırlılıklar ortaya konulmuştur. Bu yaklaşım, SLA teknolojisini geleneksel yöntemlerin yerine geçen bir alternatif olarak değil, baskıresmin tarihsel üretim ilkeleriyle ilişki kuran çağdaş bir üretim yöntemi olarak konumlandırmaktadır.

Bulgular ve tartışma

Araştırma bulguları, SLA tabanlı kalıpların uygun kalınlıkta üretildiğinde yüksek baskı süreçlerine teknik olarak uyum sağladığını göstermektedir. Özellikle 4 mm kalınlığındaki kalıplar, pres basıncı altında yapısal stabiliteyi korumuş, çatlama, eğilme ya da yüzey bozulması göstermeden tekrar eden baskılara olanak tanımıştır. Buna karşılık, 2 mm kalınlığındaki kalıplarda deformasyon ve yapısal zayıflık gözlemlenmiştir. Detay aktarım doğruluğu açısından SLA teknolojisi önemli bir avantaj sunmuştur. Dijital ortamda tasarlanan ince ve yoğun çizgisel yapılar, fiziksel kalıplara yüksek sadakatle aktarılmış, baskı çıktılarında çizgi netliği ve kenar keskinliği korunmuştur. Bu durum, manuel oyma teknikleriyle elde edilmesi güç olan düzenli ve tekrarlı yapıların baskıresimde kullanılabilmesini mümkün kılmıştır. Mürekkep tutma ve dağılım davranışı, fotopolimer yüzeylerin geleneksel baskıresim pratikleriyle uyumlu olduğunu ortaya koymuştur. Kalıplar, özel bir yüzey işlemi gerektirmeden standart elle mürekkepleme teknikleriyle başarılı sonuçlar vermiştir. Tekrarlanan baskılar boyunca tonal denge ve çizgi kalitesi korunmuş, baskı çıktılarında yüksek düzeyde tutarlılık sağlanmıştır.

Bu bulgular, SLA tabanlı kalıp üretiminin, baskıresimde dijital hassasiyet ile maddi üretim süreçlerini bir araya getiren post-dijital bir yaklaşım sunduğunu göstermektedir. Kalıp üretimindeki tekrarlanabilirlik ve kontrol düzeyi, Ivins'in baskıresme attığı değişmez görsel ifade kavramıyla örtüşmektedir.

Sonuç ve öneriler

Bu çalışma, SLA tabanlı üç boyutlu baskı teknolojisinin çağdaş baskıresim pratiğinde yüksek baskı kalıbı üretimi açısından işlevsel ve uygulanabilir bir yöntem olduğunu ortaya koymuştur. Araştırma sonuçları, SLA teknolojisinin yalnızca dijital bir üretim aracı olarak değil, baskıresmin tarihsel ilkeleriyle uyumlu bir kalıp üretim yöntemi olarak değerlendirilebileceğini göstermektedir.

SLA tabanlı kalıplar, detay aktarım doğruluğu, baskı tutarlılığı ve yapısal dayanıklılık açısından geleneksel yüksek baskı süreçleriyle uyumlu sonuçlar sunmuştur. Bu durum, baskıresimde yeni biçimsel ve yapısal olanakların önünü açmakta; dijital tasarım temelli üretimlerin baskıresim pratiğine dâhil edilmesini mümkün kılmaktadır.

Araştırma, yalnızca SLA teknolojisine odaklanması ve sınırlı sayıda malzeme türü kullanması nedeniyle kapsam açısından belirli sınırlılıklar taşımaktadır. Gelecek çalışmalarda, farklı üç boyutlu baskı teknolojilerinin karşılaştırmalı olarak incelenmesi, farklı fotopolimer reçinelerin uzun vadeli dayanıklılıklarının test edilmesi ve daha geniş edisyon denemelerinin yapılması önerilmektedir. Bu doğrultuda, SLA tabanlı kalıp üretiminin baskıresimdeki yeri, daha kapsamlı ve disiplinlerarası çalışmalarla derinleştirilebilir.

Introduction

Printmaking has historically functioned as a system of visual production grounded in reproducibility, transfer, and material mediation. Beyond its role as a technique for image multiplication, printmaking has played a central part in the circulation and stabilization of visual knowledge through mechanically repeatable processes. Throughout its historical development, printmaking has continuously evolved in relation to technological change, adapting new tools and materials while maintaining its core principles of matrix-based production, pressure, and iteration.

In recent decades, the integration of digital technologies into artistic production has significantly transformed printmaking practices. Computer-aided design, digital image processing, and computational fabrication have introduced new modes of image construction and matrix production, challenging conventional distinctions between manual and mechanized processes. Within this context, digital tools are no longer external supplements to printmaking but have become embedded within hybrid workflows that combine digital precision with material and tactile engagement. Among these developments, three-dimensional printing technologies have emerged as a particularly influential yet insufficiently examined component of contemporary printmaking practice. While traditional relief printmaking relies primarily on hand-carved matrices produced from materials such as wood or linoleum, additive manufacturing technologies offer alternative approaches to matrix production based on digital modeling and automated fabrication. Despite their increasing availability, the use of three-dimensional printing technologies in printmaking is often discussed either in generalized terms or in opposition to traditional methods, rather than being evaluated through detailed, practice-based analysis.

This study focuses specifically on stereolithography (SLA)-based three-dimensional printing as a method for producing relief printing matrices. SLA technology, characterized by high-resolution layer formation and photopolymer-based material curing, presents distinct technical and material properties that differentiate it from other additive manufacturing methods commonly referenced in the literature, such as fused deposition modeling (FDM). However, the functional compatibility of SLA-fabricated matrices with traditional relief printmaking processes remains underexplored, particularly with regard to their performance under press conditions.

In this regard, the relief matrix should be understood not merely as a fabricated object but as an operative surface whose thickness, relief depth, surface resolution, and response to ink directly determine the quality of the printed image. Examining SLA-based matrices through these material and procedural parameters allows digital modeling decisions to be connected with observable outcomes in structural stability, detail fidelity, ink distribution, and repeatable print quality.

The primary problem addressed in this research concerns the lack of systematic, practice-based investigations into whether SLA-printed photopolymer matrices can operate as reliable relief printing matrices within conventional printmaking workflows. Specifically, questions remain regarding the structural durability of SLA-based matrices under press pressure, the accuracy with which digitally designed fine linear details can be transferred into printed images, the behavior of photopolymer surfaces during manual inking, and the degree to which print outputs remain consistent across repeated impressions. The absence of empirical evaluations addressing these interconnected issues has limited a clear understanding of the practical viability of SLA-based matrix production in relief printmaking.

Accordingly, the aim of this study is to investigate the technical capabilities and limitations of SLA-based three-dimensional printing for the production of relief printing matrices through experimental testing conducted under traditional workshop conditions. By examining how digitally designed linear compositions are translated into physical matrices, how these matrices respond to inking and press pressure, and how printed images perform over successive impressions, the research seeks to clarify whether SLA-based matrices can function in continuity with established relief printmaking principles. In doing so, the study positions SLA printing not merely as a digital fabrication technique but as a potential matrix production method that engages directly with the material, mechanical, and procedural demands of relief printmaking.

The significance of this research lies in its practice-based approach, which evaluates SLA-based matrix production through direct material experimentation and analysis of print outputs rather than abstract technological claims. By situating digital fabrication within the physical conditions of relief printmaking, the study contributes to broader discussions on post-digital printmaking and hybrid production methodologies, offering both technical insight and conceptual grounding for the integration of SLA technology into contemporary printmaking practice.

Literature review

Printmaking has long been understood not merely as a subsidiary art form but as a system of visual communication grounded in reproducibility, transmission, and material mediation. From its emergence in early modern Europe, printmaking enabled the stabilization and circulation of images with a degree of precision that fundamentally transformed the production and dissemination of knowledge. As William M. Ivins argued, the defining characteristic of the printed image lies in its capacity for “exactly repeatable pictorial statements,” distinguishing it from the variability inherent in hand-drawn images (Ivins, 1969: 93). This technical condition positioned printmaking as a primary agent in the formation of modern visual epistemologies, allowing images to function as reliable carriers of information across time and space.

The relationship between printmaking and technology, however, has never been static. Each major technological shift – from woodcut to intaglio, from lithography to photomechanical reproduction – has reconfigured not only the material processes of print production but also the conceptual status of the printed image. Walter Benjamin’s analysis of mechanical reproduction remains foundational in this regard. In *The Work of Art in the Age of Its Technological Reproducibility*, Benjamin locates reproducibility at the center of modern aesthetic experience, arguing that technological reproduction alters the ontology of the artwork by detaching it from ritual and singular presence (Benjamin, 2008: 21-23). While Benjamin’s concept of aura has often been invoked to frame anxieties surrounding technological mediation, his text simultaneously emphasizes the productive potential of reproduction as a means of expanding artistic practice and social function (Benjamin, 2008: 36). Within printmaking, this tension between loss and expansion has persisted as a recurring critical theme.

In the late twentieth and early twenty-first centuries, the integration of digital technologies into printmaking practice has intensified this historical dynamic. Digital imaging, computer-aided design, CNC machining, and additive manufacturing have introduced new modes of matrix production, challenging traditional distinctions between manual and mechanized processes. Rather than signaling the obsolescence of printmaking, these developments have contributed to what has been described as an expanded or post-digital field of graphic production. Contemporary printmaking increasingly operates beyond medium-specific boundaries, incorporating hybrid workflows that combine analog tactility with digital precision (Pettersson, 2017: 9-12). Similarly, as described by Mínguez García et al. (2023: 3), digital printmaking not as a rupture but as a process of hybridization in which electrographic and computational systems extend the conceptual margins of graphic art.

The notion of the “post-digital” has proven particularly productive in articulating these shifts. Rather than denoting a period after digital technology, post-digital aesthetics describe a condition in which the digital is no longer novel but embedded, materially and conceptually, within everyday practices. Ludovico argues that post-digital print reflects a renewed attention to materiality, process, and publishing practices that emerge after the initial dematerializing enthusiasm of early digital culture (Ludovico, 2012: 13). In a similar vein, Berry and Dieter conceptualize the post-digital as an epistemic constellation shaped by computation, in which digital systems are not immaterial abstractions but operational structures that reorganize artistic production at a material level (Berry et al., 2015: 2). Within this framework, the distinction between digital and non-digital practices becomes increasingly blurred, giving rise to hybrid forms that are simultaneously computational and physical.

Printmaking has played a central role in this post-digital reconfiguration precisely because of its historical reliance on the matrix as a mediating structure. Contrary to assumptions that digital technologies eliminate the need for physical matrices, many contemporary printmakers continue to

emphasize matrix-based processes, albeit through new technical means. Maxwell notes that while digital culture has dramatically increased the speed and scope of image dissemination, printmakers have responded by exploiting material constraints and processual complexity as critical strategies within a post-print environment (Maxwell, 2015: 3-4). This persistence of the matrix underscores the continued relevance of printmaking's core principles – transfer, pressure, surface, and iteration – even as tools and materials evolve.

Contemporary practitioners such as Paul Coldwell, Endi Poskovic, and Mike Lyon exemplify this hybrid orientation. Coldwell's integration of digital imaging with traditional print techniques demonstrates how computational tools can function as extensions of established graphic languages rather than replacements for them (Kılıç Ateş, 2017: 78). Poskovic similarly frames technique as inseparable from concept, arguing that contemporary printmaking derives its critical strength from the deliberate negotiation between technological means and conceptual intent (Kılıç Ateş, 2010: 16). Lyon's use of CNC machining and digitally generated toolpaths further illustrates how computational systems can be mobilized to sustain, rather than negate, the embodied labor of printmaking (Catanese et al., 2017: 121).

Within this expanded field, three-dimensional printing has emerged as a particularly significant yet under-theorized technology. Existing literature has largely focused on fused deposition modeling (FDM) and CNC milling as alternatives for relief and intaglio plate production (Merriam et al., 2017: 30). However, comparatively little attention has been paid to stereolithography (SLA) as a matrix-producing method within traditional printmaking contexts. SLA technology, characterized by high-resolution layer formation and resin-based curing, offers distinct material properties that differ substantially from both subtractive carving and filament-based additive processes. These properties raise critical questions regarding surface fidelity, durability under press conditions, and the translation of digital depth into printable relief.

Recent studies in the Turkish context have begun to address post-digital printmaking practices, emphasizing hybrid methodologies that integrate digital modeling with physical printing processes. Korkmaz (2024: 90-92) identifies three-dimensional printing as a key component of post-digital printmaking, particularly in its capacity to generate physical matrices that exceed the limitations of manual carving. Similarly, İnan and Uğuz (2025: 340-342) highlight the role of digital fabrication technologies in expanding the technical and conceptual boundaries of contemporary printmaking, while cautioning against reductive narratives that frame digital tools as inherently opposed to traditional practices. Although these studies provide valuable contextual insights, they stop short of offering detailed, practice-based analyses of specific additive manufacturing technologies within printmaking workflows.

This article seeks to address this gap by examining the use of SLA-based three-dimensional printing as a method for producing relief printing matrices. Situated within the broader discourse of post-digital printmaking, the study investigates the technical capabilities and limitations of SLA technology in relation to traditional relief printing processes. By focusing on material behavior, surface resolution, and press performance, the research aims to contribute both methodologically and conceptually to ongoing discussions surrounding hybrid printmaking practices. In doing so, it argues that SLA-based matrix production should be understood not as a peripheral experiment but as a viable extension of printmaking's historical engagement with technological innovation.

Methodology

This study adopts a practice-based research methodology grounded in material experimentation and technical analysis. The research focuses on the production of relief printing matrices using stereolithography (SLA)-based three-dimensional printing and evaluates their performance within traditional relief printmaking workflows. Rather than treating digital fabrication as an ancillary tool, the study positions SLA printing as an integral component of matrix production, comparable in function to carved wood or linoleum blocks.

The research data were generated through practice-based material experiments conducted in 2024, including the production of SLA-printed relief matrices and the analysis of the resulting print outputs. Since the study does not involve human participants, personal data, surveys, interviews, or animal subjects, ethics committee approval was not required.

The methodological framework combines experimental making with comparative material assessment. The research process was structured into three sequential phases: digital image preparation and three-dimensional modeling, SLA-based matrix fabrication, and relief printing and evaluation under press conditions. This phased structure allowed for systematic observation of how digital parameters translate into physical relief surfaces and how these surfaces perform during inking and printing. Consistent with post-digital printmaking discourse, the study emphasizes the continuity of printmaking principles such as matrix, pressure, transfer, and repetition across both digital and analog stages of production. The digital environment is therefore treated not as a dematerialized space but as a site of material decision-making that directly affects the physical outcomes of the printed image.

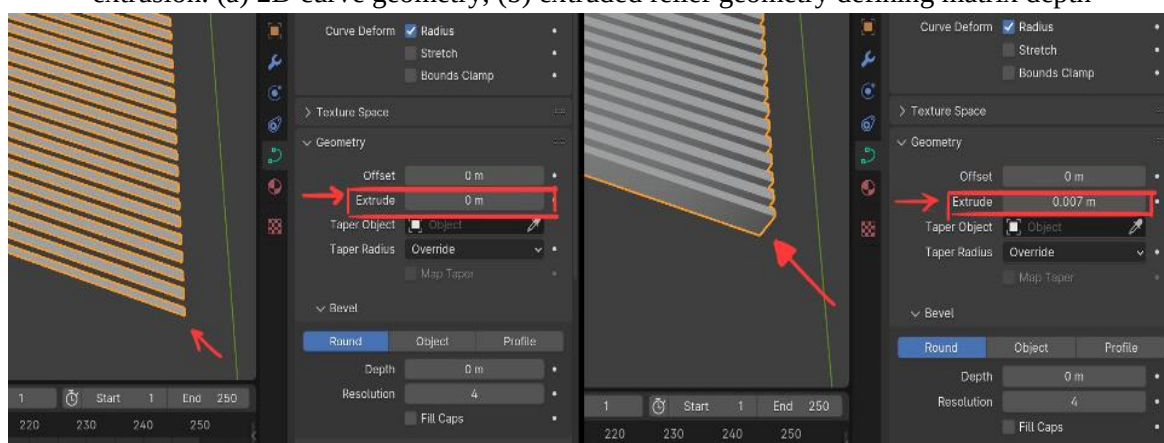
Matrix performance was evaluated according to four interrelated criteria: structural durability under repeated press pressure, fidelity of detail transfer from digital model to printed image, consistency of ink retention and distribution across the relief surface, and visual stability between successive impressions. These criteria were assessed through direct observation during inking and printing, as well as comparative visual analysis of the resulting prints.

Digital image preparation and modeling

The digital designs developed for this study were intentionally constructed around highly repetitive structures and dense configurations of fine linear elements. These visual structures were selected to exceed the practical limits of traditional manual carving techniques, in which the production of consistently spaced, thin lines would require extensive labor and remain prone to irregularity and material loss. By prioritizing repetition, precision, and uniform line density, the design phase functioned not merely as image preparation but as a methodological probe into the capabilities and constraints of SLA-based matrix production. This approach allowed the study to test the extent to which digitally modeled relief geometries – characterized by controlled repetition rather than expressive manual variation – could be translated into physically stable and printable matrices.

The initial phase of the study involved the preparation of source images for relief matrix generation. Digital images were selected based on their suitability for relief translation, prioritizing compositions with clear tonal contrast and defined structural elements. Image processing was conducted using vector- and raster-based graphic software, where tonal values were simplified and inverted to correspond with relief-print logic, ensuring that raised areas would receive ink while recessed areas remained uninked.

Figure 1: Transformation of vector-based linear structures into a relief matrix through curve extrusion: (a) 2D curve geometry, (b) extruded relief geometry defining matrix depth



Source: Author's archive, 2024

Following image preparation, three-dimensional modeling was carried out using Blender software. The processed images were converted into depth maps and subsequently extruded into three-dimensional relief forms. Particular attention was paid to the calibration of depth values in order to achieve a balance between visual clarity and structural integrity. Excessive depth variation was avoided to prevent stress concentrations within the printed resin matrix, while insufficient depth risked loss of tactile differentiation during printing. Figure 1 illustrates the transformation of vector-based linear structures into a relief matrix through controlled curve extrusion, enabling the conversion of two-dimensional digital designs into physically printable forms.

The final digital models were standardized to a uniform plate thickness of 4 mm, a dimension determined through preliminary testing as optimal for maintaining rigidity under press pressure. Earlier test models produced at 2 mm thickness exhibited deformation and, in some cases, structural failure during printing, leading to their exclusion from the final experimental set.

SLA printing parameters and materials

All relief matrices were fabricated using an SLA-based three-dimensional printer operating with UV-curable photopolymer resin. SLA technology was selected due to its high resolution and ability to reproduce fine surface details, distinguishing it from fused deposition modeling (FDM), which has been more commonly addressed in printmaking literature (Merriam et al., 2017: 29).

The printing resolution was set to a layer height of 0.05 mm to ensure precise surface definition and minimal stair-stepping artifacts. Matrices were oriented flat on the build platform to ensure uniform layer formation across the relief surface. Support structures were restricted to the underside of the matrices to prevent interference with printing areas. Post-processing procedures included isopropyl alcohol washing and ultraviolet curing to achieve full polymerization, dimensional stability, and material hardness prior to printing.

Material selection prioritized resins with moderate hardness and flexibility, allowing the matrices to withstand repeated press runs without fracturing. The selection of SLA technology over fused deposition modeling (FDM) was informed by its superior surface resolution and isotropic material properties. Unlike filament-based processes, SLA fabrication produces continuous surfaces without extrusion paths, allowing for more consistent inking and pressure transfer during printing.

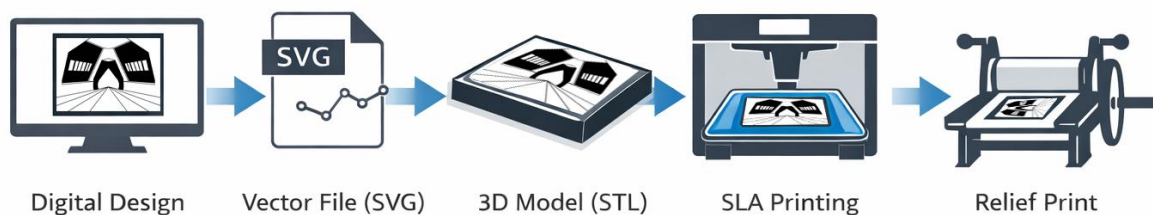
Printing Process

Relief prints were produced using oil-based relief inks applied manually with a hand roller. Manual inking was preferred in order to maintain precise control over ink distribution and to assess the tactile response of the printed matrices. Prints were pulled on acid-free printmaking paper using a traditional etching press configured for relief printing. Press pressure was incrementally adjusted through test impressions to determine optimal transfer conditions. Particular attention was paid to edge sharpness, tonal consistency, and matrix durability. Each matrix was used for multiple impressions to evaluate wear resistance and repeatability under sustained press conditions. The key technical parameters defining the SLA-based matrix production process are summarized in Table 1.

Table 1: Technical parameters of the SLA-based matrix production

Parameter	Specification
Printing technology	Stereolithography (SLA)
Layer height	0.05 mm
Matrix thickness	4 mm
Relief depth	1.5–2 mm
Printing material	Photopolymer resin
3D file format	STL
Image format	Vector-based source, converted to SVG
Inking method	Hand-rolled oil-based relief ink
Printing equipment	Traditional etching press

Figure 2: Workflow of the relief matrix production process, from digital design and vector file preparation to SLA printing and relief print production



The overall production workflow adopted in this study is illustrated in Fig. 2. The process begins with digital image design and vectorization, followed by the generation of a three-dimensional relief matrix and its fabrication via SLA printing. The resulting matrix is subsequently used in a traditional relief printing process.

Matrix performance was evaluated through a set of interrelated criteria focusing on both material behavior and print quality. These criteria included the structural durability of the matrices under repeated press pressure, the fidelity of detail transfer from the digital model to the printed image, the consistency of ink retention and distribution across the relief surface, and the overall compatibility of the matrices with conventional relief printmaking workflows. Observations were documented through successive test prints and comparative visual analysis. Rather than seeking direct equivalence with traditional wood or linoleum matrices, the evaluation aimed to identify the specific advantages and limitations of SLA-based matrices as a distinct material category within contemporary relief printmaking practice.

The methodological scope of this study is limited to SLA-based matrix production and relief printing processes; other digital fabrication methods and printmaking techniques fall outside the parameters of this investigation. This focused approach was adopted in order to enable a detailed material and process-based examination of surface behavior, durability, and ink transfer characteristics under press conditions. As such, the study prioritizes depth of technical analysis over comparative breadth across multiple fabrication technologies.

Findings and discussion

The results of this study are presented through a detailed examination of the performance of SLA-based relief matrices within conventional relief printmaking conditions. Observations are organized around four interrelated dimensions: structural durability, fidelity of detail transfer, ink retention and distribution behavior, and print consistency across repeated impressions. All findings derive from iterative, practice-based testing conducted under standardized press, inking, and material conditions, as described in the *Methodology* section.

Structural durability and mechanical stability

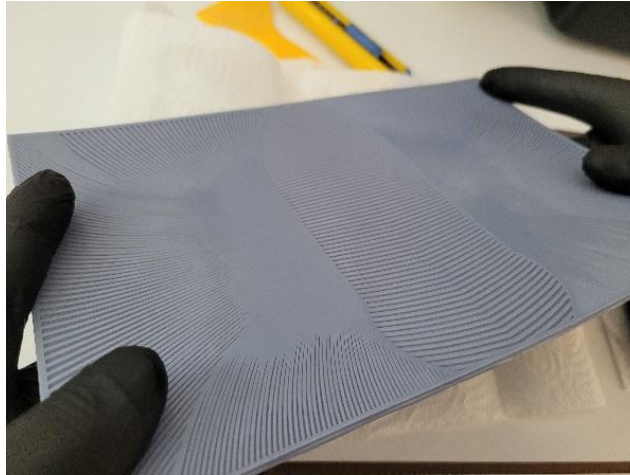
SLA-printed matrices fabricated at a standardized thickness of 4 mm demonstrated consistent mechanical stability when subjected to repeated press pressure. Across successive print runs, the matrices maintained their dimensional integrity without exhibiting visible cracking, warping, or delamination. This behavior marked a clear distinction from preliminary test matrices produced at lower thicknesses, which showed deformation and surface instability under identical press conditions. The results indicate that matrix thickness plays a critical role in determining the suitability of SLA-fabricated photopolymer matrices for relief printing applications. As illustrated in Fig. 3, the SLA-printed matrix preserved its structural integrity and surface uniformity following fabrication and post-processing, providing a stable relief surface suitable for repeated press operations.

The photopolymer material exhibited a balanced mechanical response, combining sufficient rigidity to withstand compressive forces with enough resilience to prevent brittle fracture. During printing, pressure was distributed evenly across the relief surface, and no localized stress failures were observed.

This uniform mechanical response contributed to stable print outcomes and reduced the risk of cumulative damage to the matrix over time.

Minor surface wear was observed along some raised edges following multiple impressions. This wear was primarily limited to areas with sharp relief transitions and high contact pressure. Importantly, the observed abrasion did not propagate or result in progressive material failure. Instead, the wear remained superficial and did not compromise the legibility of printed details. These observations suggest that SLA-based matrices can tolerate the mechanical demands of relief printing while maintaining functional durability within moderate edition sizes.

Figure 3: Cleanly produced SLA-printed relief matrix showing consistent relief depth and surface continuity prior to printing



Source: Photographs from the author's archive, 2024

Figure 4: Fracture occurring during build plate removal of an SLA-printed relief matrix



Figure 5: Thickness-dependent bending and warping behavior of SLA-printed matrices



As also noted in the conclusion of the study, the structural durability of SLA-based matrices emerged as a critical factor influencing their practical viability within relief printmaking workflows. While the printed matrices demonstrated sufficient rigidity and dimensional stability during the printing process itself, instances of mechanical failure were observed during post-production handling, particularly at the stage of detaching the matrix from the build platform (see Fig. 4). These fractures occurred predominantly in regions composed of high-density linear structures with minimal material cross-section, indicating that geometric complexity and reduced structural mass can increase susceptibility to mechanical stress. Such failures do not undermine the overall functional potential of SLA-based matrices; rather, they delineate the operational limits of the material system and underscore the necessity of careful handling protocols, optimized detachment strategies, and further material-specific calibration. In this respect, mechanical fragility functions not as a categorical limitation but as an informative parameter guiding future refinements in matrix design and production methodology.

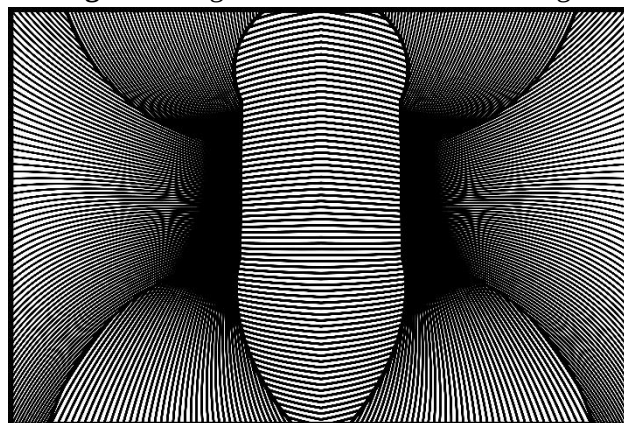
Further evidence of the relationship between structural durability and matrix thickness was observed through a direct comparison of plates printed at 2 mm and 4 mm thicknesses. As shown in Fig. 5, the thinner matrix exhibited pronounced warping and surface undulation, while the 4 mm matrix maintained a substantially flatter and mechanically stable geometry. This increased rigidity enhanced the matrix's functional performance during relief printing, particularly at the inking stage, where a stable and planar surface is critical for uniform ink transfer. In contrast, the deformation observed in thinner matrices introduced localized bending that hindered consistent inking, underscoring thickness as a key determinant of mechanical reliability in SLA-fabricated relief matrices.

Taken together, the structural results demonstrate that SLA-fabricated matrices, when appropriately dimensioned, can operate reliably within traditional press environments. While the long-term durability of such matrices under extensive editioning remains beyond the scope of this study, the observed performance indicates that SLA printing offers a mechanically viable method for relief matrix production.

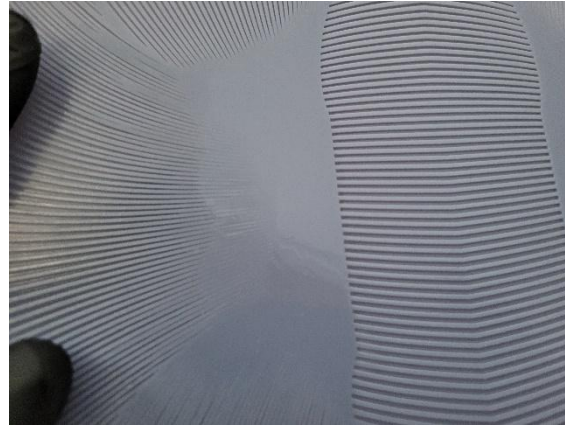
Fidelity of detail transfer and surface resolution

The fidelity of detail transfer from digital model to printed image emerged as a significant strength of the SLA-based matrix production process. The high-resolution layer height of 0.05 mm produced relief surfaces characterized by smooth transitions and minimal surface stratification. As a result, printed images displayed sharp edge definition and accurate reproduction of fine linear elements, closely corresponding to the original digital relief geometry. Fine details, including narrow lines, small negative spaces, and closely spaced contours, were consistently preserved across successive impressions. No perceptible loss of resolution or edge softening was observed during the tested print runs. This stability indicates that the digital-to-physical translation afforded by SLA printing enables precise control over relief geometry that would be difficult to achieve through manual carving alone.

Figure 6: Digital vector-based source design



Source: Author's archive, 2024

Figure 7: Detail view of the SLA-printed relief matrix surface

Source: Photograph by the author, 2024

As shown in Fig. 6, the dense linear structures of the digital vector design were transferred to the SLA-printed matrix with a high degree of fidelity. The printed relief surface (Fig. 7) preserved both line continuity and spacing, even in areas of high curvature and directional change. No visible loss of resolution, line merging, or edge deformation was observed, indicating that the SLA process reliably translated fine vector-based details into physical relief form. The surface resolution of the printed matrix closely matched the digital source, with crisp relief edges and consistent depth across the linear structures (Fig. 7). This level of precision demonstrates the suitability of SLA-based matrix production for designs composed of high-density, fine linear elements. Surface resolution also contributed to visual coherence across the printed image. The absence of visible layer artifacts prevented unintended textural interference, allowing the relief structure to function purely as an image-bearing surface rather than introducing additional material noise. In this respect, the SLA-fabricated matrices supported a clean and controlled visual outcome that emphasized image clarity and structural intention.

These findings highlight the capacity of SLA-based matrix production to sustain high levels of detail fidelity over repeated impressions. The results suggest that SLA printing is particularly well suited to relief printmaking practices that prioritize precision, consistency, and close correspondence between digital design and printed output. Detail fidelity was further examined through digitally generated designs characterized by highly repetitive structures and dense networks of fine linear elements. These configurations were intentionally selected as stress tests for the SLA-based fabrication process, as they exceed the practical limits of traditional manual carving in terms of precision and consistency. Across successive impressions, the fine linear structures retained their visual discreteness, with individual lines maintaining consistent spacing and sharp edges without observable merging, distortion, or material loss.

The stability of these high-density linear configurations was preserved throughout repeated print runs. No progressive degradation in line definition or surface flattening was observed, indicating that the digitally modeled relief geometry remained mechanically resilient under press conditions. These results demonstrate that SLA-based matrix production supports forms of relief printmaking grounded in digitally precise repetition, rather than the controlled variability typically associated with manual carving processes.

Ink retention and distribution characteristics

Ink retention and distribution behavior revealed material-specific characteristics of the photopolymer surfaces used in SLA-printed matrices. When oil-based relief ink was applied manually with a hand roller, ink adhered evenly and consistently to the raised relief areas. Optimal results were obtained when relief depth was maintained within the calibrated range of approximately 1.5–2 mm. Within this range, ink distribution remained controlled, with no observable pooling or accumulation in recessed areas.

Despite the non-porous nature of the photopolymer material, the inking process did not require any specialized techniques or unconventional handling. Standard relief inking procedures—comparable to

those used for wood or linoleum matrices—proved sufficient to achieve smooth and uniform ink application. The surface accepted ink readily, and consistent tonal coverage was achieved without the need for additional surface treatments, texturing, or modified ink formulations. As shown in Fig. 8a-b, SLA-fabricated matrices were inked using standard relief printing tools without requiring any specialized procedures. The uniform ink distribution across the relief surface demonstrates that the photopolymer material supports controlled and predictable inking behavior. The resulting print confirms that fine linear structures retain clarity and tonal consistency during manual inking.

Figure 8a-b: Inking and print output from an SLA-fabricated relief matrix



Source: Produced and photographed by the author, 2024

Compared to traditional organic matrices, the homogeneous surface structure of the SLA-fabricated matrices eliminated variability arising from material grain or fiber direction. This uniformity contributed to predictable ink behavior and repeatable results across successive impressions. Once initial ink loading and roller pressure were established, inking performance remained stable throughout the printing process.

Overall, the findings indicate that SLA-based photopolymer matrices support reliable and straightforward ink transfer using conventional relief printing practices. The absence of material-induced irregularities, combined with consistent surface response, enables controlled and repeatable inking outcomes without introducing additional technical complexity to the printing workflow.

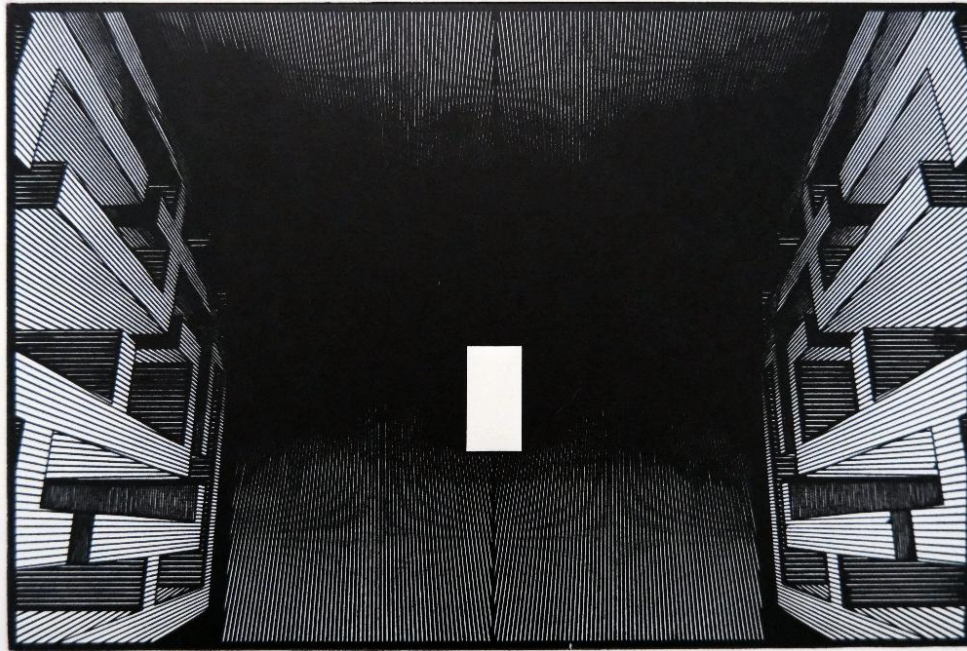
Print consistency, repeatability, and edition stability

Repeated impressions produced from the same SLA-printed matrix demonstrated a high degree of visual consistency across successive prints. Tonal variation remained minimal, and no systematic degradation of surface detail or edge sharpness was observed throughout the tested print runs. This stability indicates that the matrices retained their functional and visual integrity under repeated printing conditions. As illustrated in Fig. 9, fine linear structures and solid areas were reproduced with consistent clarity, supporting the repeatability of the relief surface across impressions. Across multiple prints, line edges remained sharply defined, with no evidence of ink bleeding, line merging, or surface breakdown. Even in densely packed linear regions, the printed lines preserved their spacing and directional clarity, indicating precise relief geometry and controlled ink transfer.

These magnified details demonstrate that repeatability is maintained not only at the compositional level but also at the microstructural scale of the printed image. The consistent behavior of fine lines across different impressions suggests that the SLA-printed matrices provide a high degree of control over surface fidelity, reinforcing their suitability for editioned relief printing where both macro-level uniformity and micro-level detail stability are critical. The controlled relief geometry and smooth surface finish contributed to predictable interactions between matrix, ink, and paper. Pressure transfer remained uniform across the printing surface, reducing the likelihood of uneven inking, tonal

fluctuation, or localized image distortion. Consequently, printed images exhibited coherent tonal structure and stable visual characteristics across impressions.

Figure 9: Relief print produced from an SLA-printed 3D matrix, demonstrating consistent line quality



Source: Produced and photographed by the author, 2024

The observed repeatability suggests that SLA-fabricated matrices are well suited to editioned relief printing contexts, where consistency across multiple impressions is a fundamental requirement. While this study did not aim to establish maximum edition limits, the absence of progressive degradation within the tested range indicates that SLA-based matrices can support moderate edition sizes without compromising print quality. Taken together, these results demonstrate that SLA-based relief matrices can function reliably within traditional printmaking systems while offering enhanced control over precision and repeatability. The combination of structural stability, high detail fidelity, predictable ink behavior, and consistent print outcomes positions SLA printing as a technically robust method for contemporary relief matrix production.

Taken together, these results demonstrate that SLA-based relief matrices can function reliably within traditional printmaking systems while offering enhanced control over precision and repeatability. The combination of structural stability, high detail fidelity, predictable ink behavior, and consistent print outcomes positions SLA printing as a technically robust method for contemporary relief matrix production.

Findings and discussion

The findings of this study position SLA-based matrix production as a materially and conceptually significant extension of relief printmaking rather than a peripheral digital experiment. By examining structural durability, detail fidelity, ink behavior, and repeatability within conventional press-based workflows, the study demonstrates that stereolithography can operate in continuity with core printmaking principles—matrix, pressure, transfer, and repetition—while simultaneously expanding the formal and technical possibilities of relief printing. From a historical perspective, the observed performance of SLA-fabricated matrices aligns closely with Ivins's argument regarding the epistemic importance of exact repeatability in printmaking. Ivins emphasizes that the power of printed images lies not merely in their multiplicity, but in their capacity to generate invariant visual statements through mechanically stabilized processes. The consistent translation of digitally modeled relief geometries into physically stable matrices, as observed in this study, reinforces this notion of repeatability as a

foundational condition of print-based knowledge. In this context, SLA printing does not disrupt the logic of printmaking; rather, it reinforces its historical role as a technology of controlled visual transmission.

Benjamin's analysis of mechanical reproduction further illuminates the implications of these findings. While Benjamin famously associates technological reproduction with the dissolution of aura, he also frames reproduction as a transformative force that reconfigures artistic practice and perception. The use of SLA-based matrices complicates this dichotomy by reintroducing material specificity into digitally mediated production. Although the matrices originate from digital models, their function within the press restores tactile engagement, resistance, and material negotiation—elements traditionally associated with relief printing. This hybrid condition challenges simplistic narratives of digital dematerialization by demonstrating that computational precision can coexist with embodied printmaking processes.

The performance of high-density linear structures assumes particular theoretical significance when considered against the constraints of traditional relief printmaking. Manual carving techniques inevitably introduce micro-variations through tool resistance, material grain, and embodied gesture, resulting in subtle irregularities that accumulate across impressions. Ivins identifies such variability as a defining limitation of pre-mechanical image production systems (Ivins, 1969: 91). The successful realization of digitally precise, repetitive structures through SLA-based matrices suggests a shift from artisanal variability toward computational regularity. Rather than diminishing expressive potential, this shift reframes expression as a function of systemic design logic and structural intention.

At the same time, the study reveals that SLA-based matrices do not eliminate the need for printmakerly calibration. Differences in surface absorbency and ink behavior required adjustments in inking technique, underscoring the continued importance of tacit knowledge and embodied skill. This finding resonates with post-digital discourse, which rejects the binary opposition between digital automation and manual craftsmanship. As Ludovico and Berry & Dieter have argued, post-digital practices are defined not by the absence of materiality, but by its reconfiguration within computationally informed systems. The results presented here support this view by demonstrating that SLA-based matrix production introduces new material conditions that must be actively negotiated rather than passively accepted.

Within the expanded field of printmaking, these findings contribute to ongoing debates concerning the role of digital fabrication in matrix-based practices. Previous studies have emphasized CNC milling and FDM printing as viable alternatives to traditional carving, yet often treat additive manufacturing as a homogeneous category. By focusing specifically on stereolithography, this study highlights the importance of resolution, surface continuity, and material homogeneity as critical variables in relief printing contexts. The observed advantages of SLA—particularly in the reproduction of fine detail and repetitive structures—suggest that not all digital fabrication methods are equally suited to printmaking applications.

Conceptually, the use of SLA-based matrices invites a reconsideration of authorship and variation in relief printmaking. The minimization of tool-induced irregularity shifts emphasis away from expressive carving gestures toward design logic and structural intention. This does not negate artistic agency; rather, it relocates it within the design and modeling stages of production. In this sense, the study supports a view of contemporary printmaking as a site where authorship is distributed across digital planning, material fabrication, and press-based realization.

Taken together, the results and their interpretation suggest that SLA-based matrix production represents a viable and conceptually productive methodology for contemporary relief printmaking. By enabling forms of precision, repetition, and surface control that exceed the practical limits of manual carving while remaining compatible with traditional printing workflows, stereolithography expands the technical and formal vocabulary of relief printmaking without abandoning its historical foundations. This hybrid positioning situates SLA not as a rupture, but as a continuation of printmaking's long-standing engagement with technological innovation.

Results and recommendations

This study has examined the use of stereolithography (SLA)-based three-dimensional printing as a method for producing relief printing matrices within conventional printmaking workflows. Through a practice-based investigation focusing on material durability, detail fidelity, ink behavior, and repeatability, the findings demonstrate that SLA-fabricated matrices can function reliably as relief printing matrices while enabling levels of precision and formal density that exceed the practical limits of traditional manual carving. Rather than positioning digital fabrication as a rupture from printmaking traditions, the study shows that SLA-based matrix production operates in continuity with the historical logic of relief printmaking. Core principles—matrix-based transfer, pressure-mediated image formation, and repeatability—remain central to the process, even as the tools and materials involved are technologically transformed. In this respect, stereolithography reinforces printmaking's longstanding role as a technologically mediated system of visual communication.

The successful printing of digitally generated designs characterized by highly repetitive structures and dense networks of fine linear elements is particularly significant. These results indicate that SLA-based fabrication supports forms of relief printmaking grounded in controlled repetition and precision rather than tool-induced variability. Such capabilities expand the formal vocabulary of relief printmaking while maintaining compatibility with traditional press-based practices, underscoring the hybrid nature of post-digital printmaking.

Taken together, the findings suggest that SLA-based matrix production constitutes a viable and conceptually productive methodology for contemporary relief printmaking. By enabling new relationships between digital design, material fabrication, and embodied printing processes, stereolithography offers a means of extending printmaking practice without abandoning its material and historical foundations. The limitations of this study arise from both its technical focus and methodological scope. First, the investigation is confined to SLA-based fabrication and does not include a comparative analysis with other digital matrix production methods such as fused deposition modeling (FDM) or CNC milling. As a result, the findings cannot be generalized across all digital fabrication technologies used in printmaking.

Second, the study employs a single category of photopolymer resin and does not examine how variations in resin composition—such as differences in flexibility, hardness, or long-term durability—might affect matrix performance. Similarly, while repeated impressions were used to assess stability and wear, the long-term behavior of SLA-fabricated matrices under extended editioning or high-pressure conditions was not systematically evaluated. From a methodological standpoint, the evaluation relies primarily on qualitative, practice-based observation and visual analysis. Although this approach is appropriate within art-based research frameworks, it is not supplemented by quantitative mechanical testing or microscopic surface analysis. Consequently, certain aspects of material performance remain described rather than measured.

Finally, the study is limited to relief printmaking processes. The potential application of SLA-based matrices within other printmaking techniques, such as intaglio, letterpress, or experimental hybrid methods, falls outside the scope of this research.

Future research could address these limitations by expanding the comparative scope of digital matrix production methods. Systematic comparisons between SLA, FDM, and CNC-fabricated matrices would provide deeper insight into the specific advantages and constraints of each technique within printmaking contexts. Additionally, investigations into alternative photopolymer resins and post-processing treatments could further clarify the relationship between material composition and print performance. Extended edition testing and long-term durability studies would also contribute valuable data regarding the sustainability of SLA-fabricated matrices for professional printmaking practice. Incorporating quantitative analyses—such as surface profilometry or pressure tolerance measurements—could complement practice-based observation and strengthen interdisciplinary dialogue between art and material science.

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Ethical approval

This study is among the studies that do not require ethics committee approval due to its practice-based nature and the absence of human participants, personal data, or experiments involving living beings.

Conflict of interest

The author declares that there is no conflict of interest regarding the publication of this article.

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